

READING AS A CONCEPTUAL REASONING TASK:

TOWARDS A COGNITIVE DEVELOPMENTAL THEORY

OF LEARNING TO READ

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Dedicated to Virginia  
and to Mark, Anita, James  
and Maria

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the requirements for the degree  
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The N.S.W. Department of Education kindly gave permission to work in schools and the Principals of the schools willingly cooperated in all aspects of the data gathering: at Burraneer Bay, Mr. Bill Brien, at Gynea Bay, Mr. Leslie Forman and Mr. Bernard Sheehan, at Gynea North, Mr. Bruce Robinson and at Laguna Street, Mr. Harold Baltins and Mr. Desmond Stein. They and the many teachers from whose classes subjects were gathered, made special arrangements to accommodate the research team during data gathering and their assistance is highly valued.

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The research team and numerous other tasks with dedication, care and humour for an intensive few weeks each year and played a critical part in the final product. Warm thanks is due to Mr. Roger Blake, Ms. Elizabeth Davis, Ms. Catherine Doig, Ms. Julie Evangelinos, Ms. Julie Evans, Ms. Joanne Faggotter, Ms. Megan Gamble, Mr. Mitchell Lane, Ms. Fiona Leach, Ms. Christine Lemney, Ms. Riki Levi, Mr. Max McBain, Mr. Ken McCarron, Ms. Kate Marwood, Mr. Glen Moran, Ms. Adel Mikhael, Mrs. Dianna Rea, Ms. Anne Ross-Kasis, Ms. Cheryl Russell, Mr. Daniel Squires, Ms. Annette Shanahan, Ms. Leslie Stubbs, Mr. William Suprunenko, Ms. Pamela Taylor, Ms. Jude Thompson, Mr. Steven Ward and Mr. Robert Wooldridge.

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The cognitive developmental theory of reading proposed was tested in three empirical studies.

The first study, with grade 4 pupils, used correlational procedures to make an initial test of the conceptual reasoning variables and of their relationship to reading whilst controlling for the effects of an alternative explanatory variable, oral language. A multiple seriation test (from Piaget) was developed as one index of conceptual reasoning (operativity) and a perceptual regulations test was used as another. The construct validity of the predictor variables proved to be satisfactory. Multiple regression analysis indicated that conceptual reasoning (operativity) was significantly related to reading and was partly distinct from the influence of oral language in this relationship. This positive result gave encouragement to extend the investigation using a longitudinal approach to study developmental change during the early school years.

## Abstract

A second study, with a three year longitudinal design, asked what. On the basis of a range of theory and research it is argued that reading is fundamentally a conceptual reasoning task. Studies of strategic processes in reading, the examination of children's concepts of the nature of print and the naturalistic study of oral reading behaviour, give support for this contention. Since, in Piagetian theory, the emergence of concrete operations gives major new impetus to the conceptual reasoning capacities, the significant positive relationship of concrete operations to reading provides further evidence for this view. The relationship also gives a basis for studying the development of these conceptual processes in regard to the emerging reading competence of young school pupils.

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A second study, with a three year longitudinal design, asked whether the metalinguistic knowledge of beginning readers can be explained in terms of the underlying cognitive developmental characteristics of the learner. A units of print test was developed to measure metalinguistic knowledge. Path analysis gave support for the theory proposed that conceptual reasoning exerts a causal influence partly distinct from oral language and reading competence on the formation of an understanding of the units of print. This finding calls into question the view that print experience is a sufficient condition for awareness of the units of print.

The third study allowed a more extensive testing of the cognitive developmental view by comparing the development of the conceptual reasoning and the oral language variables during the first five years of school and by tracing their inter-relationship with reading during that time. The results support the construct validity of all variables and suggest that conceptual reasoning (operativity) and oral language display different forms of developmental change over this period. The development of operativity was found to be more surgent and discontinuous while oral language was more stable and continuous. This difference was manifest in their different relationships with reading as revealed by path analysis. Operativity exerted both direct and indirect effects on reading which were distinct from the effects of oral language at least in this middle class sample and with the measures employed. These effects do not seem to be explained by the influence of language awareness, IQ or reading instruction. This important conclusion leads to the working hypothesis that operativity is a necessary but not a sufficient condition for learning to read and

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provides the foundations for a cognitive developmental theory of reading.

THE SCOPE AND SETTING OF THE STUDY

Building on these foundations, three stages of early reading are proposed, several instructional implications are suggested and some issues for further investigation are raised.

Despite great current interest in reading and many decades of intensive reading instruction, there is still much that is not understood about learning to read and advice upon how instruction should be carried out is often confused and even at times contradictory. This is not the result of a lack of research. In its annual summaries of reading research studies for the years 1971-1980, the International Reading Association surveyed no fewer than 6001 articles. Indeed, Robinson (1970) suggested that there has been too much research; much research being of a trite and insignificant kind. She believes that we are like the blind man describing the elephant;

The parts we touch appear to be the total or the most important parts. As long as we deal with parts, ignorant of the total process we will continue to disagree on minutiae and squander time. (p.77)

One problem of much of the research has been the absence of a clear conceptual basis. Recently, however, the importance of developing a broad theoretical framework for understanding the nature of the reading process and of testing predictions from that in research

CHAPTER ONE

REVIEW OF THE LITERATURE

THE SCOPE AND SETTING OF THE STUDY

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has become more widely recognized. From such an approach empirical studies can be given more purposeful direction, the theoretical framework can be modified and strengthened, and instructional practice can be made more coherent and effective. In this way many of the pitfalls of the past can be avoided. By ordered instruction, Bagné (1970) and Staats, Brewer and Gross (1970), who provide examples of this. This investigation first proposes a cognitive developmental framework as a basis for research and instructional practice and seeks to test some of the predictions of the theoretical framework using longitudinal procedures. focus of the behaviourist model is upon the instructional sequence rather than upon <sup>the</sup> nature of the learner's act. Reading is a term which may assume several different meanings in ordinary language. It may refer to the material being read, e.g., "Here is some light reading for the trip", or to the process of making a graphic code meaningful e.g., "His reading has improved lately" or to the instruction a teacher might give, e.g., one teacher asks another, "have those new workbooks helped your reading?". In the present investigation our concern is with reading as a process of making a graphic code meaningful. Although there is general acceptance of this starting point, theorists and researchers diverge sharply once they begin to explicate the nature of the process. intends, as the child makes more accurate first guesses by better sampling text. During the past decade a wide variety of models of reading have been proposed as the basis for research and practice. Although they overlap in various ways, four different emphases in conceptualization may usefully be distinguished; the behaviourist, psycholinguistic, information processing and cognitive developmental views. Although this psycholinguistic view seems to have captured something of the dynamic nature of reading in its emphasis upon language functions, it gives

