TESTING TWO COMPONENT PROCESSING MODELS OF READING ACQUISITION

by

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TESTING TWO COMPONENT PROCESSING MODELS OF READING ACQUISITION

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ABSTRACT

In spite of sophisticated models of reading acquisition available to reading teachers implementation of reading programs, even at the beginning grade 1 level, often appears to be based on whatever fad or cycle happens to be sweeping a particular school district at the time. Recently, in the present researcher's experience, Whole Language programs, some with and some without supplementary phonics instruction, are increasingly being implemented for grade 1 as well as higher grades. A point of disagreement between reading theorists has important implications for the sequencing of reading instruction in these and other beginning reading programs. A question has been raised concerning whether whether meaning can aid word identification as has been implicitly assumed by some reading theorists. Instead the suggestion was put forth that processing to word identification involves only phonological/orthographic codes and that it is past the word identification level that context utilization processing aids passage comprehension. In order to investigate the predictive validity of these two models of word identification, empirical measurements were taken of processing involving phonological-orthographic codes and processing related to context utilization and reading

outcomes at the end of grade 1. Structural equation modelling procedures were used to test whether a relationship would be found for either or both processing involving phonological-orthographic codes and processing relating to context utilization and word identification.

The participants of the study were 127 regular class grade 1 students from seven classrooms randomly selected from a pool of classrooms in 44 schools in one large school district in British Columbia. This sample was augmented by including 17 pilot study participants who had been administered identical measures.

The results of the study support the position that, while phonological/orthographic coding is involved in processing to word identification, it is past the word identification level that processing related to context utilization aids passage comprehension, at least for a grade 1 population. It is suggested that grade 1 students would benefit from sequencing instruction at the start of grade 1 to first bring word identification skills to minimal levels before instituting training to extract meaning from context to aid passage comprehension.

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CHAPTER 1

Introduction

Statement of the Problem

Two decades have passed since reading practitioners first debated whether the most efficient route to beginning reading was through a code or meaning emphasis (Chall, 1967; Goodman, 1967). Despite this passage of time, the code emphasis versus meaning emphasis debate continues in the present, often in response to the implementation of Whole Language reading programs at the grade 1 level. Whole Language programs often concentrate on language related ways to develop reading skill and sometimes do not include direct code emphasis training.

Perhaps one of the reasons that the code emphasis versus meaning emphasis debate continues, particularly regarding primary reading programs, is that some reading theorists and practitioners implicitly assume that word identification, an important goal of beginning reading instruction, is aided by context utilization (e.g., Taylor & Taylor, 1983). While most current reading models do take into account the possibility of involvement of parallel coding systems (orthographic, phonological, and morphemic)

in accessing the mental lexicon or in identifying printed words, a fine point of disagreement in the coordination of these parallel coding systems has implications for the code emphasis versus meaning emphasis debate at the grade 1 level.

Seidenberg (1985) raised the question of whether context utilization can aid word identification. He suggested that it is more likely that meaning is accessed past the word identification stage as interaction takes place between word meaning retrieved from the lexicon and sentence context. The answer to this question has important bearing on the sequence of curriculum taught during the grade 1 year. If word identification can be aided by sentence context utilization then it is likely that the teaching of meaning extraction procedures would be relevant even at the start of grade 1. However, if word identification is not aided by context utilization, it might be a better practice to bring decoding to automatic levels by an emphasis on letter-sound correspondence before beginning to practice extracting meaning.

Regarding tests of questions like this one, Cooley (1979) believes that the current challenge to educational researchers is to produce more convincing causal models. He suggested that the use of causal modelling has a better chance of producing cumulative research than the many quasi-experimental studies of the last twenty years.

The present study adopts the point of view that beginning reading is a complex process involving the development of several areas of reading subskills by a cognitively active student. The present research uses the structural modelling methodology available to analyze correlational data to test the two plausible models of reading, one postulating meaning extraction from context aiding word identification and the other postulating meaning extraction from context aiding passage comprehension but not word identification.

Background Of The Problem

Regarding word identification, some disagreement can be seen to be underlying some present reading instruction concerning whether context clues aid word identification at the grade 1 level. Certainly, attention has been paid to developing reading programs. However, little empirical testing of these programs for effectiveness has taken place. Code-based reading emphasis programs often differ considerably from meaning emphasis reading programs. Controversy at the practice level often exists as to whether whether explicit code emphasis instruction is needed at all for beginning reading acquisition. As a result some classroom teachers focus on a meaning emphasis approach in isolation.

The switch in recent years to information processing models may have also confused some teachers and diagnosticians. Current reading theories are replete with information processing flowcharts diagramming interactive processing involving multiple factors (Downing & Leong, 1982; Taylor & Taylor, 1983). Teachers are simultaneously coping with the change to a view of reading as involving interactive processing, attempting to understand the complicated flowcharts of information processing models, and implementing the rather vague exhortation by many experts to take into account the "whole child" in the reading process.

One of the reasons that some reading practitioners may favor either a code emphasis or meaning emphasis in isolation may be that they focus exclusively on either decoding or comprehension. Lomax (1982a) criticizes many reading researchers for restricting their investigations to pairs of components of the reading process. He suggests instead that they include all components that have been shown to be related to the process of reading. He stated, "If there is one thing that we are certain of in reading research, it is that reading acquisition cannot be adequately modeled with only two processes" (Lomax, 1982a, p. 342).

The major goal of the present research is to test two causal models of reading acquisition to determine which

best describes the interrelationships of reading subskill areas and reading outcome areas at the end of grade 1. The accomplishment of this goal can be expected to make explicit the reasons for underlying suggestions for sequencing of instructional objectives and practices in grade 1. Practically, if successful, the present research would be able to suggest to a novice teacher a sequence of beginning reading instruction that would be likely to result in most students being capable of reading simple passages with understanding by the end of grade 1. Also, the study might contribute to resolving the controversy concerning the use or non-use of a supplementary code emphasis in Whole Language programs at the grade 1 level.

Academically, the present research, if successful, would help to resolve the disagreement in the literature concerning whether or not context utilization aids word identification for the grade 1 reader. It could also fill in some of the gap left by three previous reading studies adopting the causal modelling approach. Lomax (1983) detailed the interrelationships of reading subskills and word identification for learning disabled children "past the level of a visual-perceptual component" (p.33). Lomax and McGee (1987) detailed the interrelationships of reading subskills and development of word identification for kindergarten students. Leong (1988) suggested that processing of word structure and word knowledge as well as

phonological/orthographic processing predict reading outcomes for grade 4, 5, and 6 students. The present research takes measures at the end of grade 1 and can be expected to provide detail about the interrelationships of reading subskills and word identification/passage comprehension for students at this level.

Research Question

The main purpose of the study was to address the question of whether word identification can be aided by context utilization at the grade 1 level. To do this, structural equation modelling using the LISREL VI computer program was utilized to check the fit of the parameters that would be expected from two competing reading acquisition models against actual measures taken from a grade 1 student population.

Keywords

Mental Lexicon - Mental representations of the words of a language analogous to a dictionary, albeit complete with word meanings.

Word Identification - "Identification (or recognition) is derived when a unique entry in the mental

lexicon (e.g., a logogen) is activated" (Seidenberg, 1985, p. 203).

Lexical Access - "Involves the activation of information associated with the lexical items, including its semantic, phonological and orthographic codes" (Seidenberg, 1985, p. 203).

Prelexical Processes - "Analysis of the written or spoken input which results in its identification as a particular word" (Seidenberg, 1985, p. 203).

Postlexical Processes - "Involves the selection, elaboration, and integration of lexical information for the purpose of comprehending a text or utterance" (Seidenberg, 1985, p. 203).

Phonological Awareness - "One's awareness of and access to the phonology of one's language" (Wagner & Torgesen, 1987, p. 192).

Phonological Recoding - "Getting from the written word to its lexical referent by recoding the

written symbols into a sound-based representational system" (Wagner & Torgesen, 1987, p. 192).

Organization Of The Thesis

The thesis is organized into six chapters. Following the introductory chapter, the review of the literature is divided into two parts. The first review chapter (Chapter 2) discusses views on the theory of learning to read and empirical studies that have been conducted to investigate this area. The second review chapter (Chapter 3) looks at theory-testing methods that are appropriate for investigating complex academic tasks such as the reading process. Chapter 4 describes the research methods and procedures followed in planning and carrying out the present research. Chapter 5 presents the results of the data analysis and contains a brief discussion of results. Chapter 6 discusses implications of the research results in more general terms and makes suggestions for future research.

CHAPTER 2

Review of the Literature - Reading Models

Introduction

A review of reading models over the past three decades suggests that two complementary themes run through the literature. First, theorists who emphasized decoding aspects of reading tended to concentrate on models of word identification. They emphasized lexical access or ways the reader reaches words stored in the mental lexicon, an hypothesized memory storage of printed words analogous to an English dictionary, albeit complete with word meanings attached. Crowder (1982) for example, chose to emphasize models of word identification in his book on the reading process.

Second, theorists who emphasized comprehension aspects of reading were generally more concerned with models of passage comprehension and aligned with more general models of language comprehension. Goodman (1967), for example, regarded reading as a "psycholinguistic guessing game" and suggested that extraction of meaning from context aided word identification as well as reading comprehension.

Recent textbooks on the reading process are careful

to emphasize both the decoding and comprehension aspects when reading models are reviewed. For example, Downing and Leong (1982) defined the reading task as deriving meaning from printed symbols. Samuels (1986) considered both decoding and comprehension in his model of reading skill acquisition. The information processing model reported in the Samuels'(1986) article postulated a device which monitors comparing of input to memory representation. As processing proceeds, comparisons are made from visual features, phonologically related input and semantically related input to memory representations until words are recognized and meaning is extracted from written material. He also hypothesized that the more automatic the processing to word recognition becomes the more information processing time can be freed for comprehending what is being read.

While the majority of reading models in the literature are meant to explain the information processing going on in a population of skilled or adult readers, the claim is often made that the models also may be relevant for reading skill acquisition as well. From the point of view of instructional reading practice in grade 1, it would be helpful to validate a model that describes the processing involved in both decoding and comprehension at the stage of reading skill acquistion.

A recent integrative review (Carr & Pollatsek, 1985) provides an organizational framework into which most

reading models of the last three decades can be classified. This organizational framework was found helpful in constructing a testable reading skill acquisition model for the purpose of guiding reading instructional practice at the grade 1 level. The Carr and Pollatsek (1985) model differentiates between "Lexical Instance Models" and "Parallel Coding Systems Models".

The "Lexical Instance Models" depend on "visual access to a memory system that represents individual words rather than using general rules in order to achieve recognition" (p.5). The "Lexical Instance" models are further differentiated into three subclasses including "Logogen or Word Detector" models, "Lexical Search" models and "Verification" models.

The "Parallel Coding Systems" models of word identification postulate storage into the mental lexicon from both a visual memory method such as "look-say" and retrieval from the mental lexicon through phonological recoding or by sounding out a word and recognizing it through comparisons to memory representations of speech words. The following review of the literature will take advantage of the Carr and Pollatsek (1985) integrative system to classify the models under review.

Memory Representation For Words

When reading comprehension is considered, reading can be seen to be fairly closely aligned with the more general language comprehension capabilities of the human species. With relative ease, even young children perform the task of recognizing vocabulary words and deriving meaning from them. Common human experiences of this phenomenon are referred to as "remembering" or "understanding". Experiences such as "It was on the tip of my tongue" and "I can't find the answer" testify to the assumption of the relative ease and permanence of word memory access and storage.

Johnson-Laird (1987) gave a much more complex consideration to this phenomenon. He formulated some of the mechanisms involved in the acquisition of vocabulary by young children and the nature of the memory representational system for words. He hypothesized the existence of a type of mental dictionary. Words and their meanings are stored in this mental dictionary. It was also suggested that the dictionary is formed directly through association of real-life forms and their names. The lexicon may also be built indirectly through additions to a semantic network derived from inferring relations with other words. It is possible that abstract vocabulary words

are placed into the dictionary through manipulation of mental models by humans as they use internal representations to describe and interpret how things function in the environment around them. With age and experience, storage into and retrieval from the lexicon becomes automatic and occurs rapidly without conscious awareness. From such a viewpoint, even a young child can be seen to be cognitively active in formulating and developing a mental lexicon.

Lexical Access Models

"Lexical Instance" Models

The Carr and Pollatsek (1985) integrative review separated reading models into two basic classifications, "Lexical Instance" models and "Parallel Coding Systems" models. "Lexical Instance" models are differentiated from "Parallel Coding Systems" models by the lack of a pre-lexical phonological recoding system that allows for lexical access via blending the sounds within words and comparing to speech word representations. Carr and Pollatsek (1985) defined a "Lexical Instance" model as follows:

> A Lexical Instance model is one in which, like the dictionary, each word has its own separate representation in a memory system, and that

> representation is responsible for recognizing all occurrences of the word in print, regardless of variations in typeface, ink color, letter spacing or other stimulus properties that do not change the identity of the word. (p. 5)

One type of "Lexical Instance" model, termed the "Logogen or Word Detector Model," postulated threshold word detectors sensitive to visual inputs that are checked against the particular words represented by the detector. As visual evidence accumulates, the detector for the logogen (mental representation) of an actual stimulus word reaches its threshold and fires, resulting in word recognition. Another type of "Lexical Instance" model, termed the "Lexical Search Model" postulated a representational scheme mapping individual detectors to letter clusters or morphemes. In the "Lexical Search" model, instead of the whole lexicon offering possible candidates for matching, an access code such as a morpheme or letter cluster of some kind is postulated to allow possible word recognition candidates to be chosen from the whole contents of the lexicon. A third type of "Lexical Instance" model, named the "Verification Model," postulates a top-down checking process verifying that particular lexical candidates are in fact the visual stimulus being presented.

"Logogen or Word Detector Models"

Many of the reading models emphasizing direct whole word comparisons to the mental lexicon can be classified as "Logogen or Word Detector" models. One of the most recent of this type of model is the "Pattern-Unit Model" (Johnson, 1981). Johnson took a firm position that direct visual access to the lexicon is the primary route to word identification. In the "Pattern-Unit Model" it was hypothesized that printed information is "unitized" or formed into a unit at a pre-memorial stage. This unit of information (the icon) is then checked against long-term memory storage by means of a comparison process. Orthographic information was considered as all important to word recognition with phonetic processing relegated to a trivial role. In Johnson's words:

> In terms of the reading process, these considerations would suggest that the word is the most elementary unit that can be processed using cognitive mechanisms and any subword analyses should necessarily entail processes that are not normally used in the efficient execution of the skill. For example, while the analytic skills included within the study of phonics may have some pedagogical value (albeit unknown) in the teaching of reading, there is no reason to believe that these skills have any function in the efficient execution of the reading act. (p. 123)

Evidence for the direct visual access route to the lexicon was claimed in the Johnson (1981) article from

studies that showed a faster identification time for words rather than letters in words. A updated version of the original Logogen or Word Detector model by its originator is Morton's (1980), in which memory representations were called "logogens". An older Logogen or Word Detector model is that of Mackworth's (1972b), in which memory representations were called "iconic images". These iconic images were said to be transformed from the primary sensory trace and said to last as long as the normal eye-voice span.

Support for Logogen or Word Detector models operating at the reading skill acquisition level came from a study by Ehri and Wilce (1985). This study sought evidence to support Mason's (1980) formulation of three stages of processing used for word identification. These stages included "context dependency", treating the words as unique visual patterns; "visual recognition", recognizing initial consonants; and "letter-sound analysis", mastery of the orthographic system as a map for speech. In the Ehri and Wilce (1985) experiment, three levels of beginning readers were distinguished: "pre-readers", who could not read any words; "novices", who could read a few words; and "veterans", beginning readers who could read more than a few words. Two kinds of word spellings were tested: a simplified phonetic spelling and a highly visual spelling lacking sound-symbol correspondence. Results showed that

pre-readers were able to identify more words visually while novices and veterans made more correct phonetic choices. These results suggest that the phonetic recoding route to the lexicon might be utilized after at least some associations have been stored by a "look-say" method.

Another model classified as a Logogen or Word Detector model by Carr and Pollatsek (1985) is the McClelland and Rumelhart (1981) model that proposed an interactive model of word perception. This model hypothesized levels of processing in which feature detectors, letter detectors and phoneme detectors converge interactively to process visual input. Component processes that were thought to be involved in such interactive levels of processing include attending, analyzing, associating, predicting, inferring, synthesizing and monitoring (Malicky, 1986).

"Lexical Search" Models

Carr and Pollatsek (1985) described a variation on the Logogen or Word Detector model which they labelled a "Lexical Search" model. What differentiates this visually-based lexical access model is that, instead of one-to-one mappings between logogens and words, it postulated an access code (a morpheme or letter cluster) that is checked against memory representation. Therefore, models of word

recognition that can be classifed as "Lexical Search" models are those that postulate rule-based, orthographically related subword access codes to reach the mental lexicon.

Lott (1970) investigated use of sequential redundancy (the way letter strings are commonly put together) for word identification by elementary students. The 20 grade 1 students in the study demonstrated knowledge that three-letter words are likely to be in the order of consonant-vowel-consonant. The students in the study used this probability to guess the identification of missing letters in a tachistoscopic display.

Posner (1979) suggested that to view the beginning reading stage as simply that of decoding is to see only part of the scene. He stressed that orthographic and visual familiarity are part of the skill of reading and hypothesized that these skills may be crucial to later reading stages. Venezky and Massaro (1979) prepared a very detailed and specific model of the visual processes involved in beginning reading skill. They spoke of a primary recognition process using the orthographic structure of the language, that is, the way letter groups can be put together to form words. A hypothesis was put forth that the rapid word recognition which is essential for skilled reading requires an awareness of orthographic regularity. Adams (1981) suggests that use of processing

involving sequential redundancy would be rather complex as codes involved would involve some use of letter-to-phoneme correspondence.

Estes (1975) put forth an information processing reading model that postulated processing involving both feature detection of letter patterns and detection of linguistic properties from context in word identification. From evidence that the presence of additional letters prolongs single letter recognition time in a tachistoscopic letter identification task, Estes (1975) concluded that familiar or orthographically regular letter patterns supply positional information that influences processing. Further evidence for this conclusion was found in Mason's (1975) study on the effects of single letter positional frequency on letter search time. The sixth grade readers in the study varied in their use of a spatial redundancy strategy (using spatial frequency of individual letters within the string) as a clue. Good readers used the spatial redundancy strategy while poor readers failed to do so.

Juel (1983) investigated the facilitative effect of orthographic versatility (the frequency with which specific letters occur in specific positions in a number of different words) in word recognition. Hypothesizing that orthographic versatility would increase with age, Juel (1983) compared processing between adults and children. Results showed that children were both less sensitive to

orthographic versatility and less automatic in phonological recoding than adults.

Barron (1981) reviewed the literature on four topics that he considered might serve as clues to children's beginning reading ability. The topics included ability to use English orthographic structure, units of processing in word recognition, use of partial graphic information such as initial consonants and the outline of a word, and stages in the use of visual and phonological information in lexical access.

Regarding use of orthographic structure, Barron (1981) concluded that kindergarten and grade 1 students did not use orthographic structure for clues as they had considerable difficulty discriminating letter strings from pseudo-words. The consensus from the various studies reviewed was that it was somewhere between grades 2 and 4 that knowledge of orthographic regularity became a clue for word recognition. According to Barron's (1981) review, this coincides with the development of the ability to attend to several different units of processing, for example, spelling patterns, syllables and morphemes. The review concluded that children learn very early to attend to initial letters followed by final letters. However, little use was made of the outline (envelope shape) of the word until later grades.

The implication from the above articles for the

present research is that although letter-feature detection would be quite likely to affect reading development, it is not likely that grade 1 readers would be using envelope shape as clues for word identification as this strategy likely develops at a later reading stage. However, poor detection of letter reversals at the grade 1 level could be expected to slow reading development and a measure of discrimination of correct letter features was adopted as one part of the measures administered in the present study.

"Verification" Models

A third Lexical Access model classification in Carr and Pollatsek's (1985) integrative review of word identification models is the "Verification" model. Instead of the internal competition among logogens until one reaches its threshold level and fires, the Verification Model postulates a verification procedure used to confirm recognition decision. Differentiating the verification procedure from the McClelland and Rumelhart (1981) interactive inhibition model, Carr and Pollatsek (1985) state:

> like McClelland and Rumelhart (1981), Paap et al. (1982) postulate a set of letter representations, called the "alphabetum" and a set of word representations called the lexicon. Also like McClelland and Rumelhart, visual input goes to the letter level which in turn feeds excitation to appropriate codes at the word level. From

> this point the models diverge. Paap et al. do not rely on inhibitory interactions within and between levels of representation to identify the stimulus. Instead, all word representations that have surpassed a threshold degree of activation join a set of candidates for the next step in the recognition sequence, which is a verification process. The candidates are used one-by-one as probes in a top-down comparison that attempts to match the expected visual characteristics of each candidate against the actual visual characteristics of the stimulus. When a match is found the stimulus is identified as the candidate word that produced the match. (p. 23)

Parallel Coding Systems Models

Pre-Lexical Phonological Recoding Models

According to Carr and Pollatsek (1985), a type of Parallel Systems Coding Model that emphasized phonological recoding before lexical access flourished during the 1970's. The phonological recoding models favored pre-lexical phonological recoding as a means of access to the mental lexicon for the beginning reader.

Coltheart is credited by Humphreys and Evett (1985) as proposing that a phonological code connected to grapheme-phoneme translations could be used to link to the mental lexicon. He regarded this route as a non-lexical processing route that could either go directly from the printed word to speech ouput or link up with the lexical access route to sound out pseudowords. Humphreys and Evett (1985) question the existence of a separate non-lexical

route to speech output, suggesting that orthographic characteristics are present in nonwords as well as phonological characteristics and coding connected to orthography may be aiding sounding out of pseudowords through the usual lexical access route rather than articulation through an alternate indirect route to speech output.

More Versatile Parallel Coding Systems Models

Carr and Pollatsek (1985) criticized the pre-lexical phonological recoding models for their postulating only a limited set of correspondence rules (e.g., spelling to sound translation rules). They suggest that more viable parallel coding systems models are ones that allow both "rule-based or alphabetic knowledge about orthography and grapheme-to-phoneme correspondence plus paired associate knowledge about specific words or lexical instances" (p.18).

Examples of these models are ones that postulate beginning reading depending on phonological recoding or the use of sounding to access the lexicon via comparison to inner speech representations. Next these models postulate that once a bank of visually-recognized vocabulary is built up, direct visual access is used for familiar words. Jorm and Share (1983), for example, took a firm stand on the

benefit to beginning readers of the use of pre-lexical recoding or the use of recoding connected to inner speech phonological representation. In their words, "although phonological recoding may play a minor role in skilled adult reading, it plays a critical role in helping the child become a skilled reader" (p. 105).

In the article by Jorm and Share (1983) attention was concentrated on theories of processing in beginning reading tasks. As the authors of the study pointed out, it is intuitively appealing that children would at first use their existing phonological route to the lexicon and then switch to visual access as their visual memory for words builds up. However, as Jorm and Share (1983) pointed out, one of the stumbling blocks to acceptance of phonological recoding as one of the key processes involved in reading acquisition is the lack of specificity of how phonological processing functions. Is it, for example, connected to grapheme-phoneme correspondence or is it an automatic lexical process based on word segmentation which takes place as words are stored in the lexicon?

Jorm and Share's (1983) conclusion considered the effect of level of phonological processing skills on word identification. They speculated that, in the earliest stages of reading acquisition, only sight word identification is possible. However, it was speculated that "efficiency of phonological processing will have an

enormous influence at the point that the student is taught letter-sound correspondence" (p. 131). It was also speculated that the type of word to be read determines the choice of processing method. Less frequent, abstract or function words may require phonological recoding before lexical access while frequent, concrete words can be processed efficiently by visual processing alone. Jorm and Share (1983) also postulated a "comparator" process that evaluates information received from the phonological route and assigns a probability weight to it and also assigns a weight to the visual route. Presumably, some kind of internal processing takes place and a decision is reached as to which route to try. The authors called this explanation of beginning reading development the "Comparator Theory Of Lexical Access" (p.121).

Regarding the problem of a lack of specificity as to how phonological processing functions, a recent article (Wagner & Torgesen, 1987) differentiated three separate areas of phonological processing. The authors of this article separated three strands in the phonological processing literature which may be causing confounds in some of the multiple regression studies involving phonological processing. These three phonological processing areas include phonological awareness, phonological recoding in lexical access, and phonetic recoding to maintain information in working memory.

Phonological awareness is defined as "one's awareness of and access to the phonology of one's language" (p. 192). Phonological recoding in lexical access is described as "getting from the written word to its lexical referent by recoding the written symbols into a sound-based representational system" (p. 192). Phonetic recoding to maintain information in working memory is defined as "reading written symbols into a sound-based representational system that enables them to be maintained efficiently in working memory during ongoing processing" (p. 193). Wagner and Torgesen (1987) raised the question of whether these three separate phonological processing areas are related to one or more latent factors. They also pointed out that care must be taken not to confound phonological awareness with phonetic recoding in working memory. This would be easy to do by combining, for instance, tasks like syllable and consonant blending which measure phonological awareness with a task like pseudoword sounding which they point out cannot have lexical access.

Carr and Pollatsek (1985) suggest that even more versatile than Parallel Coding Systems Models that allow for both visual word detector lexical access and phonological recoding lexical access, are the ones that allow multiple pathways to the mental lexicon, including one based on accessing representation through morphemes. Subword units in word recognition that the above authors

postulate as "clear candidates for psychological reality" (p.55) include phonological units such as the syllable or phoneme, orthography related units such as spelling patterns, and semantically related units such as morphemes.