Behaviourist reading models, which give attention to observable responses, use laws of effect, contiguity and reinforcement to explain how associations are established. Discriminations are thereby made and by chaining, hierarchies of response capacities are developed as a result of sequential, hierarchically ordered instruction. Gagne (1970) and Staats, Brewer and Gross (1970), who provide examples of this "bottom-up" processing approach, believe the most basic skills of reading are discriminations of sounds and letters which are chained to form syllables, words and so on to more complex skills such as content discriminations. The focus of the behaviourist model is upon the instructional sequence rather than upon <sup>the</sup> nature of the learner's activity.

Believing that a "bottom-up" explanation of reading fails to account adequately for the reader's active and complex processing, some psycholinguists have developed a "top-down" model. It emphasises decision making upon the basis of the reader's language and his knowledge of the world. Smith (1982) and Goodman (1970) have argued that reading is a selective process in which minimum language cues are used to confirm, reject or refine guesses based on semantic and syntactic expectations. Skill in reading develops, Goodman contends, as the child makes more accurate first guesses by better sampling techniques, greater control over the language structure, broadened experience and increased conceptual development. The reader must learn strategies to select the most productive cues since to use all would be inefficient. As a reader becomes more proficient, he uses graphophonic cues less and semantic cues more. Although this psycholinguistic view seems to have captured something of the dynamic nature of reading in its emphasis upon language functions, it gives

little or no place to the perceptual, memory or thinking activities that are implied by the decision making process it proposes.

Information processing theory, by contrast, gives central place to perceptual and memory activities and is, in most cases, an extension of the associational views of the behaviourists. Both behaviourist and information processing approaches seek to describe the discrimination, generalisation and transfer of skills and concepts which are called upon in learning to read. Information processing models differ from behaviourist views, however, by placing emphasis upon the learner rather than upon the instruction. La Berge and Samuels (1976) provide an example of an information processing model in which the role of attentional processes is traced as reading subskills become automatic. In the pattern of "bottom-up" models it begins at the sensory surface with graphemic information analysed by "feature detectors" which feed into letter codes, spelling codes and word codes all within the visual memory. From here the input follows a range of pathways which may include phonological memory, episodic memory and semantic memory, depending upon previous perceptual and associative learning. Information flow will follow little-known pathways only with the assistance of attention but will follow well-learned pathways without attention. Because information processing theories place less emphasis upon observable behaviours than do behaviourist views, they are sometimes described as cognitive theories. They are, however, cognitive theories in a limited sense because they do not include the higher cognitive processes in their explanation of learning to read.

It is one of the most demanding learning activities of childhood, taking several years to master and needing extended pupil effort for which much social support is usually

Nevertheless the need to organise appropriate memory pathways and to direct attention processes implies higher mental activities as does the hypothesis evaluation suggested by other information processing models such as the interactive view of Rummelhart (1977). Furthermore, psycholinguistic theory and research, although giving little prominence to the mental operations implied by the decision confirming, rejecting and refining activity discussed (e.g., Goodman, 1970), is clearly arguing for a problem-solving process which again demands an explanation in terms of the higher mental processes.

Additional impetus for a cognitive explanation of reading has recently come from a growing research emphasis upon reading comprehension. This has produced many empirical studies of strategic processes in reading (Ryan, 1979) which, although mostly atheoretical in basis, imply that reading is a hypothesis testing activity which requires an explanation in terms of mental operations. A cognitive view of reading is thus implicit in the patterning of information processing models, the decision-making of psycholinguistic theory and the strategic processes of comprehension research. The central contention of the present study is that reading is a cognitive task requiring higher mental processes.

Not only is learning to read in the study conceived as a cognitive activity it is also viewed as a developmental process. Although mature reading seems to be a unitary activity (it is usually referred to by only one name, "reading"), there is good reason to view learning to read as a multi-component task. It is one of the most demanding learning activities of childhood, taking several years to master and needing extended pupil effort for which much social support is usually

required. It is not a single task learnt in a short time but calls for the complex integration of many learnings over a lengthy period. The child learns one task (or skill, or understanding, or piece of knowledge) and is thereby enabled to progress to the next. The recent reading curriculum statement issued by the N.S.W. Department of Education expresses this well:

Progress is marked by leaps, pauses, periods of consolidation, regression and by periods of slow or moderate progress. It is a succession of merging and overlapping phases rather than a series of isolated skills taught in rapid succession. (Dept. of Education. 1979, p.7)

This makes the task of explaining its nature particularly complex. Reading may well call upon different capacities at different phases of its learning. The ability of children to respond to reading instruction may well be subject to differences in the developmental status of their cognitive system. Providing an appropriate match of reading's changing demands with the child's emerging cognitive capacities is a central instructional responsibility which this thesis will seek to illuminate. To do this, a cognitive developmental view of reading is proposed. Such a view of learning to read has been suggested by Elkind (1974; 1975; 1981b) who has discussed some aspects of it in detail. His empirical work, however, has largely focused on perceptual decentration in reading and much yet remains to be done; its roots need to be followed into the broader emerging corpus of reading theory and research; the inter-relationship of the "down-stream" or associative processes and the "up-stream" or higher mental processes (Anderson, 1975) in learning to read needs to be explicated; the relationship of reading to the higher mental operations as such requires clarification and detailed specification

upon the basis of empirical study. These are the general purposes of this series of studies.