The Question Of Whether Context Can Aid Access To The Mental Lexicon

Theorists who emphasized the comprehension aspects of reading have often implicitly assumed that context aids word recognition. Goodman (1967) was one of the reading theorists who gave emphasis to the possibility that beginning readers might figure out printed words by using context clues for meaning. His formulation of reading as a "psycholinguistic guessing game" generated much inquiry and research into semantic and syntactic processing of printed sentences. Goodman (1967) postulated the simultaneous use of grapho-phonetic clues, semantic clues and information extraction from sentence syntax to weigh alternate possibilities of word choices.

Mackworth (1972b) put great emphasis on the cognitive aspects of reading. In a vein similar to present instructional psychology theorists he regarded the reader as undertaking active processing of text being read. He hypothesized comparisons to past experiences and learned material taking place in reading. He emphasized the role of

long term memory in inferring meaning from what is being read. In his words:

> Our expectancies and predictions make it possible to read as rapidly as we do. Internal representations of external events obviate the need for completely continuous checking between the actual and the expected events. These internal programs provide grammatical probabilities as well as trends related to the acquisition of meaning from the words being read. (p. 679)

Evidence for the ability of primary children to recognize syntactic information comes from a study (Menyuk, 1964) that investigated developmental trends in the use of syntactic structures of children two to seven years old. Analysis of written transcriptions of language output revealed that very young children are sensitive to the syntactic structure of sentences. It was also indicated that most can correctly use transformations (changes to negative, passive and imperative) by the end of grade 1. Gleitman, Gleitman and Shipley (1972), interviewing articulate five to eight-year-olds, concluded that not only could the children correctly classify deviant sentences in fair conformance with adult judgements, they could also give interesting and relevant accounts of what was wrong with many of the deviant sentences. The incongruous sentences used to test syntactic recognition in this study were at a level suitable for the participants in the

present study. This task provided a novel and interesting means to test level of sensitivity to incongrous/congruent sentence context.

Leong and Haines (1978) studying children from grades one to three concluded that children's knowledge of the grammatical structure of sentences, as reflected in their ability to repeat sentences of high complexity, facilitated their learning to read. In a further study investigating the relationship of language awareness and reading ability for grade 2 and grade 4 children (Leong, 1984), awareness of linguistic ambiguities and incongruities accounted for 54% of the variance of a word recognition task.

Brown, Smiley, Day, Townsend and Lawton (1977) investigated young children's comprehension and retention of stories and put forth the claim that young children are not only sensitive to the grammatical and syntactic structure of sentences, but they also appear to be actively reconstructing story lines from schemata in long-term memory. Evidence for this ability was claimed from the influence on children's recall for text when a prior story orientation was given preceding a recall task. The authors argued that "a reader's personal history, knowledge, and belief system will influence the interpretation that is given to a passage" (p. 1454).

Leong (1984) compared the effect of simultaneous/successive processing tasks, phonological awareness tasks, and language awareness tasks on word identification in grade 2 and grade 4 children using multiple regression analysis. Differentiation of incongruous sentences entered the regression equation first accounting for 31% of the variance in word identification. Phonological awareness entered next capturing an additional 8% of the variance followed by the successive processing component that captured an additional 1% of the variance.

Support for the position that grade 1 students are sensitive to differences in sentence structure during reading came from another recall study. Gourley (1984) analyzed primer and grade 1 texts for reading portions found difficult by students. She used miscue analysis to locate the difficult portions. Results of the analysis showed students were more succesful when repetition in the story and illustrations were related closely to the narrative. They were also more successful when normal as opposed to simplified sentence structure was used. The author of the above study concluded that when texts are written to ensure normal, grammatically correct discourse rather than simplified sentence structure, more efficient reading results for beginning readers.

Freebody and Rust (1985) developed a multi-factor model for grade 1 readers that involves reading

comprehension as well as word articulation in the successful completion of a reading task. Multiple regression procedures were used in the study of 140 grade 1 children in Australia. Picture sequencing, listening comprehension, memory, letter knowledge, and knowledge about print conventions were used as predictors of both word articulation and discourse level reading achievement. Results showed that children having knowledge of books and print conventions were better at inferentially linking two pieces of information that were separated in a reading passage. This lends support to Downing's (1979) contention that children must grasp the communicative purpose of reading before reading acquisition proceeds smoothly. It also suggests that aspects of meaning, or components concerning reasoning, are activated early in the grade 1 year as the child attemps to successfully complete assigned reading tasks.

Tunmer, Herriman and Nesdale (1988) investigated the relationship between metalinguistic abilities ("the ability to use control processing to perform mental operations on the products of the mental mechanisms involved in sentence comprehension", p. 136) and initial stages of reading in a two year longitudinal study. In this study, 118 participants were administered pre-reading tests, tests of metalinguistic ability, and a measure of concrete operational thought at the end of grade 1. The reading

achievement measures were re-administered at the end of grade 1.

An examination of the diagram of processing mechanisms shows that the authors are postulating both processing at the pre-lexical and post-lexical levels relating to beginning reading. At the pre-lexical level, phonological awareness linked to phonemes was postulated to lead to lexical access. Once word awareness was reached meaning from lexical access was postulated to interact with both syntactic awareness (structural representation of sentences) involving derivation of pragmatic and inferential rules and with pragmatic awareness (sets of interrelated propositions).

The metalinguistic ability measures included a phonological awareness task requiring sounding of nonword syllables, a syntactic awareness task requiring correcting word-order violation in three and four word sentences, and a pragmatic awareness task that required detecting intersentence inconsistencies in an orally presented passage. Reading achievement was measured by tests of real word decoding, pseudoword decoding and reading comprehension. Regression analysis indicated that at the end of grade 1, when the metalinguistic abilities tasks were allowed to enter the regression analysis first they accounted for 48% of the variance in a "concepts about print" test. Vocabulary level and a measure of concrete

operational thought when entered next added another 11% to the variance accounted for. Moderate correlations (.46 and .40) were obtained at the end of both the first and second grades between overall metalinguistic abilities and pseudoword decoding and reading comprehension. The authors of the study concluded that some introduction of training in metalinguistic skills to all children should be given before formal reading instruction begins.

Recent sophisticated reading models assume interactive processing taking place in beginning reading (Downing & Leong, 1982; Taylor & Taylor, 1983). Bi-directional processing of grapho-phonetic codes and extraction of meaning from context using syntactic or semantic codes is postulated to take place during reading activity (Malicky, 1986).

The "Bilateral Cooperative Interactive Processing Model of Reading" (Taylor & Taylor, 1983) hypothesized two parallel tracks of interacting processes. The left track of the model was said to be linguistically related while the right track was said to be primarily a visual pattern matching channel. According to this model, processing in the left track involves feature analysis of graphemes, phonetic recoding, word linkages, consideration of phrase and syntax, function and relationships, all leading to word naming. Processing in the right track involves visual feature analysis, holistic word recognition, association of

real world contexts, all leading to understanding. Much interaction was thought to take place between tracks.

A number of recent multiple regression studies offer tentative support for these sophisticated reading models. For example, a recent longitudinal study of 543 kindergarten students (Share, Jorm, MacLean & Matthews, 1984) found visual, phonological and meaning related attributes to collectively account for 59% of the variance in reading achievement at the end of grade 1. Independent variables considered in the study totalled ten. Early literacy was broken down into five measures: letter names, name writing, name reading, letter copying, and recognition of letters and numbers. Oral language ability was measured by two standardized tests as well as a measure of sentence memory. Two sets of motor skills were also used, as was a questionnaire examining social behaviour and teacher's predictions of achievement. Multiple regression analysis of the total battery of 39 measures showed reliable effects for only six measures: phoneme segmentation, letter names, letter copying, sentence memory, finger localization and sex of participant.

A recent study (Tunmer & Nesdale, 1985) investigated the causal relationship of beginning reader's phonemic segmentation skills and reading achievement. The authors of the study investigated whether phonemic segmentation skill was both necessary and sufficient for

reading achievement. Sixty-three grade 1 children in Perth, Australia were measured on phonemic segmentation skill, decoding skill and reading comprehension. With reading comprehension as the dependent variable, multiple regression analysis showed phonemic segmentation skill accounting for an additional 23% of the variance beyond that of verbal intelligence. Method of instruction accounted for an additional 2% of the variance while ability to decode pseudowords accounted for a further 11% of the variance of reading achievement. The authors concluded that phonemic segmentation was a necessary prerequisite for decoding as good decoders were not found lacking segmentation skill. However, since other factors were involved in reading comprehension this eliminates the possiblity that phonemic segmentation skill alone was sufficient for reading comprehension.

In order to ascertain the merits of general intelligence measures against more specific reading-related information processing subskills, Stanovich, Cunningham and Feeman (1984) conducted a multivariate study. Relationships of general intelligence, decoding speed, phonological awareness and listening comprehension were explored using multiple regression analysis in a sample of 56 grade 1 children. Developmental comparisons were also made against groups of grade 3 and grade 5 children. If the general intelligence measures were forced to enter the

regression analysis last, they accounted for an additional 9.2% of the variance in reading comprehension ability in the Grade 1 sample. However, when the more specific reading measures, decoding speed and phonological awareness were entered last they as a set accounted for an additional 19% of the variance.

Stanovich (1986) detailed a tentative phonologically-based framework for beginning reading that he felt could focus further research efforts. Several commonly postulated routes to the lexicon have been eliminated in Stanovich's (1986) article as he claimed that they are an artifact of reading achievement rather than causally related to it. These include eye movement, which it is claimed "reflects the efficiency of ongoing reading - with the number of regressions and fixations per line increasing as the material becomes more difficult, and decreasing as reading efficiency increases" (p.365). Also suspected of being an artifact of increased reading achievement by Stanovich are the meaning extraction skills that some meaning emphasis reading programs assume aid word identification for beginning readers. According to Stanovich (1986) context is generally an aid to comprehension processing not to word identification. He claims that it is only when bottom-up decoding processes that lead to word recognition are deficient that information is extracted from contextual information.

Self-esteem is also considered to be the result of poor achievement rather than a cause of it. Included in Stanovich's (1986) framework for reading acquisition are phonological awareness and automaticity of decoding.

Summary And Implications For Research

From their integrative review of reading models, Carr and Pollatsek (1985) concluded that it is likely that a sophisticated parallel systems coding model describes most accurately the information flow during the word recognition part of the reading task. Their schematic diagram of both "bottom-up" and "top-down" information flow (p.64) allows the possibility of successful word recognition from one or many of a variety of routes to the lexicon. Postulated are orthographic, phonological and morpheme-related parallel coding systems leading to lexical access or recognition of a word contained in the mental lexicon. Crowder (1982) in summarizing his descriptions of both the bottom up and top down routes to word identification and passage comprehension concluded that a sophisticated model taking into account both word identification and passage comprehension is necessary to grasp the complete picture of the reading task. He also offered some questions of interest to the empirical

psychologist looking for testable research hypotheses. In his words:

> For the moment, it is enough to comment that the either-or approach to bottom-up and top-down processing could hardly be more wasteful. Both directions simply have to be occurring in normal reading and the only questions of interest are three: (1) How do the bottom-up systems work? (2) How do the top-down systems work? (3) How do they coordinate? (p.113)

Regarding the coordination of bottom-up and top-down processing, Seidenberg (1985) raised a related question for research when he questioned whether or not meaning generally facilitates word recognition. In his words:

> The autonomy hypothesis is simply that word recognition is not influenced by nonlexical ("message-level") information provided by the context. Although nonlexical information contributes to the comprehension of text or discourse, it does not affect the recognition of words per se. Processes within the lexicon are not penetrated by these other types of information; rather, the lexicon automatically makes available information which is then available to be acted upon by other comprehension processes involved in interpreting sentences. Those processes operate upon the output of the lexical module, but do not affect its internal operations. (p. 201-202)

What appears to be a difference in choice of emphasis between meaning and code in choosing beginning reading programs has implications for instructional practice aimed at reading skill acquisition. For example, if Seidenberg (1985) is correct and context utilization

does not generally aid word recognition unless decoding skills are inefficient, then in the words of Crowder (1982) "probably there is no better procedure than good old rote drill" (p.111) to bring word recognition skill to automatic levels to free time for passage comprehension. If, on the other hand, the full power of the parallel systems coding models, including some type of top down decision making based on morphemic representation, can be tapped at the word recognition level then a Whole Language approach, training extraction of meaning from context for word recognition may well be the program of choice even at the start of grade 1. It might be possible to test a causal model of word identification and separate the latent factors of othographic/phonological decoding processing and processing related to context utilization to tease out an answer to the question of whether context utilization appears to facilitate word recognition at the grade 1 level. A hint for indicator measures for processing related to context utilization comes from the Seidenberg (1985) article which claims that "resolving ambiguities involves interactions between lexical and contextual sources of information" (p. 204). The "Silly Sentence" task from Gleitman, Gleitman and Shipley (1972), which requires stating whether a sentence is "ok" or "silly" involves resolving ambiguities. The Grammatical Understanding subtest from the Test Of Language Development

(Newcomer & Hammill, 1982) requires lexical access and comparisons to sentence context to solve which picture the orally stated sentence is referring to; and such would be a good measure of interaction between the lexicon and post lexical processing of sentence syntax.