## AN ARGUMENT FOR A COGNITIVE DEVELOPMENTAL VIEW OF LEARNING TO READ

### An Overview of the Argument

Four major areas of research have contributed significantly to an emerging emphasis upon cognitive processes in the understanding of reading; the comparison of good and poor reader strategy usage and conceptual style, the examination of beginner readers' concepts about the nature of reading, the naturalistic study of oral reading and the study of Piagetian operations in early reading.

The basic contention of the investigation is that reading is a conceptual reasoning task. The term "conceptual" refers to the abstraction of common qualities to display relationships and to structure experience. By "reasoning" is meant making a determination upon the basis of the manipulation of symbols in a sequence. Conceptual reasoning means the mental activity of determining response by the sequential manipulation of relationships and structures suggested by the input. It is viewed as a central aspect of thought processes. Although associative learning has often been regarded as the basis of reading and information processing theories have extended the explanatory power of behaviourist views, emerging emphasises in theory and research call for an explanation of reading which gives the higher cognitive processes a central place. Furthermore, it is maintained that the automatic associative responses called upon are depen-

dent upon executive control by the higher cognitive processes in their learning and in their application. As will be discussed, studies which compare good and poor readers have shown that salient differences are found between the two in strategy usage and conceptual style at several levels of processing, ranging from discourse integration to letter synthesis. Good readers impose structure upon printed input and display an integrative ability that poor readers do not possess. The understandings which beginning readers develop of the technical concepts of reading and of its communicative purpose also show consistent and significant relationships to reading progress. These conceptual tasks seem to be part of the cognitive demands of early reading. Naturalistic study of oral reading of younger and older children indicates that reading involves decision making upon the basis of an integration of linguistic cuing systems. There is thus a confluence of evidence from studies of strategic processes in reading, from an examination of children's concepts of the nature of reading and from naturalistic studies which indicates that reading at a variety of levels is a conceptual reasoning task. However, the evidence does not adequately specify the conceptual operations involved nor does it provide a clear indication of the extent to which mental operations and language competence are complementary or overlapping explanations of reading development. Evidence upon the developmental origins of conceptual reasoning in regard to reading has provided further grounds for believing that

reading requires higher mental processes and also gives specific content for the empirical investigation of this thesis which will involve a study of mental operations and oral language in relationship to reading.

Before making a detailed review of the four areas of research it is necessary to answer an immediate objection which can be raised to a cognitive view of reading. If executive control is so critical in learning to read why, after decades of intensive research and teaching, is its importance not already accepted? Why has learning to read been treated for so long as a lower-level associative task? Part of the answer seems to be that all who are interested in the issue are highly proficient readers whose awareness of the mental constructions involved in gaining automatic performance has long since vanished. It is rather similar to the way older children and adults cannot conceive of their own earlier inability to conserve and find the young child's non-conserving responses surprising. A further part of the answer seems to be that task analysis of competent reading is often used to determine instructional programmes for beginners. But analysis of the expression of competence is an inadequate guide to the means towards that competence, especially in an extended learning task such as reading. The higher mental processes are readily taken for granted and their importance is more easily recognised when they are deficient. This lends particular point to the first source of evidence; a consideration of the differences between good and poor readers. Good readers more often than poor readers would anticipate a whole phrase even before they saw all the words, and, after seeing the words, they would spontaneously correct any mistakes. Most grouped the words into meaningful syntactic units

### Poor Reader Deficiencies

A wide range of evidence indicates that poor readers, in contrast to good readers are deficient in the structuring processes required by making sense of print. Two recent reviews of the literature upon strategy usage (Ryan, 1979; Schwartz, 1976) and one concerned with a comparison of comprehension in good and poor readers (Golinkoff, 1976) provide a comprehensive coverage of much of the evidence. The present review will deal with those aspects of the data which throw particular light upon the place and nature of higher mental operations in reading. Strategy usage has been shown to be important at two levels: the integration of words and phrases for the comprehension of extended discourse and the integration of graphophonemic units to form words.

#### Strategy Usage: Processing of Passages

Strategy deficiencies of poor readers in discourse processing have been identified in several studies involving children from grades 1 to 5 under conditions of both oral and written response to print, to pictorial and logograph integration tasks and to the structure of the reading task.

In an oral response condition, Steiner, Wiener and Cromer (1971) presented words of a passage one at a time at the turn of a handle controlled by the child (grade 5). Good readers more often than poor readers would anticipate a whole phrase even before they saw all the words, and, after seeing the words, they would spontaneously correct any mistakes. Most grouped the words into meaningful syntactic units

despite the difficulty which the machine placed in the way of this strategy. Sometimes they remained silent until the whole phrase had appeared. By contrast, the poor readers seemed to respond to the words one at a time as isolated units. Structuring of words into meaningful units was not helped by the prior provision of a context summary. They did not impose order upon the visual input as readily as the good readers.

The superior ability of good readers to recall meaningfully ordered word lists (Weinstein and Rabinovitch, 1971), their awareness of ungrammatical errors (Isakson and Miller, 1976; Weber, 1970,) and their processing of words at phrase and sentence levels rather than singly (Clay and Imlach, 1971) all provide support for the conclusion that poor readers lack structuring strategies.

However, poor readers make many more word recognition errors than do good readers and it is possible that the need to focus upon recognising words prevents them from using organising strategies. The poor readers may be deficient in word identification and this deficiency may not allow them to employ structuring capacities that are present. Two approaches to clarify this have been employed; one provided poor readers with word recognition training, the other used a pictograph and logograph synthesis task to control for word recognition.

Four different input conditions were used with 5th grade readers to determine the relative importance of identification and organising capacity for reading comprehension (Oaken, Weiner and Cromer, 1971).

Poor readers' comprehension was tested with a passage read normally

(called 'poor visual input') and by a passage read after relevant word recognition training had been given ('improved visual input'). Good readers' comprehension was assessed with a normal passage ('good visual input') and with a transcript of a poor reader's attempt that included a teacher's corrections ('impaired visual input'). Listening comprehension for both good and poor readers was tested under two conditions, one in which a good reader and the other in which a poor reader read a passage. Some artificiality seems to be involved in the 'impaired visual input' condition which required the good readers to use a poor reader's transcript annotated with teacher corrections. This certainly would disorganise the cueing pattern but cannot be equated with the poor reader's normal comprehension. Nor can the 'impaired visual input' of the good readers be equated with the 'improved visual input' of the poor readers. Yet by using a comparison of means the method is useful to highlight the difference between listening and reading comprehension and to clarify the nature of the processing involved.