Seidenberg (1985) also provided precise definitions of the processing components likely present in a parallel systems coding model of reading. Prelexical processes are defined as "analyses of the written or spoken input which result in its identification as a particular word" (p. 203). Word identification is described as "Identification (or recognition) is achieved when a unique entry in the mental lexicon (e.g., a logogen) is activated" (p. 203). Lexical access "involves the activation of information associated with the lexical items, including its semantic, phonological, and orthographic codes" (p. 203). Post-lexical processes, according to the article "involve the selection, elaboration, and integration of lexical information for the purpose of comprehending a text or utterance" (p. 203).

Regarding indicator measures of orthographic and phonological processing, suggestions are available from Wagner and Torgesen (1987) who suggested that tasks likely to be present in phonological processing include some type of "efficient phonetic coding for storing the sounds of the letters" and "blending the sounds to form words" (p. 193).

Common measures of these tasks used in research (e.g., Lomax, 1982) include the Consonant Blends and Syllables and Common Phonograms from the Diagnostic Reading Scales (Spache, 1972).

CHAPTER 3

Model-Testing Methodology

Introduction

Much concern has been expressed in recent years about the gap between theories and research techniques that test their validity (Blalock, 1985). Problems at both the conceptual and measurement ends of the research spectrum have been blamed for this gap. Barrow (1981) complained that a great deal of educational empirical research is not done well because of the failure to use logical procedures in conceptualizing the research. In a similar vein, Cooley (1979) outlined the probem of specification error found in the evaluation of educational programs as well as other educational research. Specification error occurs when a predictor variable that does directly affect an outcome measure is left out of a theoretical model. In situations where this variable correlates with one of the indicator variables that has been included in the model, a "spurious" correlation occurs with resulting incorrect attribution of causation to the indicator variable. Regarding measurement in research, Dwyer (1983) blamed measurement problems for

the "apparent failure of most attempts to establish empirical generalizations about social and/or psychological phenomena" (p.209).

Mulaik (1987) places part of the blame for the poor reputation correlational research methods have with many philosophers and experimental researchers on the view of causality seemingly adopted by some of the associationistic researchers. He suggests they have misused trial and error methods until they locate a model that fits the data collection they have taken. In his words:

> Those trained primarily in the use of Pearsonian association statistics tend to regard the scientific enterprise as one in which the researcher uses statistical methods to discover associations between phenomena. These associations are then interpreted and the theoretical implications are extracted. However, little emphasis is placed on testing these interpretations. (p. 19)

While deploring this tendency to manipulate correlational data until a model emerges that fits the data and then concluding that one has discovered a real causal connection, Mulaik (1987) proposes that, used properly, the conceptualizing and measurement capabilities of the recent structural equation modelling approach offers considerable improvement to past associationist approaches. In his words:

> In particular, the causal modeling methods demand more rational-analytic and definitional activity on the part of the researcher at the outset of a

> research undertaking than do the associationist methods. And the statistical procedures employed by the causal modelling methods are not used primarily for the discovery of causal connections but for the purpose of testing hypotheses about causal connections. These hypotheses are generated by the initial rational activity applied to previous research. (p. 19)

Blalock (1985) and Pedhazur (1982) shared Mulaik's (1987) concerns that the researcher and not the data must determine the explanatory scheme of the research. In a similar vein, Dwyer (1983) claimed that the appropriate unit of observation in the human sciences is the flow of organized activity, not associations between isolated variables. He proposed that the task should be to test models that predict and explain regularities in the flow of organized activity. Pedhazur (1982) also suggested that the proper procedure for scientific investigation in the social sciences is to test a priori hypotheses about causal relations. In his words:

> Covariation or correlation among variables may be suggestive of causal linkages. Nevertheless, an explanatory scheme is not arrived at on the basis of data, but rather on the basis of knowledge, theoretical formulation and assumptions, and logical analysis. It is the explanatory scheme of the researcher that determines the type of analysis to be applied to data, and not the other way around. (p. 579)

Blalock (1985) stated that structural equation modelling offers a systematic set of rules to conclude causal direction on the basis of a series of empirical

interrelationships. The systematic rules of causal modelling require close attention by the researcher to selection of theoretical constructs or latent traits under investigation, their interrelationships and their measurable indicators.

An answer to some of the measurement problems plaguing mutivariate statistical analyses is also possible in the structural equation modelling approach. Dwyer (1983) and Mulaik (1987) recommended the use of multiple indicator measures of a latent trait. The use of multiple indicators increases the chances of obtaining construct validity as presumably there is a better chance of capturing more aspects of a concept. Provided that wise choices of indicator measures for each construct are made, it should be possible to reflect more of the construct under consideration. Hertig (1985) pointed out the improved potential for theory testing from the structural equation modelling techniques. In his words:

> What this means to the researcher is that theoretical propositions can be developed and tested unencumbered by the contamination of measurement error that may seriously bias parameter estimates and threaten the validity of conclusions drawn from their values. The model can estimate the parameters among the unobserved concepts of interest, derive the epistemic correlations between measured indicators and concept, and recognize and control for the effects of differential bias among indicators." (p. 264)

Structural Equation Modelling In LISREL VI

The LISREL VI computer program (Jöreskog & Sörbom, 1984) is a causal modelling program composed of two parts, the Structural Equation Model and the Measurement Model. Specifying the Structural Equation Model forces the researcher to precisely describe (in mathematical terms) the postulated causal flow and relationships among the predictor and outcome latent variables of the model under consideration. Specifying the measurement model forces the researcher to precisely specify in mathematical terms the links between the indicator measures or observed variables and their latent factors or hypothesized constructs. The computer program describes the measurement properties of the observed variables.

According to Hayduk (1987) "LISREL's three basic equations (containing four matrices of coefficients) and four additional covariance matrices provide a general model into which almost any model can be fit" (p.88). The first of the three basic matrix equations is the structural model and "demands that we locate all the concepts or latent variables in our model" (p.88), classify them as outcome (directly caused) or predictor (acting as a cause), list the names of all outcome and predictor concepts in separate

column vectors [outcome concept vector named η (eta); predictor vector named ξ (ksi)] and add an error vector ζ (zeta) in the form of $\eta = B\eta + \Gamma\xi + \zeta$. B(Beta) and Γ (Gamma) are matrices containing structural coefficients that will be generally estimated by the computer program. The other two equations of the measurement model link the observed indicators to the postulated latent factors.

Following Hayduk (1987) the outcome indicator variables (y's) and predictor indicator variables (x's) are expressed as linear combinations of the latent variables and are listed in separate column vectors [Λy(lambda y and ϵ(epsilon)] for the outcome indicators and their measurement error and [Λx(lamda x) and δ(delta)] for the predictor indicators and their error of measurement. Four other matrices of coefficients to be estimated are reported to be "required to complete the specification of the general model" (p.93) including Φ(phi) the covariance among the predictor latent factors, Ψ(psi) the covariance among the zeta's (error influencing the outcome latent factors), $\Theta\epsilon$(theta epsilon) the measurement error variables in the observed outcome variables, and $\Theta\delta$(theta delta) measurement error variables in the observed predictor variables.

Using the matrices calculated by the computer program it is possible to compare the actual variances and covariances of the observed indicators to the variances and

covariances that would be expected from the postulated model under consideration. According to Hayduk (1987):

> comparisons of the model's predictions matrix (Σ) with observed reality (the actual observed covariances) provides the fundamental basis for testing a model's adequacy and for obtaining reasonable estimates of the model's coefficients. (p. 107)

The Σ(sigma) matrix is a variance/covariance matrix among the observed predictor and outcome indicator measures that is computed based on partial outcomes of the analysis. The S matrix is the actual observed covariances among the indicators. In Hayduk's (1987) words:

> the closeness of the match between Σ and S gives not only a criterion for deciding which of the alternative models is better but also a criterion for determining the best estimates for the free coefficents in any given model. (p. 117)

In using structural equation modelling via the LISREL VI computer program in the recommended confirmatory fashion to test a model constructed from previous findings, the researcher is faced with much more responsibility to hypothesize possible causal relationships than under associationistic practices. As well as specifying the causal interrelationships of predictor and outcome latent factors in advance, the researcher has the option of fixing measurement reliabilities or error values at specified values. According to Hayduk (1987) "the strategy of

fixing error values at specified values gives the researcher some direct control over the meaning of the concept" (p. 120). For example, if it is the researcher's opinion that a measure of intelligence used is tapping only restricted aspects of the concept the researcher can set the error value of the indicator measure of intelligence at a value of .20 or so, reflecting the view that only certain aspects of the concept of intelligence are being tapped.

When structural equation modelling is used as a confirmatory procedure for testing postulated models, a great degree of precision is required for model specification. The contrasting of the matrices for a comparison of fit between the postulated variances and covariances expected from the postulated model and the actual variances and covariances of the observed indicators make it a much more objective procedure than former associationistic practices of deriving models from data. Hayduk (1987) points out that:

> If we discover that our model provides a good fit to the observed data, we have moved beyond confirming our reliability judgements and closer to confirming the validity of our concepts, since the concepts as specified through our decisions regarding error variances will have been shown to operate in precisely the manner required for construct validity through confirmation of predicted relationships among a multitude of theoretically relevant variables. (p. 123)

Statistical significance of the estimates can be checked using a table of standard errors of the estimate and their t-values which we can compare against a normal probability table. A matrix of correlations among the estimates is also provided in the LISREL output. According to Hayduk (1989) a correlation near 1.0 or -1.0 alerts the researcher to the problem of colinarity between the estimates of two coefficients (p. 175). A standardized solution of the estimates is also optional in the LISREL output that rescales the estimates such that all the concepts are standardized with a variance of 1.0 but all the indicators remain in their original scale.

Possible Problems With Maximum Likelihood Estimation

Hayduk (1989) reports that two problems may exist in deriving unique structural equations when using maximum likelihood estimation. These problems are identification and colinarity. The identification problem concerns the necessity for the theory specifications to be sufficient to allow certain or unique estimates of structural coefficients of interest. Five symptoms of problems of identification in the LISREL output include large standard errors of coefficients, reports of an inverse (a nonzero determinant) in the information matrix, wildly unreasonable estimates such as negative error variances, standardized

variances, standardized coefficients exceeding 1.0, and correlations between coefficient estimates exceeding about .9 (p. 142, 143).

The problem of colinarity involves highly correlated indicator variables of different hypothesized latent factors. This will affect the specification of paths to outcome factors making identification difficult.

Statistics For Comparing The Fit Of The Model(s)

In the LISREL VI computer program (Joreskog & Sorbom, 1984) statistics that compare the fit of the model include an overall X^2 measure. "Large X^2 values correspond to bad fit and small X^2 values to good fit" (p. 139). Hayduk (1987) suggests using X^2 as one of several indicators of the quality of fit and giving it more weighting if the number of participants is between 50 - 500. He warns that studies with very large numbers of participants are particularly likely to be detectable as more than mere sampling fluctuations. An adjusted goodness of fit index (AGFI) is also available that takes into account the number of degrees of freedom in the model. This goodness-of-fit index "is a measure of the relative amount of variances and covariances jointly accounted for by the model" (Joreskog & Sorbom, 1984, p.141).

different models for the same data" (p. 1.41). A very small RMSR value indicates little substantial residual left unaccounted for. Should a fit be very poor for a hypothesized model the program provides normalized residuals tables. "Residuals larger than two in magnitude are indicative of specification error in the model" (Jöreskog & Sörbom, 1984, p. 1.42). Thus it is possible to alter a poorly fitting model providing the modifications are in keeping with theoretical reasoning in order to tentatively suggest improvements for further research. What is labelled a Q-Q plot in the LISREL output helps the researcher determine if the residuals are normally distributed. According to Hayduk (1987) "if the residuals are normally distributed, we get a line of points rising at 45 degrees in the Q-Q plot" (p. 171).

The Use Of Structural Equation Modelling For Developmental Models

A recent issue of the journal Child Development was reserved for discussions concerning pros and cons on the use of structural equation modelling for developmental studies. A number of helpful pointers emerges from a perusal of this issue.

Connell (1987) addresses the issue of pros and cons of using structural equation modelling in developmental

studies. He outlines three reasons why developmental researchers will likely incorporate structural equation modelling into their research tools. First, in his opinion, the current "zeitgeist" concerning theory and research is both eclectic and has returned to tolerating hypothetical constructs as long as they are firmly attached to observable indicators. Second, he thinks that the availability of user-friendly structural equation modelling computer programs and multivariate research requirements for graduate students will result in a better conceptual grounding in factor analysis and regression. Third, he thinks that the confirmatory factor-analytic and regression procedures in structural equation modelling provide the possibility for "perspective enhancement" as they allow hypotheses to be statistically evaluated for acceptance or rejection and comparisons of competing models.

Regarding the common finding that indicator measures in developmental studies have a non-normal distribution, Huba and Harlow (1987) conclude that a caution is to be exercized concerning uncritical acceptance of goodness of fit statistics and standard errors for non-normal measures. They recommend "when the data are not normally distributed, trust the maximum likelihood parameter estimates but not necessarily the goodness-of-fit statistics or the standard errors for the individual parameter estimates" (p. 165).

Structural Equation Modelling Applied To Reading

There have been some direct applications of structural equation modelling techniques to investigate reading development. In one of these applications, Lomax (1983) used the LISREL IV computer program to investigate the relationship between phonological processing and reading comprehension in learning disabled students. A component process was defined as a category of performance. In this study, component processes that underlie reading achievement were hypothesized to emerge in a hierarchical manner. A hypothesized causal model of the component processes was constructed to describe the causal pathway to reading achievement. Four components: a phonological component, a word recognition component, a reading rate component and a decoding component were postulated to be involved in reading comprehension. The use of causal modelling allowed investigation of the causal network amongst these four components. Participants for the study were 101 learning disabled students in elementary grades. Indicator variables were chosen for the four components. Through a series of model fitting procedures in the LISREL computer program, an optimal model in terms of goodness of fit was chosen. Ninety-three percent of the variance in the word recognition component

was explained by the development of phonological skills and reading rate. It was concluded that some proficiency in phonological skills was important for developing word recognition skills.

In another application of the LISREL program to reading (Lomax & McGee, 1987) word reading acquisition in kindergarten children was investigated. In this study interrelationships of five components of word reading, early knowledge about print concepts, graphemic awareness, phonemic awareness, grapheme-phoneme correspondence, and isolated word reading were investigated. Eighty-one private school children, aged from three years to six years, were measured on indicator variables of the five components.

The use of the LISREL VI program allowed the reconstruction of the observed correlational matrix in accordance with the imposed theoretical structure postulated by the researchers. Good fit to the data was demonstrated for the five component model that hypothesized progression through concepts about print leading to graphemic awareness to phonemic awareness to grapheme-phoneme correspondence and finally to word reading.

Summary

In recent years educational philosophers have increasingly made objections to the applications of research findings from both controlled laboratory experiments and quasi-experimental designs to the educational practice level. These objections are made on the grounds of both inadequate conceptualization at the research formulation stage (Barrow, 1981) and the question of generalizability of research findings. The question of generalizability includes references to both representativeness of results and the possibility of interaction effects that vary between research settings (Blalock, 1985).

Recent methodological advances offer promise for improving both the conceptualization of research at the formulative stage and for strengthening of the external validity and generalizability of research findings. This is particularly true for research that tests theory. Methodological advances that offer this promise are structural equation modelling and the development of the LISREL computer program (Jöreskog & Sörbom, 1984). LISREL VI includes a measurement model that specifies the relationships of observable indicator variables to latent variables. It also includes a structural equation model

that specifies the interrelationships of predictor and outcome latent variables. The use of path analytic procedures in causal modelling demands the careful, logical formulation of the causal relationships amongst a system of interrelated variables. Estimation procedures provide any unknown parameters for the structural equations in identified models allowing the comparison of hypothesized models to reality. Ill fitting models can be eliminated and modification indices aid tentative formulations to improve models for future research. It is possible that adoption of these procedures by researchers could improve research standards, particularly at the conceptual stage and prevent premature implementation of untested models to curriculum instruction.

The state of the art in structural equation modelling is successively becoming more refined. There is a growing body of understandable explanations of the technique (Bentler, 1980; Blalock, 1985; Hertig, 1985; McArdle, 1984). Critics are now emerging (Freedman, 1987) and their criticisms should keep researchers who use the methodology alert to defects and pitfalls. Recent applications in the Social Sciences include studies in the reading area (Leong, 1988; Lomax, 1983; Lomax & McGee, 1987).

CHAPTER 4

Design Of The Study

Introduction.

The purpose of the study was an empirical testing of two models of reading skill acquisition to see if evidence could be found to support student's use of context utilization as well as othographic and phonological coding to reach word identification at a grade 1 level. Of particular interest was the question raised by Seidenberg (1985) concerning whether the use of context clues aids word recognition. The answer to this question could be expected to have bearing on the sequence of grade 1 reading instruction. If Taylor and Taylor (1983) were correct that clues from context can be used to aid word recognition then the implementation of a Whole Language type program stressing meaning extraction from print even at the start of reading instruction would likely be viable. If however, Seidenberg (1985) was correct that context utilization was only used infrequently as when decoding skills are dysfunctional, then it could be expected that initial code emphasis practice to quickly establish automaticity of word recognition (identification) would be a good beginning strategy. As argued by Laberge and Samuels

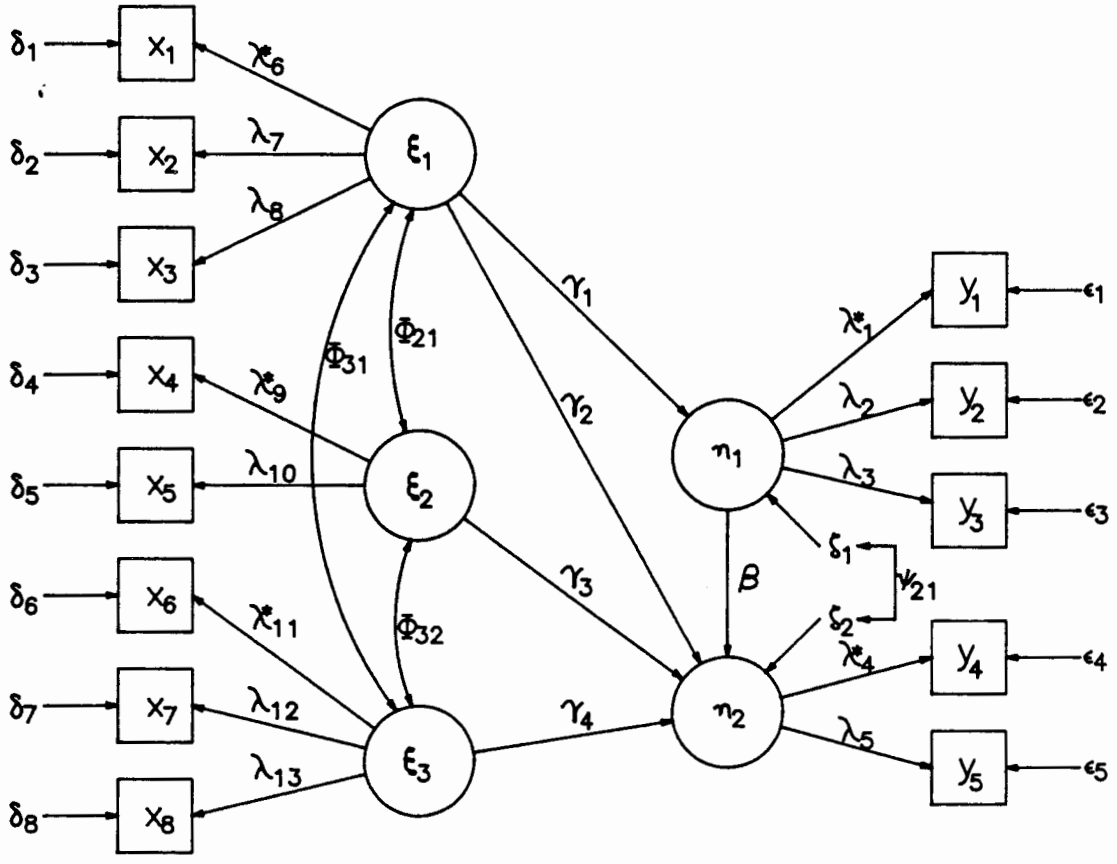
(1974) it is likely that, in a limited capacity processing system like the human information processing system, freeing time from decoding to processing would allow more processing time for comprehension. A Whole Language type program could then be implemented past the word recognition stage in which the emphasis on context utilization focused on the integration of lexical information to aid comprehension of text.

In this chapter, details on the sample, materials used and the procedures followed in the pilot and main study are outlined. Table 1 lists the predictor (ξ) and outcome (η) latent variables and the indicator measures used to test the parallel systems coding model diagrammed in Figure 1.

Table 1: Predictor And Outcome Latent Variables And Their Indicator Measures For The Parallel Coding Systems Models

Independent Latent Variables	Indicator Measures	Task
Orthographic/ Phonological Processing	X_1 Reversal Detection	Jordan Left-Right Reversal Test
	X_2 Syllable Sounding	DRS Syllables and Phonograms
	X_3 Consonant Blends	DRS Consonant Blends
Context Utilization-Related Processing	X_4 Incongruous Sentence Detection	Silly Sentence Task
	X_5 Lexicon/Context Interaction	TOLD, Grammatical Meaning subtest
Pre-existing Aptitude/ Knowledge-base	X_6 Vocabulary	TOLD Vocabulary
	X_7 Symbol-Name Association	Modified WJPB Visual-Auditory Learning
	X_8 Intelligence	WJPB Brief Cognitive Cluster
Word Identification (recognition)	Y_1 Pre-primer word list	BODER Pre-Primer word list
	Y_2 Grade 1 word list identification	BODER Gr. 1 word list
	Y_3 Word identification in passages	Basic Reading Inventory Grade 1 passage
Passage Comprehension	Y_4 Recall Questions	Basic Reading Inventory Recall Questions
	Y5 Inference Questions	BRI Inference Questions

Figure 1. Hypothesized Model Of The Reading Process At The End Of Grade One.



λ* = coefficients fixed to unity

Method.

Participants

The participants of the present study were 127 grade 1 students (67 males, 60 females, mean IQ 106), attending school in Coquitlam, B. C., Canada. Coquitlam, B. C. is a suburb of a large metropolitan city. Mixed socio-economic conditions exist in the suburb due to new subdivisions intermingling with older areas. Seven classrooms were randomly chosen by draw from the 44 elementary schools in the Coquitlam School District. One school refused participation. Of the remaining six elementary schools, three were in older areas of Coquitlam and three were in areas of new subdivisions. Parental request was asked for participant participation and a 70% rate of approval was received.

Materials

The measurement tasks for the study consisted of the following:

1) Five subtests from standardized tests.

2) One modification to the materials of a standardized subtest.

3) Four informal measures of reading subskills and outcomes from informal reading assessment instruments.

4) One context utilization related task borrowed from previous research.

A. Standardized Tests.

1. Jordan Left-Right Reversal Test Level 1 (Jordan, 1980).

2. Picture Vocabulary subtest of the Test Of Language Development (TOLD), Newcomer & Hammill, 1982).

3. Grammatical Understanding subtest of the TOLD.

6. Brief Cognitive Cluster of the WJPB (Woodcock & Johnson, 1977).

7. Use of Rebus Picture Symbols from the Visual-Auditory Learning subtest of the WJPB.

B) Informal Reading Inventories.

1. Common Syllables or Phonograms subtest of the Diagnostic Reading Scales, (DRS), Spache (1972).

2. Consonant Blends & Digraphs subtest of the DRS.

4. Pre-primer and Grade One word lists from the BODER.

5. Grade One Reading Passage, Form A, of the Basic Reading Inventory (BRI), Johns (1985).

D) Previous Research Task.

1. Silly Sentence Task from Gleitman, Gleitman & Shipley (1972).

Assignment Of Tasks To Latent Factors

Component skills processing clusters were selected on the basis of key areas of information processing areas formulated from the literature review, namely:

Latent Independent Factors:

Orthographic/Phonological Processing	-	Jordan Left-Right Reversal
	-	Consonant Blends & Digraphs.
	-	Common Syllables or Phonograms
Context Utilization	-	Grammatical Understanding.
Related Processing	-	Incongruous Sentences.
Pre-Existing Aptitudes/ Knowledge Base	-	Intelligence - WJPB Brief Cognitive Cluster
	-	Vocabulary - TOLD Vocabulary
	-	Symbol-Name Assoc. - Modified WJPB Visual-Auditory Learning.
Outcome Latent Factors		
Word Identification	-	Number correct on BODER

Primer and Gr. 1 list.

- Words read correctly on BRI reading passage.

Passage Comprehension - Number correct on the comprehension questions of the BRI broken down into recall and inference questions.

Pilot Study

The pilot study was conducted in March and April of 1987 as part of a more complex study involving predictors relating to reading outcome measures to test the suitability of the informal tasks and find out the time required for administration of the measures.

Participants of the pilot study were 55 grade 1 pupils (28 females, 27 males), mean age 6 yrs. 10 mo. who attended school in Hope, B. C. Permission from the School District, the two elementary schools involved, and parents was solicited. The return rate for participation was 55%.

Procedure

All measures were individually administered by the experimenter. The Picture Vocabulary subtest of the TOLD was administered first and praise given for answering to build rapport. Order of administration of the remaining tasks was revolved in order to control for either possible fatigue or presentation effects.