Although listening comprehension was no different for both groups, the good readers' comprehension of normal print was far superior to that of poor readers. Even when given word recognition training, the poor readers' comprehension did not improve significantly. The difference between good and poor readers does not lie in comprehension of oral language but in comprehension of written language and the more difficult structuring task which that seems to imply. Print, which has no cues for structure in the form of stress, pause and intonation, seems to require a greater level of mental organisation than auditory input. Poor readers are deficient in this organising capacity. This interpretation is supported by the comparative difficulty of poor

readers in the poor listening condition. Although good and poor readers were not different in listening comprehension under normal conditions, under poor listening conditions, good readers maintained their level of comprehension while poor readers dropped in level. Good readers are better able to cope with a more difficult structuring task. In spontaneous synthesis of units to form a message different from the individual components.

The superior ability of the good readers to process the unique 'impaired' input, both visual and auditory, seems to indicate that they have a greater capacity to apply strategic operations to structure symbolic experience. presented and some children, although able to synthesise mentally, produced independent enactions. This was test. Similar results have been obtained by Denner (1970) who used a pictograph and logograph task to control for differences in decoding ability. The study assessed the strategy usage of 56 children in 4 treatment groups. One group comprised grade 1 problem readers, a second group grade 1 average readers, a third group grades 3 to 5 problem readers and a fourth group, Head Start children predicted to have difficulty learning to read. Each group was given four tasks: 1) oral commands e.g., 'walk around teacher', 2) the same commands in pictographs which were taught to the children, 3) logograph (abstract graphic forms) recognition of words used in the commands, 4) logograph synthesis e.g., three logographs were placed in a line to make an instruction 'walk around teacher'. All groups successfully completed the oral commands and there was little difference between the groups upon the pictograph commands and the logograph recognition tasks. Upon the logograph synthesis, the Grade 1 average readers ( $\underline{M} = 7.2$ ) were overwhelmingly superior to both the Grade 1 problem readers ( $\underline{M} = 1.2$ ) and the Head Start children ( $\underline{M} = 0.2$ ). The grade 1 average

readers were also significantly superior ( $P < .05$ ) to the older problem readers ( $M = 5.7$ ). Although there was no difference in listening comprehension, poor readers of the same age and older were less capable than average readers in spontaneous synthesis of units to form a message different from the individual components. It may be objected that, with the artificiality of the task (function words were omitted e.g., 'jump around teacher'), normal syntactical patterns were not presented and some children, although able to synthesise mentally, produced independent enactions. This was tested by Keeton (1977) who replicated this experiment asking her subjects to recall the logograph sequence after the task. The poor integrators tended to recall independent words with little of the semantic structure whereas the good integrators were more likely to recall the 'sentence' as a unit.

Poor readers are thus deficient in ability to transform separate parts to make a meaningful whole which is more than the sum of those parts. Reading, of course, requires a much more complex transformation than was involved in this word-logograph task and differences are likely to be more marked when there is a need to synthesise graphophonemic units at the word level as well as words and phrases at the sentence level and sentences and paragraphs at the level of extended discourse.

When provision of structure has been successful, it has helped

If inability to impose structure upon input is a source of reading deficiency, the provision of a greater level of structure in the material or the training of a structuring technique should promote better reading. Several studies have demonstrated this by providing preorganised print, by stimulating visual imagery during reading and by interspersing meaningful questions throughout the text. Cromer (1968) preorganised the reading material into meaningful phrase units and poor readers with sound vocabulary knowledge significantly improved their comprehension. Furthermore, under this condition, poor readers scored as well as did the matched group of normal readers upon regular or preorganised print. A similar result was reported by Levin (1973) following training of poor readers (with normal vocabulary) to use a visual imagery organisational strategy as they read. Poor readers who created vivid images of each sentence as they read improved their reading comprehension significantly. A number of studies have shown that poor readers improve significantly if meaningful questions are interspersed throughout the text (Maroon, Washington and Frase, 1971; Rickards and Hatcher, 1978).

An exception to the finding that provision of structure or a structuring strategy assists poor readers is the failure of poor readers to improve when given contextual information in the form of a preliminary summary (Steiner, Weiner and Cromer, 1971). Perhaps in this case the task of transfer from the synonyms used in the summary to the whole passage was too difficult, asking too many simultaneous co-ordinations of lower level skills (e.g., translating the synonyms) over too extensive a task (the whole comprehension passage) (Case, 1975). Where provision of structure has been successful, it has helped

readers (Mason, 1975). Positional redundancy was better utilised by

to break down the prose into more manageable units either pre-organising it into small sections with or without questions, or training the child to pause long enough to build a mental image after each sentence. which the characters occurred in various serial positions but poor readers were unable to learn these positional red. Studies of strategy usage in the processing of passages carried out with children from grades 1 to 5 using oral and written response modes indicate that poor readers are deficient in the ability to synthesise and transform smaller units into syntactical and semantic wholes but may be helped to do this by provision of appropriate structure for the task. Reading clearly requires higher mental operations in the performance of these strategic processes and especially with respect to word and phrase synthesis. able to utilize this positional distribution information to read.

#### Strategy Usage: Recognition of Words

ferred from these studies, taken together they suggest that one valuable strategy for word recognition which The importance of strategic activities in word recognition has been demonstrated in several studies which have compared good and poor readers' use of letter position redundancy, word segmentation, hypothesis testing and phonic subskill integration. words.