Orthographic/Phonological Processing Tasks

At the grade 1 level visual/phonological coding leading to word identification can be expected to involve feature detection of letter symbols as well as sensitivity to sounds within words. Common measures of sounding of phonemes used in research at the primary grade level include the Syllable Sounding and Consonant Blends subtests from the Diagnostic Reading Scales (e.g.,Lomax, 1982a). In order to avoid confounding visual processing with phonological, use of a measure that involved letter-feature comparison to memory rather than letter-name or letter-sound correspondence was utilized. A common reversal detection standardized test, that at a face validity level can be seen to require comparison to letter and number features to identify reversals was utilized. This

consisted of the Jordan Left-Right Reversal Test, (Jordan, 1980). In the present researcher's clinical experience, children who are slow to develop beginning reading skills often fail to detect reversed letters on this test. This measure was used in the present study to check correct perception and comparison to memory representation for letter features. Participants were told:

"Some of these letters are backwards and some of them are OK".

Each letter was pointed to with a pencil by the assessor and the child asked:

"Is this letter OK or backwards"?

An X was placed on reported errors by the assessor.

To test word identification access via phonological codes both the Common Syllables or Phonograms and the Consonant Blends And Digraphs subtests of the Diagnostic Reading Scales (DRS, Spache, 1972) were administered with the children told:

"These are pieces of words. Please read them for me."

Context Utilization Related Processing

While ideally, the use of a task that required morphemic processing during reading of print would have been ideal to see if a morphemic code was used at a pre-

lexical access level, it was not thought possible to separate out phonological/morphemic processing during an actual reading task. Therefore a task was used for which successful completion could be seen to be related to context utilization during reading. This task involved processing concerning interaction between meaning from the mental lexicon and context. To check ability to derive meaning from the lexicon to identify which picture from a choice of three described spoken sentences the administration of the Grammatical Understanding subtest of the Test Of Language Development (TOLD, Newcomer and Hammill 1982) was done. In this subtest a spoken sentence is accompanied by a choice of three pictures representing the sentence. At a face validity level, it can be presumed that processing involving some interaction of word meaning from the lexicon and picture context must take place for participants to choose the matching picture.

Sensitivity to ambiguity in sentences has been used in past research to test the meta-linguistic awareness level of children. (e.g., Leong, 1984; Tunmer, Harriman, & Nesdale, 1985). In the present study to test processing involving meaning/context interaction via differentiation of nonsense sentences the "Silly Sentence" task from Gleitman, Gleitman and Shipley (1972) was administered to all participants. Participants were told:

"Some of these sentences are silly. They don't make sense or words are used in the wrong way. For example, if I said "The house ran down the Street" - that would be silly - right?. You tell me if the sentence is silly or OK".

Word Identifiction (Recognition) Tasks

The pre-primer and grade 1 word lists of the Boder Tests Of Reading-Spelling Patterns, (BODER, Boder & Jarrico, 1982), which alternate phonetic and non-phonetic words, were administered to check word recognition level.

To check words read in the context of passages, words read correctly on the Basic Reading Inventory (BRI) by participants were noted.

Passage Comprehension Task

The grade 1 reading passage of the Basic Reading Inventory (BRI) was administered to all participants in the following manner:

"I want you to read a story for me. I will record your voice on the tape recorder as you read and let you hear it later. Read this for me please."

The black and white printed passage was placed before each youngster and the tape recorder activated. No

help was given for the reading passage and the children were allowed to take as long as they needed to read as much of the passage as possible.

Pre-Existing Aptitude/Knowledge Base

As well as facility at orthographic/phonological and context utilization related processing components a pre-existing or already learned aptitude/knowledge base component was assembled in the present research to take into account aptitude/knowledge base levels of competency that could be expected to influence ending grade 1 reading outcome measures. Intelligence and vocabulary levels are routinely included in reading research during developmental levels (e.g., Stanovich, Cunningham and Feeman, 1984). In the present researcher's experience, poor memory for sight words often impedes buildup of reading skills at the grade 1 level.

The Brief Cognitive Cluster of the WJPB was administered to all participants as a brief-time measure of intelligence.

The Vocabulary subtest of the TOLD was administered to all participants as a brief-time measure of receptive vocabulary.

Storage and retrieval into and from memory representation was measured by use of a memory storage

task. In this task, six sets of rebus picture symbols (1) dog, horse, cowboy, and; (2) black, white, green, is; (3) big, little, tree, the; (4) on, under, by, ground; (5) in, house, Bob, Jeff; (6) saw, are, not, they) were reproduced onto 1 1/4 white cards and the names taught as follows:

The first card of a set was placed in front of the participant and the following directions given:

"Each of these drawings is a word. As soon as I say the word I want you to say it back to me."

After the participant repeated the name of each set of four cards, the cards were shuffled and placed individually in front of the participant who was asked:

"What was the name of this drawing?"

Scoring Of The Measures

Error scores on the Jordan Left-Right Reversal Test were reversed for data analysis so that high scores corresponded to number correct.

The number of correct answers were recorded for all standardized subtests, informal measures and the symbol-name association and Silly Sentence tasks.

An intelligence quotient was derived from age and Brief Cognitive Cluster age equivalent discrepancies as follows:

Mental age / Chronological Age X 100 percent.

CHAPTER 5

Data Analysis And Results

Introduction

Following Leong (1988) for presentation format, the present research was conducted as followed: From current literature it can be argued that word identification (recognition), particularly at the end of grade 1, may be dependent on three hypothetical constructs (ξs): (a) a orthographic/phonological processing component, (b) a context utilization processing component and (c) a pre-exising aptitude/knowledge base component (Figure 1). These interrelated components can be viewed as necessary prerequisites for word identification and passage comprehension. Although the latent components can not be directly observed they can be estimated through indicator variables (xs) with their error of the measurement (δs). Through structural equation modelling we can assess the effects of the predictor latent factors on the reading outcome measures. Reading competence at the end of grade 1, as measured by both word identification and passage comprehension, are represented by latent hypothetical constructs (ηs) which are estimated by the measurable indicator variables word lists and passage comprehension questions (ys) with their errors of measurement (εs or epsilons). As outlined in chapter 3, the LISREL VI

program permits the testing of two variations of the above model using actual data collected from an ending grade 1 population. Quoting Leong (1988):

> In essence, there are two components to the maximum likelihood approach using the LISREL VI program: (a) the measurement model and (b) the structural model. The measurement model estimates the relationships between observed variables and unobserved domains on occasion t, when these relationships are defined a priori. Without loss of generality, each observed or manifest variable for the independent component is a function of some weight(s) (γ) times some underlying independent exogenous variable(s) (ξ[s]) plus a residual.
> Similarly, each manifest variable for the dependent (endogeneous) variable is a function of some weight(s) (γ) times some underlying dependent variables (ηs) plus a residual. The measurement model can be expressed as:
>
> Manifest variables = factor pattern matrix x unobserved variables + residuals.
>
> The structural model estimates the interrelations of the unobserved or latent domains. The betas (βs) are structural coefficents interrelating the dependent variables etas (η); the gammas (γ) are structural coefficients that relate latent independent components to latent dependent components; and zetas (ζs) are the residuals for the latent dependent variables. The phi (Φ) is the variance/covariance matrix of residuals of latent dependent variables, whole psi (Ψ) is the variance/covariance matrix of residuals of latent dependent variables.
> Thus:
>
> Structural coefficient matrix x dependent variables = structural coefficient matrix x independent variables + residuals. (p. 99,100)

The purpose of the data analysis was to test two competing causal models of reading acquisiton. One parallel coding systems model postulates that at a pre-

lexical access level processing involving context utilization as well as orthographic and phonological codes aids word identification (Taylor & Taylor, 1983). The competing causal model postulates pre-lexical processing involving orthographic and phonlogical codes only aiding word identification with context utilization processing involving interaction of word meaning from the lexicon and sentence context aiding passage comprehension (Seidenberg, 1985).

The Question Of Transformation

As is common in developmental studies with a restriction on age, a perusal of histograms of the indicator measures revealed that many were not normally distributed. Log10 transformations converted response times to normality. Reflexing (subtracting each value from a number that is one point more than the maximum obtained score) followed by Log10 transformations converted the remaining skewed variables to normality. However these transformations resulted in changing the direction of the relationships for many variables causing difficulties with interpretation in the structural equations. It was decided to accept the degrading of the analysis because of lack of normality rather than attempt to interpret transformed variables.

Augmentation Of The Sample

Ten of the 127 Coquitlam participants were removed from the analysis because of missing data. LISREL analysis is reported to be quite robust to the effects of a small sample size (Gallini & Mandeville, 1985) and a sample size of 100 is considered allowable (Boomsma, 1982). However, it was thought advisable to augment the sample size. Seventeen of the pilot study participants who had been administered identical measures close to the same time as the main study were added to the analysis.

Descriptive Statistics

Table 2 presents the names, means, standard deviations and correlation matrix for the indicator variables. From a perusal of the correlation matrix in Table 2, it is evident that moderate to high correlations between the phonological coding indicator variables Syllable Sounding and Consonant Blends and the word identification indicator variables Pre-Primer List, Word List and Words In Passages tentatively support the hypothesis of phonologically related coding facilitating both word identification and passage comprehension. A low positive correlation is also present for the orthographic-

TABLE 2: CORRELATION MATRIX, MEANS, STANDARD DEVIATIONS OF THE INDICATOR VARIABLES

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.00	.73**	.68**	.38**	.21*	.25**	.59**	.46**	.11	.05	.11	.24**	.28**
2	.73**	1.00	.90**	.52**	.26**	.21*	.74**	.74**	.23*	.27**	.13	.47**	.46**
3	.68**	.90**	1.00	.52**	.29**	.27**	.67**	.65**	.20	.23*	.13	.35**	.39**
4	.38**	.52**	.52**	1.00	.31**	.20	.50**	.46**	.16	.26**	.13	.30**	.38**
5	.21*	.26**	.29**	.31**	1.00	.14	.24*	.21*	.16	.12	.20	.09	.20*
6	.25**	.21*	.27**	.20	.14	1.00	.25*	.17	.10	.03	.09	.08	.11
7	.59**	.74**	.67**	.50**	.24*	.25**	1.00	.76**	.21*	.14	.17	.43**	.42**
8	.46**	.74**	.65**	.46**	.21*	.17	.76**	1.00	.19	.21*	.20	.47**	.47**
9	.11	.23*	.20	.16	.18	.10	.21*	.19	1.00	.16	.16	.11	.31**
10	.05	.27**	.23*	.26**	.12	.03	.14	.21*	.18	1.00	.17	.21*	.26**
11	.11	.13	.13	.13	.20	.09	.17	.20	.16	.17	1.00	.20*	.26**
12	.24**	.47**	.35**	.30**	.09	.08	.43**	.47**	.11	.21*	.20*	1.00	.35**
13	.28**	.46**	.39**	.38**	.20*	.11	.47**	.47**	.31**	.26**	.26**	.35**	1.00
X	18.94	17.02	84.55	3.77	1.65	11.99	14.95	12.47	13.78	17.87	16.37	16.90	106.01
sd	1.67	4.10	22.95	1.64	.88	3.45	3.94	2.35	2.03	3.06	2.57	3.60	11.67

1 PRE-PRIMER LIST
2 GRADE 1 LIST
3 WORDS IN PASSAGES
4 RECALL QUESTIONS
5 INFERENCE QUESTIONS
6 REVERSAL DETECTION
7 SYLLABLE SOUNDING
8 CONSONANT BLENDS
9 INCONGRUOUS SENTENCES
10 LEXICON/CONTEXT INTERACTION
11 VOCABULARY
12 SYMBOL-NAME ASSOCIATION
13 INTELLIGENCE

* $p < .05$
** $p < .01$

related coding variable Reversal Detection and the word identification indicator variables tentatively suggesting that ability to discriminate reversals does have bearing on word identification at the grade 1 level. Support for word identification through context utilization related variables is not as evident with the indicator variable Incongruous Sentence Detection failing to significantly relate to the word identification indicator variables Pre-Primer List and Words In Passages. The possibility of context utilization related coding aiding word identification can not be ruled out altogether, however, with Incongruous Sentence Detection receiving a low significant correlation with Grade 1 list (r,.23), and the indicator variable Lexicon/Context Interaction correlating positively with Grade 1 List and Words In Passages (r, .27 & .23), respectively.

Testing The Fit Of The Lexical Access Models

Data Analyses

In the present study the main hypothsis tested concerned the hypothesis that context utilization related processing would have a greater effect on passage comprehension than it would on word identification. Also investigated were the interactions of the independent latent domains and the dependent latent domains as hypothesized in the formulated reading model used to test the first hypothesis (Figure 1 model specifications). Another question concerned the a priori specification that the three independent latent domains would be found to be inter-related rather than orthogonal.

Results

Tables 3 and 4 detail the maximum likelihood estimates obtained in the testing of the two competing lexical access models. Figures 2 and 3 add detail concerning the paths linking the Independent Latent Factors and the Dependent Latent Factors. Despite the degrading of the analysis by using untransformed variables even though

TABLE 3: LISREL VI ANALYSIS OF MODEL OF VISUAL/PHONOLOGICAL PLUS CONTEXT UTILIZATION LEXICAL ACCESS IN READING (N=134)

Variables	Initial Estimates			Squared Multiple Corr(SMC)	Maximum Likelihood			Standardized Solution		
	I	II	III		I	II	III	I	II	III
Syllable Sounding	1.00			.77	.99			.87		
Consonant Blends	.99			.76	.98			.87		
Reversal Detection	.27			.06	.28			.25		
Incongruous Sentences		1.00		.20		.79			.41	
Lexicon/Context Interaction		.93		.17		.96			.50	
Intelligence			1.00	.42			1.08			.66
Symbol-Name Assoc.			.95	.38			.96			.58
Vocabulary			.45	.09			.51			.31

Factor Correlations

Initial Estimates			Maximum Likelihood			Standardized Solution		
I	II	III	I	II	III	I	II	III
						1.00		
						.55	1.00	
						.82	.89	1.00

Not available from program due to indeterminacy in Matrix.

Chi Square x^2_{51}=62.88 p = 0.123

Goodness of Fit Index (GFI) = 0.929

Adjusted Goodness of Fit Index (AGFI) = 0.839

Total Coefficient of Determination for x= 0.808

TABLE 4: LISREL VI ANALYSIS OF MODEL OF VISUAL/PHONOLOGICAL LEXICAL ACCESS IN READING (N=134)

Variables	Initial Estimates			Squared Multiple Corr(SMC)	Maximum Likelihood			Standardized Solution		
	I	II	III		I	II	III	I	II	III
Syllable Sounding	1.00			.77	.98			.87		
Consonant Blends	.99			.75	.98			.87		
Reversal Detection	.27			.06	.28			.25		
Incongruous Sentences		1.00		.20		.78			.40	
Lexicon/Context Interaction		.93		.17		.88			.46	
Intelligence			1.00	.42			1.15			.66
Symbol-Name Assoc.			.95	.38			1.00			.58
Vocabulary			.45	.09			.55			.32

Factor Correlations

Initial Estimates			Maximum Likelihood			Standardized Solution		
I	II	III	I	II	III	I	II	III
Not available from program due to indeterminacy in Matrix.						1.00		
						.55	1.00	
						.82	.89	1.00

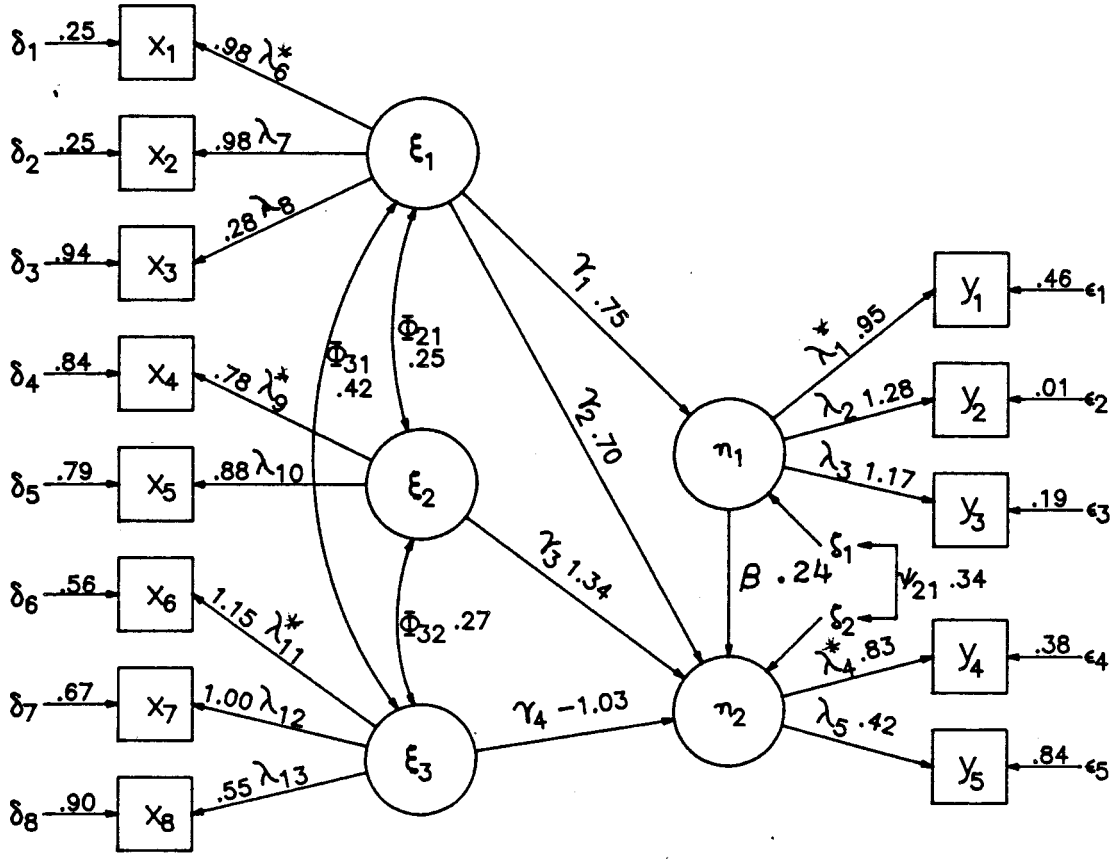
Chi Square χ^2_{52}=64.71 p = 0.111

Goodness of Fit Index (GFI) = 0.929

Adjusted Goodness of Fit Index (AGFI) = 0.835

Total Coefficient of Determination for x= 0.922

Figure 2: Maximum Likelihood Estimates For The Phonological/Orthographic Lexical Access Model



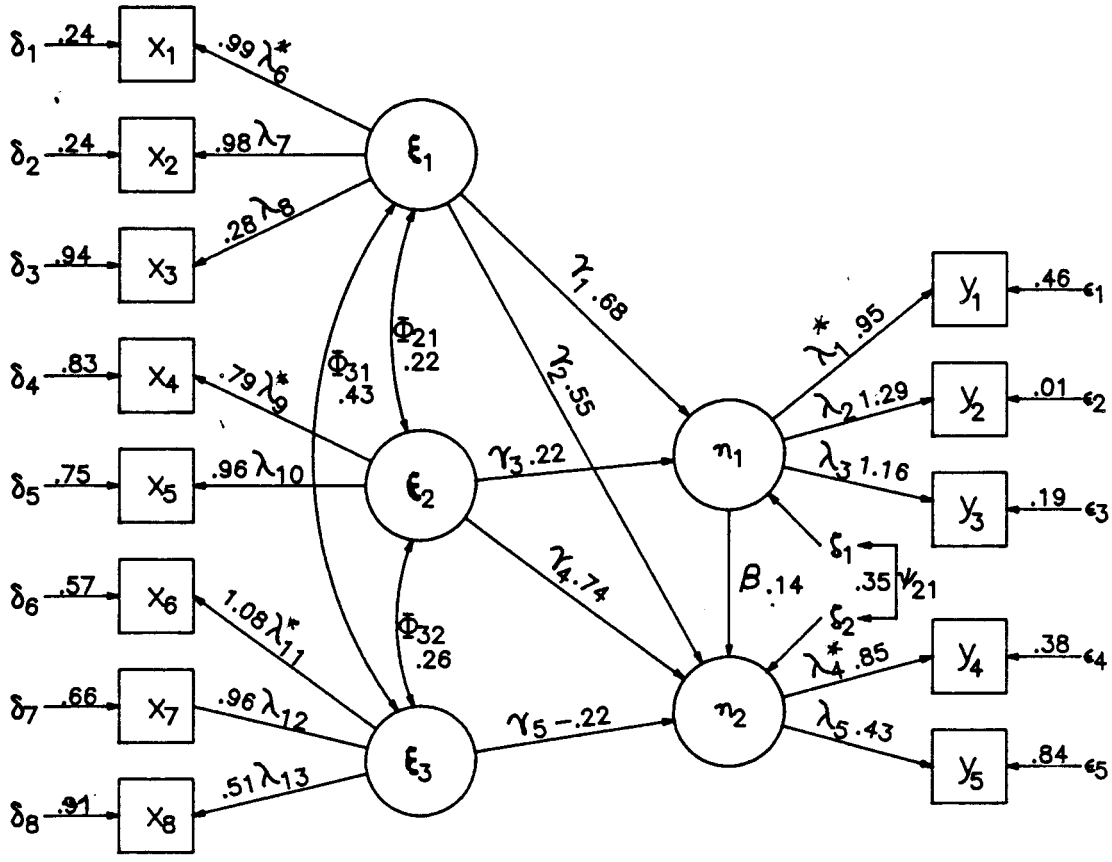
ξ_1 Orthographic/Phonological Processing
ξ_2 Context Utilization Processing
ξ_3 Pre/Existing Aptitude/Knowledge Base

X_1 Syllable Sounding
X_2 Consonant Blends
X_3 Reversal Detection
X_4 Incongruous Sentence Detection
X_5 Lexicon/Context Interaction
X_6 Intelligence
X_7 Symbol–Name Association
X_8 Vocabulary

η_1 Word Identification
η_2 Passage Comprehension

y_1 Pre–Primer List
y_2 Grade 1 List
y_3 Words In Passages
y_4 Recall Questions
y_5 Inference Questions

Figure 3: Maximum Likelihood Estimates For The Phonological/Orthographic Plus Context Utilization Lexical Access Model



ξ_1 Orthographic/Phonological Processing
ξ_2 Context Utilization Processing
ξ_3 Pre/Existing Aptitude/Knowledge Base

X_1 Syllable Sounding
X_2 Consonant Blends
X_3 Reversal Detection
X_4 Incongruous Sentence Detection
X_5 Lexicon/Context Interaction
X_6 Intelligence
X_7 Symbol–Name Association
X_8 Vocabulary

η_1 Word Identification
η_2 Passage Comprehension

y_1 Pre–Primer List
y_2 Grade 1 List
y_3 Words In Passages
y_4 Recall Questions
y_5 Inference Questions

some of the variables did not demonstrate normality, the LISREL VI program did reach convergence. Regarding the structural model and the hypothesis specified a priori that the independent latent factors would be low to moderately correlated reflecting the complexity of the reading task, some clarification can be seen to be present in the results. From the standardized solution the Factor Correlations indicate substantial interrelatedness of the independent latent factors. The Pre-existing Knowledge Base Factor appears related to the Orthographic and Phonological Processing Factor (r, .82.). This relationship also appears to be causing an identification problem for the LISREL computer program indicated by a warning in the computer printout that Φ3,1 may not be identified. This identification problem is likely the cause of the lack of Factor Correlations in the Initial and Maximum Likelihood Estimates and the subsequent inability of the program to provide standard error estimates and T-values. The Pre-Existing Knowledge Base factor also appears related to the Context Utilization Related Processing factor (r, .89). Modification indices for the model diagrammed in Figure 1 suggest that this difficulty is likely related to the Pre-Existing Aptitude/Knowledge Base indicator variable vocabulary being correlated with the indicator variables in the Orthographic and Phonological processing factor (modification index, .79).

Otherwise the modification indices do not indicate any other significant positive relationships confounding the indicator variables of the separate latent factors.

Despite this limitation, it can be argued that enough information is available through diagnostics on the remaining computer output to tentatively support one of the two competing lexical access models under consideration. Regarding the question of whether context utilization related processing generally facilitates word identification at the grade 1 level, the goodness of fit statistics do not evidence enough differences to warrant choosing one model over the other (e.g., Goodness of Fit indices for both models identical at .93). However, the low Squared Multiple Correlations for the context utilization related indicator variables Incongruous Sentences and Lexicon/Context Interaction (R^2, .20 and .17) in contrast to the high Squared Multiple Correlations for the phonologically related indicator variables Syllable Sounding and Consonant Blends (R^2, .77 and .75),suggest that at the grade 1 level context utilization related processing does not yet capture much of the variance of reading outcome measures. From the Total Effects section of the computer printout the Total Effects of Context Utilization Related Processing on Word Identification of .22 indicate a minimal if any effect. From Figure 3 when the path from Context Utilization Related processing, with

its meaning-related indicator variables, to Word Identification is freed, which allows it to be estimated, the low path coefficient of .22 suggests minimal if any causal influence on Word Identification from Context Utilization Related Processing. Although t-values are not available from the computer printout it is unlikely that the path coefficent of .22 for Context Utilization Related Processing and Word Identification would be significant. In contrast, the path coefficient between Orthographic and Phonological Processing and Word Identification of .68 would likely indicate significant causal influence if t-values were available. The path coefficent between Context Utilization Related Processing and Passage Comprehension of .74 suggests that it is at the passage comprehension level that meaning related processing aids understanding rather than at the word identification level.

Regarding the full model of the reading process at the end of grade 1, as specified in Figure 1, the information in Figures 2,3 and Tables 3,4 from the LISREL VI testing of the model and other information included in the computer output provides some suggestions as to its veracity. The LISREL VI analysis of this model shows a X^2 of 64.71 ($p = .111$) and a GFI of .929. The root mean square residual (RMSR) is at .044. This suggests that the overall fit of the model to the data is marginally acceptable.