Poor reader deficiencies were shown in recent studies which examined children's ability to take advantage of the characteristic asymmetric spatial distribution of letters across serial positions within words. A measure of letter position frequency was devised from letter counts of 20,000 words, and then letter strings (non-words) of varying letter redundancy strength were presented to good and poor readers (Mason, 1975). Positional redundancy was better utilised by

skilled readers than by poor readers but when positional redundancy was low there were no differences. Mason and Katz (1976) used non-alphabetic characters to show that good readers could learn the frequency with which the characters occurred in various serial positions but poor readers were unable to learn these positional redundancies. In order to determine whether readers use single letter positional redundancy as distinct from interletter sequence patterns, 5th grade good and poor readers' capacity to determine characteristic and uncharacteristic letter positions within five letter words with all but the key letter omitted (e.g., \_ \_ \_ t, \_ \_ t \_) was compared with that of adult competent readers (Katz, 1977). Good 5th grade readers' responses were closer to adult responses than those of poor readers and the results suggest that good readers are better able to utilize this positional distribution information to read.

Although no causality can be inferred from these studies, taken together they suggest that one valuable strategy for word recognition which poor readers lack is the capacity to detect and to utilize letter position redundancy. Poor readers fail to notice a visual regularity inherent in the task (Mason, Katz and Wicklund, 1975) and so fail to impose structure upon letter patterns in words.

Deficiencies of poor readers in word segmentation strategies have been demonstrated in a series of studies conducted in Germany by Scheerer-Neuman (1977, 1978, cited in Valtin, 1978-1979). Poor readers were unable to take advantage of efficient processing units by grouping letters into syllables. They either guessed the whole word or sought to recode the word letter-by-letter. When given tachistoscope presentations of pseudo-words possessing either strong or weak

segmentation possibilities the difference in scores was far greater for the poor readers who did not seem able to take advantage of the stronger cues for segmentation. If, however, the pseudo-words were broken into syllables and thus structure was provided, the performance of the poor readers improved.

Further support for the contention that poor readers have word segmentation deficiencies is found in a study of reversals (Scheerer-Neuman, 1978, cited in Valtin, 1978-1979). Good and poor readers were presented with letter sequences ordered by chance or ordered so that it was possible for them to be broken into chunks. With chance order, poor readers made fewer reversal errors than good readers, but when segmentation was possible the good readers showed better left to right scanning responses. It seems much easier to correctly report the order of letters (of a long word) grouped into syllables ("pul-me-rat") than to report that order when processing the word letter by letter ('p-u-l-m-e-r-a-t'). Again, poor readers seem to be deficient in the cognitive organising capacities which impose syllable structure upon words.

Several studies of hypothesis usage indicate that poor readers lack flexible hypothesis testing strategies for the decoding of words. Better readers were found to be more willing to modify an incorrect hypothesis when identifying words (Samuels, Begy and Chin, 1975-1976) and were significantly more flexible in providing feasible alternative pronunciations for a three syllable nonsense word (Jenkins, Longmaid, O'Brien, and Sheldon, 1980). In addition, training to test hypotheses in word recognition produced better word reading and comprehension than training using high frequency word flashing with

a projector (Samuels, Dahl and Archwamety, 1974). Training to make and test hypotheses seems to promote the better word reading strategies in which poor readers are deficient.

Although many studies have isolated specific subskill defects of poor readers there is important evidence to indicate that disabled readers lack skill integration strategies. Guthrie (1973) found that although the poor readers were inferior to their normal peers upon skill knowledge they scored at about the same level as normal readers two years younger. When, however, the intercorrelation of skills (e.g., long-vowel production, consonant cluster recognition) was compared a different pattern emerged. For normal readers there is a consistently high pattern of intercorrelation ranging from .47 to .94 with 9 of the 10 significant at the .01 level. For the disabled readers there was little relation between the production skill subtests. Correlations ranged from .18 to .85 and only 4 of 10 were significant at the .01 level. Guthrie concludes that interfacilitation amongst subskills is necessary for normal reading and that one source of difficulty for disabled readers is a lack of interfacilitation and integration amongst subskills. Not only are poor readers deficient in phonic skills they are, more importantly, deficient in the cognitive strategy which relates skills together. In a similar way Vernon's classic review of reading disability (Vernon, 1957) which draws together a wide range of evidence upon visual, auditory and language problems in reading, points to a cognitive capacity underlying these difficulties.

The commonest feature of reading disability is the incapacity to perform the cognitive processes of analysing

accurately the visual and auditory structures of words. The backward reader guesses wrong letters, or the right letters in the wrong order... severe cases of disability seem to have a deeply rooted incapacity to perform the process of analysis with facility, and to synthesize or blend phonetic units to form complete words. (p.71)

After citing studies which found that backward readers had very little ability to analyse words into graphophonic parts or to integrate these parts to form whole spoken words, she concludes that the fundamental characteristic of reading disability appears to be cognitive confusion and lack of a system. From the work of Guthrie and Vernon on recognition of words, it appears that, underlying both subskill disability and sensory or language defects, there are strategic cognitive processes which are critical for reading success.

Thus, both in the processing of passages and the recognition of words, strategic activity of a similar nature is called upon. Poor readers lack the organising capacities that good readers possess. It has also been noted at both levels that poor readers can benefit from an organisational pattern provided for them (e.g., Cromer, 1968; Scheerer-Neuman, 1977-1978, cited in Valtin, 1978-1979). This seems rather similar to the production deficiency Flavell (1970) noted in regard to memory strategies. Children who could not produce an organising label for themselves could use one provided by the experimenter (Moely, Olsen, Halwes and Flavell, 1969).

Third grade pupils given verbal category labels with or without training to group pictures of common objects, spontaneously used the mediating behaviours to assist memory. By contrast only the stronger training treatment produced mediating behaviour in younger children

(Kindergarten and first grade). There are clearly developmental implications in this but where spontaneous structuring of a task does not occur, i.e., where there is a production deficiency, specific teaching to encourage children to organise the material may help. This gives promise that children's integration of printed input could be assisted when it is not spontaneous by providing teaching which requires and assists the child to organise the print according to rules of structure. Perhaps tasks such as word and sentence anagrams would be a means of helping children develop the print organising strategies required.

or conceptual and integrative abilities. Related studies of good and poor readers' concept forming ability (Braun, Cognitive Style 1956) and problem solving style (Wirtenberg and Faw, 1975) further indicate the importance of conceptual reasoning for read.