From Figures 2 and 3 and other computer printout regarding the Measurement model, a perusal of the normalized residuals reveals no residuals greater than two that would indicate substantial wrong specifications in the model. A perusal of the section of the modification indices that deals with the indicator variables of the measurement model does not indicate a modification index anywhere near 5, suggesting that the model would not be improved substantially if any of the indicator variables were rearranged into different factors for suggestions for future research. However a negative modification index of - 1.08 for Pre-Primer List and Passage Comprehension suggests that this indicator variable does not manifest as expected by contributing to the overall positive influence of word identification on passage comprehension. It is possible the not enough variance was present in this indicator due to a ceiling effect for the ending grade 1 readers. A perusal of the δ(delta) and the ϵ(epsilon) matrix, that contain a quantification of the error in the indicators of the exogenous and endogenous dimensions, however, reveals that either poor precision of measurement is present in the sample for some of the indicator variables including Reversal Detection and Vocabulary or these variables contribute little to the variance of the dependent latent factors at the ending grade 1 level. The best construct validity is demonstrated by the loadings for

the phonological-related indicator variables Syllable Sounding and Consonant Blends.

As mentioned previously regarding the Structural Model, the present strong path coefficient obtained for the causal influence of Orthographic/Phonological Processing on Word Identification and the strong path coefficient obtained for the causal influence of Context Utilization Related Processing on Passage Comprehension give support to the position of Seidenberg (1985) that it is at the passage comprehension level not the word identification level that meaning following lexical access aids the reading process resulting in better passage comprehension. Looking further at computer output for diagnostics that contribute to an evaluation concerning the veracity of the model, the model can not be completely eliminated as a probable descriptor of the reading process at the ending grade 1 level. As mentioned earlier, the goodness of fit statistics suggest a marginally acceptable fit. From the variance/covariance matrix there are no correlations above .90 suggesting that there is no problem of colinarity among the variables. Modification indices do not contain large enough indications to warrant presuming a substantial wrong specification in the model. There are not substantial normalized residuals (above 5.0) that would suggest ways the model could be improved for future research. The only normalized residual above 1.0 is the one reported for the

indicator variable Lexicon/Context Interaction and Pre-Primer List of -1.60. Again, this could be due to a ceiling effect on the list for ending grade 1 students. The largest Eigenvalue of the Stability Index of .019 does not indicate a problem with a possible feedback loop between the Dependent Latent Factors. Comparisons between the Total Effects section of the computer printout for the independent latent factors on the dependent latent factors and the Maximum Likelihood Estimates of the Direct Effects of the independent latent factors on the dependent latent factors do not reveal any striking quantitative differences that would suggest substantial indirect effects by any of the latent independent factors.

One difference in the expected results is the failure of the Pre-Existing/Knowledge Base to account for a significant amount of the variance of Passage Comprehension. The path coefficent of -.22 for the factor Pre-Existing Knowledge/Base and Passage Comprehension, obtained when this parameter was freed or allowed to be estimated, suggests that for the present sample population, the level of intelligence, vocabulary and ability to store picture-symbol associations does not contribute significantly to reading outcome measures at the grade 1 level.

CHAPTER 6

Discussion

Introduction

The intent of the present research was twofold. Academically, two objectives were present. The first objective was to add to the findings of three previous causal modelling studies concerning the interrelationships between reading subskill levels and the attainment of reading outcome goals as reading development proceeds through the primary grades. The second academic objective was to gather evidence concerning the question of whether context utilization related processing can be seen to generally facilitate word identification at the end of grade 1.

Practically, one objective was to provide suggestions for sequencing of beginning reading instructional practice based on tests of two competing word identification models suggested from a review of the literature. Whole Language reading programs, some without phonics emphasis, are increasingly being implemented at the beginning grade 1 level. Of key importance to instructional practice at that level is the debate of long

standing of whether the path to word identification is facilitated by a code and/or meaning reading emphasis.

Academically Related Findings

Word Identification At The End Of Grade 1

Previous research (Lomax & McGee, 1987) found the causal flow during reading acquisition for children three to six-years-old to start from a "concepts about print component" and proceed to a "graphic awareness component" to a "phonemic awareness component" to a "grapheme-phoneme awareness component" which led to word reading. The present study found that many, regular class, grade 1 students by April of the school year possessed automatic levels of grapheme-phoneme correspondence (pilot study results). Despite the problems of restriction of age causing the lack of normality in many developmental studies, the information available from the LISREL VI structural equation modelling of the two competing word identifications models did have relevance for the question concerning the use of context utilization to aid word identification raised by Seidenberg (1985). The analysis of the data suggested that the context utilization factor linked to passage comprehension rather than word identification at the ending grade 1 level. This finding

suggests that the model found by Lomax's (1983) causal modelling study that had a "phonological component" linking to reading outcome measures for learning disabled primary and intermediate level students may be incomplete for normal primary and particularly intermediate level students. As Leong (1988) has suggested, it is likely that the processing of word meanings and sentence context as well as orthography and phonology takes place during the primary and intermediate grades. It would also seem likely that context utilization processing, while generally not aiding word identification for good decoders at least, is already aiding passage comprehension by the end of the grade 1 year. While further phonologically related processing may continue to develop in grade 2 and on for normal readers as well as learning disabled readers (Lomax, 1983), it may be the context utilization processing that is more relevent to reading outcome measures in higher grades, particulary passage comprehension.

Many routes to the lexicon have been postulated by reading theorists. The tentative finding from the present study that at the ending grade 1 level, processing involving orthographic and phonological codes appears to aid word identification while contextual utilization processing appears to link to passage comprehension, suggests that reading is a sophisticated process even in the grade 1 year. It is likely that at least two of the

reading processes postulated by Gagne (1987) to be involved in information processing during reading tasks are occurring in the grade 1 year. As postulated by Gagne, "Decoding" involves both "Matching" to known sight patterns in long-term memory and "Recoding" or matching sound patterns to the word's meaning in long-term memory (Gagne, 1987, p. 167). The other reading process is "Literal Comprehension" which involves both lexical access or "recognition of the patterns of print or sound" produced by the decoding processing, and "Parsing" which involves extraction of propositions to aid understanding of sentences (Gagne, 1987, p. 169.).

Findings Related To Instructional Practice

The finding that phonological/orthographic coding aids word identification while context utilization related processing aids passage comprehension has implications for sequencing reading instruction during the grade 1 year. If the many theorists emphasizing the importance of automaticity of decoding are correct, it is necessary to bring word identification to automatic levels to free time for the information processing required to extract meaning for reading understanding (Curtis, 1980; McLelland & Rumelhart, 1981; Samuels, 1986). Thus it would make good sense initially to establish concepts about print, memory

for letter features and beginning phonological awareness during Kindergarten and early grade 1. Another implication for practice is that monitoring reading rate and reading expression to see if fluency is developing over the grade 1 year would be an important way to guarantee that students are making adaquate progress towards speed of word identification as it can be expected to relate to passage comprehension. Once some proficiency with decoding was established, the introduction of instruction aimed at getting the student to actively attempt to extract meaning from context to aid passage comprehesion could be done.

The finding that phonological/orthographic processing aids word identification while context utilization related processing aids passage comprehension provides support for a general eclectic reading program in grade 1. This result suggests that successful grade 1 readers use both code and meaning emphasis to successfully complete reading tasks. The strength of the relationship betwen the phonologically/orthographically-related tasks and word identification supports making explicit the use of sounding and comparison to speech word memory representation as a way to identify phonetically regular words whether the reading program is a Whole Language program or not. The linkage of context utilization related processing to passage comprehension supports emphasizing ways to extract meaning from context clues and any words

that can be decoded. Taken as a whole, the results of the present research suggest that rather than implement a Whole Language program relying solely on buildup of sight word vocabulary, it might be better to accent both phonological/orthographic cues to decoding and meaning extraction to passage comprehesion during the grade 1 year.

Implications For Future Research

Several suggestions for future research emerge from the results of the present study. The present study can be regarded only as a tentative study. Results did not support the hypothesis of an independent separate pre-existing aptitude/knowledge-base factor from an orthographic and phonological processing factor or a context utilization related processing factor and this would need to be eliminated from future research. As the present study focussed only on ending grade 1 reading outcome levels it is not possible to describe in detail the progression of decoding and meaning extraction processing skills across the full grade 1 range. In fact, given the level of difficulty that some students experience in learning to read, the present researcher was quite surprised at the apparent rapid movement to reading fluency by the end of grade 1 by most of the regular

students in the study. A longitudinal study taking repeated measures throughout kindergarten and grade 1 could be expected to reveal more detail of developmental aspects of both context utilization and phonological/orthographic related processing and reading acquisition as it seems to quickly develop in the grade 1 year. In the same vein, a causal modelling study using repeated measures throughout grades 2 and 3 could be expected to capture detail of developmental aspects of context utilization processing at a point where reading comprehension may become the purpose of the reading activity for normal students. For this study, it might be possible to use new on-line computer and eye-movement recording using the new computerized visagraphs that are now on the market to improve the precision of measurements taken. It might also be possible to try to include a morphemic code related task as well as orthographic and phonological code tasks to see if parallel processing involving all three codes links to word identification.

It would also be interesting to devise a study that would allow measurement of code and meaning emphasis processing development with the method of instruction more closely controlled. In the present study, a school district was chosen that used eclectic beginning reading programs. As all the participating teachers in the study reported using a basal reader as well as some

supplementary phonics training, it can be expected that some presentation to students of both decoding and meaning related instruction took place over the year. However, it would be preferable to compare reading outcome measures for students who had been exposed to differing emphases within a Whole Language approach, along a continuum of code and meaning emphases.

The finding that the Pre-Existing Aptitude Knowledge Base factor did not significantly contribute to either Word Identification or Passage Comprehension at the ending grade 1 level suggests a direction for research in reading. First the finding reinforces the findings of other research that traditional global psychometric measures like intelligence and memory storage often do not account for as much variance of reading outcome measures as more directly reading-related processing measures (Stanovich et al., 1986). Another possibility is that in normal populations like the regular classrooms used in the present study a restriction of range exists for such measures as intelligence, vocabulary and memory storage. It may be only in non-normal populations such as the mentally handicapped and severely learning disabled that a sufficent range of variation of these abilities exists to capture a significant amount of the variance in reading tasks. An interesting study would be to see if the reading model outlined in the present research including the Pre-

Existing Aptitude/Knowledge Base factor, and found to have a marginally acceptable fit would hold up in a more handicapped population.

Concluding Remarks

The results of the data analysis of the present study suggest implications for Grade 1 reading instruction. First, the results strongly suggest that the current trend towards implementation of Whole Language approaches in grade 1 should take care to cue the sounding of phonetically regular words as well as the extraction of meaning from sentence structure and context cues. While it is possible that in later grades decoding processing is at automatic levels for most students and the whole language approach can be implemented without cueing phonics, this should be established with controlled research rather than presumed. At the grade 1 level, results of the data analysis of the study suggest that multi-factor reading theorists appear to be more accurate than single-factor ones. Beginning reading, if both word identification and passage comprehension are included, involves multi-factor, processing with processing based on orthographic and phonological coding leading to word identification while context utilization related processing involving interaction of meaning derived from the lexicon and

sentence context facilitates passage comprehension. Therefore, it is likely that reading instruction should aim to promote both decoding and reading for meaning. As well as teaching beginning phonics blends and cues from orthographic features, it would seem reasonable to attain two meaning-related goals within the grade 1 year. Initially, the goal of "cognitive clarity" (Downing, 1979) should be attained quickly so that the student realizes that the goal of the reading activity is to translate the printed symbols into meaning. Once some expertise at decoding words has been established, to take advantage of the thinking skills of the young student, clues for passage comprehension through word meaning/context interaction processing can be pointed out and trained by practice. The linkage in the present study of phonological/orthographic coding processing aiding word identification and context utilization related processing aiding passage comprehension strongly suggests that cognitively active beginning readers use all sources of information available to them to complete beginning reading tasks in the grade 1 year.

More generally, the use of improved methodology for theory testing has been found useful in the present study by the successful utilization of structural equation modelling and the LISREL VI program to investigate the "flow of activity" (Dwyer, 1983) during beginning reading

activity. While the common problem of lack of normality for measures in developmental studies prevented the full diagnostic power of the structual equation modelling techniques, the information available from the LISREL VI computer printout provided was sufficient to tentatively describe the reading process at the ending grade 1 level. The LISREL printout illumines many aspects of the structural and measurement models under inspection. While it may be disconcerting to the researcher to realize the measures chosen may lack precision and models specified may be in error the use of structural equation modelling can be seen to hold a lot of potential for improved research at both the conceptual and measurement level. It can be expected that continued use of causal modelling techniques to explore the "flow of activity" during information processing on academic tasks in future research will provide useful findings for instructional practice.

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