The suggestion that specific response characteristics shown in reading may be examples of more general modes of functioning has led to the comparative study of cognitive style in good and poor readers. This has produced research which extends the work of Kagan, Moss and Sigel (1963) who have investigated cognitive style, conceived as the mode of categorizing, in its effect upon school learning. Such research may illuminate the cognitive processes which underlie learning to read as also may other related studies which have originated independently of cognitive style theory but, because they relate reading to relatively stable modes of conceptual response, properly belong here.

with language, especially that which related to reading. Ability to abstract a common element was tested with a sample of 139 good and poor

The categorising styles of 24 boys (aged 8 to 10 years) with reading disability, matched for age and social class with 28 normal readers was studied using the Sigel Cognitive Styles Test which asks, for example, why two different pictures are alike. (Serafica and grades

Sigel, 1970). Although the deficient readers did not lack analytic ability (e.g., to discriminate parts from wholes) they were unable to synthesize upon the basis of their analysis, unlike the normal readers. Rather than form concepts by abstracting and relating common qualities, they form "complexes" in which the relationship between the parts are "concrete and factual rather than abstract and logical" (p.111). Serafica and Sigel remark that such thinking is still partly tied to the egocentric and subjective and is analogous to what Piaget calls sensorimotor behaviour. The principal conclusion is that normal readers have superior conceptual and integrative abilities. Related studies of good and poor readers' concept forming ability (Braun, 1963; Kress, 1956) and problem solving style (Wirtenberg and Faw, 1975) further indicate the importance of conceptual reasoning for reading. Wirtenberg and Faw (1975), following Harlow's studies of

learning sets, examined the ability of adequate and retarded readers to The concept forming ability of 25 <sup>reading</sup> retarded boys (8.0 to 11.9 years) was compared with that of normal readers matched for age, school experience and IQ (Kress, 1956). On a series of object and colour-form sorting activities, verbal opposites and other conceptual tasks, Kress found both quantitative and qualitative differences that favoured the adequate readers. By contrast with the good readers, the retarded readers lacked ability to handle hypotheses and inferences, were highly concrete in their thought and lacked adequate concepts to deal with language, especially that which related to reading. Ability to abstract a common element was tested with a sample of 139 good and poor readers (in third, fifth and seventh grades) who were presented with a series of six cards each with four words printed on it (Braun, 1963). They had to detect a word on each card which had something in common with one on all other cards. Scores in fifth and seventh grades

correlated more highly with reading than did IQ. A stronger relationship was also found between concept formation and reading than between concept formation and IQ. Underachieving readers, though little different than overachievers in IQ were significantly lower in concept formation. These poor readers had great difficulty in holding several qualities of a word in mind so they could be successively checked against qualities of another word and so on until a synthesis of common elements is arrived at to give the concept. Good readers possess conceptual reasoning qualities which poor readers do not.

The study of children's problem solving ability in abstracting common qualities and applying solutions across different settings points to a similar conclusion regarding the cognitive style of good readers. Wirtenberg and Faw (1975), following Harlow's studies of learning sets, examined the ability of adequate and retarded readers to generalise from their solution of one problem to the solution of a similar problem presented after it. Sixty boys in the age groups ( $\bar{M}$  = 8 yrs 2 mths,  $\bar{M}$  = 11 yrs 5 mths) learnt the relevant dimensions upon which to choose a nonsense syllable and were then given opportunity to generalise this learning set to another similar problem. The results confirmed the hypothesis; the retarded reader was not deficient in ability to solve simple discrimination learning problems but was slow to conceptualise the similarity among the several problems he encountered. He approached each problem by seeking out a new solution in a trial and error fashion. The good reader attended to consistent aspects of all the problems and called on his past experiences to help in the solution of new problems. Younger retarded readers were as slow (or slower) to conceptualise this similarity as older retarded readers. It is suggested that if these results are confirmed, training

in learning strategies would be part of remediation.

### Summary of Differences between Good and Poor Readers

The evidence surveyed indicates that one important difference between good and poor readers is that good readers have a capacity to integrate and structure symbolic input which poor readers do not possess. This has been widely demonstrated both at the level of letter and syllable processing to form words and at the level of word and phrase processing to form passages.

Strategy usage studies with word recognition controlled either by criterion training or use of logographs, have shown that poor readers are deficient in the ability to synthesize the parts to form a meaningful whole. Given appropriate assistance in the structuring of the material these pupils improved their reading performance significantly. Several studies have indicated that they can use an organising structure if it is provided but cannot produce it spontaneously. Further clarification of the organising process may be gained by examining the effects of instruction which requires pupils to organise the print according to rules of structure.

Cognitive style studies suggest that specific response characteristics shown by poor readers are examples of a general mode of cognitive activity which hinders reading progress. Poor readers with ages ranging from 8 to 13 years whose cognitive style was assessed by four different techniques were unable to handle hypotheses and inferences, lacking the conceptual and integrative capacities reading seems to require. There is thus a considerable body of evidence from

the study of good and poor reader differences which indicates that the critical ingredient in successful reading lies in several aspects of higher mental processing. The results are consistent across subjects of both sexes (though more commonly boys) ranging over grades 1 to 7 and upon a wide variety of tasks including processing of words to form discourse, of letters to make syllables and words and of logographs to express a message, integrating phonic subskills, comparing pictures, sorting objects and solving nonsense-syllable problems. Although it is possible to take the synthesizing and integrative facility of good readers for granted, the deficits of poor readers clearly indicate that reading requires the ability to impose structure upon input using conceptual reasoning.

#### Specific Reading Concepts

The evidence from a comparison of good and poor readers has provided substantial support for a cognitive theory of reading. Further strengthening of this argument and some clarification of the nature of the higher cognitive processes involved is provided by the study of beginners' metalinguistic knowledge of reading and of the concepts used in early instruction. Early research by Reid (1966) traced the emergence of an understanding of specific reading concepts during early instruction although it did not examine their relationship to later reading progress or explicate the nature of the relationship suggested. During their first year at school, 12 Scottish children were interviewed on three occasions (at 2 months, 5 months, 9 months) to trace the development of such concepts as "reading", "word", "sound", "letter", and the relationship between them (Reid, 1966). Although the children began with very little grasp

of what reading is and of the symbols involved in it, during the year (in which reading instruction was given) this 'vagueness' cleared considerably. They learnt the difference between pictures and print and between alphabetic and numeric symbols.

They had to discover what 'words' are, and that almost all language, written or spoken is composed of these, though written language also contains marks of other kinds. They had to learn, furthermore, to think of a 'sound', and to realise that written words are spatially ordered groups of letters bearing a systematic relation to the temporally ordered sounds of speech. (p.61)

1. They better understood the communication purpose of the

This is a highly important exploratory investigation of an area in which little had been done. The study suggests the nature of some of the conceptual components of early reading. Children come to understand the communication purpose of reading and the nature of its technical concepts as they learn to read. One problem in determining the full significance of the study, however, is that the twelve subjects were chosen at random from a class of over forty but no information is given about IQ, or socio-economic status and the generality of the results is thus very difficult to determine. One would also like to see the relation between concept development and reading progress examined. Is there a significant correlation between the two and what is the nature of any relationship which might exist? Is it causal or incidental? Other studies have thrown some light upon these questions. This replaces the cognitive confusion they show when they begin to read. Downing (1971-72) replicated Reid's study with twelve British children but extended it with tests to show the developmental process which lies behind these children's increasing ability to use linguistic concepts. He included concrete examples of literacy behaviour which

would permit non-verbal as well as additional verbal responses by the subjects. He also compared their understanding of 'a word' and 'a sound' with their general cognitive growth as shown in the records of interview, in discussion with the experimenter and by responses to puzzle games. This analysis is rather subjective and must be accepted with some caution. In supporting Reid's conclusions, however, five characteristics of children's progress towards clarity are given. At the conclusion of the study:

method and confirmation of these findings using other techniques is desirable.

1. They better understood the communication purpose of the written form of language.
2. Their conception of the function of symbols was clearer.
3. Their concepts of linguistic segments, such as "word" and "sound" more nearly approached those of the teacher.
4. Their command of the abstract technical terminology of language improved.
5. They better understood the process of decoding alphabetic letters to speech sounds and vice versa in encoding (Downing, 1971-72).

Calling for a cognitive theory of reading, Downing claims that it needs to be seen as a problem solving task rather than as an association task. One aspect of that problem-solving task is the attainment of cognitive clarity regarding the language of reading. This replaces the cognitive confusion they show when they begin to read. Again, however, in his study, no relationship between level of conceptual development or of general cognitive growth and reading progress was examined. Furthermore, some doubt may be entertained about the adequacy of children's verbal statements to indicate their

thinking development. As Piaget (1964) has suggested, words may be used without the underlying cognitive structure being present, or the child may understand but not be able to verbalize about that understanding. Reid is aware of this problem and in the interviews and her analysis of them seeks to allow for it. Downing used Piagetian-style checks by challenging the child's answer with the question of how he knew it was so. However, to some degree the problem is inherent in the method and confirmation of these findings using other techniques is desirable.

One alternative technique for determining the sound-orthography relationship is the "mow-motorcycle" test (Rozin, Bressman and Taft, 1974) which determines whether the child understands that larger written words take longer to say. The word choices were grossly different in length so that a non-reader could perform perfectly if the relationship between written and spoken length was understood. As a check, pupils were asked about their basis for responding. Although no comparison with reading levels was made, the results of the test administered to inner-city children at the end of the first year at school (during which a phonics-reading approach was used) confirmed Reid's and Downing's findings regarding conceptual confusion. A substantial number of these lower class children did not comprehend the basic nature of the writing system, and for some, this extended through to second grade. Middle class suburban children did not have the same level of difficulty. The study does give independent support for Reid's and Downing's conclusion that doubt exists in some beginner's minds "that written words are spatially ordered groups of letters bearing a systematic relation to the temporarily ordered sounds of speech" and that this confusion clears (for most but not all)

as reading instruction proceeds. Similar confusion among young children over the speech-print relationships was found by Meltzer and Herse (1969), Holden and MacGinitie (1973) and Clay (1972).

The relationship of conceptual understanding and reading achievement was studied by Johns (1972) who interviewed 53 grade 4 pupils to ascertain their conception of reading and who assessed their vocabulary and comprehension with the Survey D of the Gates-MacGintie Reading Tests. Vocabulary and Comprehension correlated at .31 and .33 respectively with concepts of reading (significant at .05 level) and the author concluded that this result prompts further investigation of the relationship, as one of the factors of reading achievement may be the learner's understanding of what reading is.

There is thus a wide array of evidence to support the view that grasp of the nature of reading and of the technical vocabulary involved is called upon as the child learns to read. This conclusion is reminiscent of Kress' finding (Kress, 1956) discussed earlier, that poor readers' lacked adequate concepts to deal with language, especially reading. It also seems to parallel Vernon's comment (Vernon, 1957) that poor readers fail to grasp the idea of the correspondence of print and phonetic units. Is this an expression of a general conceptual ability such as might be measured by a vocabulary test or does it involve some more specific cognitive capacity than this?

Francis (1973) investigated this question with a sample of 50 young children whom she tested on four occasions at six monthly inter-

vals beginning in their first year at school when their average age was 5 years 9 months. The tests measured <sup>word</sup> reading (Schonell), technical concepts of reading ("word", "letter", "sentence"), suffix identification and general concept understanding (vocabulary). At age 7 years 3 months reading and technical concepts correlated the highest (.41,  $P < .001$ ) of all the measures and even when general vocabulary skill was statistically controlled, a considerable correlation remained (partial Kendall  $r = .34$ ). These findings provide further support for the suggestion above that understanding the terminology of reading instruction is positively related to reading achievement. It is significant that understanding the concepts of reading instruction was a stronger correlate of reading than was a more general measure of conceptual ability (vocabulary). Francis suggests that factors independent of a general ability to deal with abstract concepts are involved:

perhaps the difficulty experienced by the children was not so much that the concepts are abstract, as suggested by Downing, but that they overlap in their application and are somewhat ill-defined. (p.22)

The difficulty of understanding the technical vocabulary of reading instruction "appears to be an integral part of the difficulty of learning to read, rather than a separate conceptual difficulty" (p.23). Since, however, Francis does not elaborate upon what is this "difficulty of learning to read", it is hard to see why it must be something separate from general conceptual capacity. Certainly it can be distinguished from whatever is measured by a test of vocabulary. The nature of this difference leads to an issue of critical importance for our consideration of conceptual reasoning and reading. The differ-

ence between the conceptual ability required by vocabulary building and the conceptual ability needed to understand units of print may be explained by the newly emerging capacities many researchers have found in children of the 5-7 year age bracket used by Francis. In particular it may well be explained in terms of the decision zone of response suggested by White (1965, 1970) or the logical operations of Piaget. Francis quite rightly indicates that the child needs to understand the concept of a unit of written language as he reads. In Piaget's terms the unit concept requires a co-ordination of the operations of classification and seriation (Piaget 1967), capacities which underlie conceptual development.

The explanation offered in this study for Francis' findings is that early reading soon calls upon a concept forming ability which depends upon concrete operations. An alternative view, based on an information processing approach, claims that experience of print is a sufficient condition for the development of word and phoneme awareness and that cognitive development, therefore, has no necessary contribution towards this metalinguistic knowledge (Ehri, 1979). While print experience is undoubtedly very important for language awareness this need not deny the contribution of cognitive development to this awareness. The print experience explanation seems less well able to account for the discontinuity between general vocabulary and print vocabulary especially after all subjects have had eighteen months of reading instruction. For the cognitive developmental view, the general vocabulary test does not seem to monitor the operational capacities that emerge at six or seven years, which form the basis of subsequent conceptual reasoning and which may be necessary for understanding the units of print. If this interpretation is correct

a measure of logical thinking would be expected to have a higher relationship with reading than would vocabulary. We shall shortly examine evidence which gives support both for the relationship of logical operations to reading and for this explanation of the conceptual process used to understand a unit of language. Before doing so, however, it is necessary to examine some recent discussions of linguistic aspects of early reading which suggest that the difference between learning to speak and learning to read may reflect different cognitive abilities called upon by the two learning tasks.

A major theoretical proposal which regards concepts about the nature and function of print as an aspect of linguistic awareness and as critical to early reading has been raised by Mattingly (1972). Processing print and processing speech are different kinds of activities, he argues.

Speaking and listening are primary linguistic activities; reading is a secondary and rather special sort of activity that relies critically upon the reader's awareness of these primary activities. (p.138)

There are many differences between reading and listening, he maintains, which are not explained by the difference of modality; difference in the form of the input information (a complex acoustic signal and a discreet visual symbol); difference in linguistic content (for speech; a "complex code," for print, a "simple cipher") and difference in the speed and difficulty of processing (reading can be quicker to process but is more difficult to learn). Because of these differences the child must be aware of linguistic units, their vocabulary (the language unit) to reading progress. In conclusion,

nature and function, if print is to be processed. By contrast the processing of spoken language does not require this awareness.

These differences can be explained only if we regard reading as a deliberately acquired, language-based skill, dependent upon the speaker-hearer's awareness of certain aspects of primary linguistic activity. By virtue of this linguistic awareness, written text initiates the synthetic linguistic process common to both reading and speech, enabling the reader to get the writer's messages and so to recognize what has been written. (p.145)

Luria (1971), in discussing the same issue, points out that young children, although using words to become aware of the world, cannot make a word or a verbal relationship the object of their awareness. It is as though they have been looking at the world through a window without being conscious of the window itself. They have not made the word itself the object of their awareness nor even suspected that it has its own existence. (Luria, in Elkonin, 1971). In reading, unlike speech, a consciousness of the word is required, i.e., children become aware of the "window".

It would not be surprising if these differences in processing spoken and printed language indicated differences in the cognitive activity required to learn them. It is the argument of this study that there is an important difference in the cognitive processes involved to understand speech and to understand print. It is a difference Francis (1973) uncovered in the distinction she found between the relationship of general vocabulary and of specific reading vocabulary (the language unit) to reading progress. In conclusion,

(a) featural information - visual information from the page,  
 (b) orthographic information - information from the way letters are grouped,  
 (c) syntactic information - knowledge from the grammatic patterns of the sentences, and  
 (d) semantic information - knowledge of the meaning.

whether specific concepts of reading are "abstract" or "complex" in their demands, an understanding of them requires a difficult cognitive task to be performed. This is consistent with evidence examined earlier that reading critically involves conceptual reasoning. Understanding the communicative purpose and the technical concepts of reading is at least one aspect of the conceptual task which children learning to read are called upon to perform. There are other aspects of learning to read that have been illuminated by studies of the error patterns of children's oral reading and which seem to require the child to perform conceptual reasoning.

(Rousch and Cambourne, 1979, p.87). This supports the psycholinguistic theory of Naturalistic Studies of Oral Reading whose model of reading (Goodman, 1970), includes such activities as selecting,

The naturalistic study of children's oral reading has recently received much attention from theorists and researchers because of the insight it offers into the reading process. The conception of reading it proposes views decision making as the central activity of the reader and thus seems to imply a cognitive theory of reading.

The overwhelming consensus from this perspective is that the child samples from the range of cues available to determine meaning. Smith (1971) has suggested that a skilled reader uses:

- (a) featural information - visual information from the page,
- (b) orthographic information - information from the way letters are grouped,
- (c) syntactic information - knowledge from the grammatic patterns of the sentences, and
- (d) semantic information - knowledge of the meaning.

The view that reading is the attaining of meaning through an integration of cues using such strategies as sampling, predicting, confirming and correcting is further supported by a study of the oral reading responses of 130 Australian children from the Riverina area (Rousch and Cambourne, 1979). This study analysed and compared the kinds of cues proficient, average and low ability readers use to attain meaning. While they found that better readers make far more use of contextual cues than do poor readers, "irrespective of degree of success at extracting meaning, all readers make use of at least three kinds of information, viz, graphophonic, syntactic and semantic" (Rousch and Cambourne, 1979, p.87). This supports the psycholinguistic theory of reading proposed by Kenneth Goodman whose "model" of reading (Goodman, 1970), includes such activities as selecting, predicting, comparing, searching, testing and choosing, which are represented diagrammatically by a very complex maze of arrows, boxes, circles, triangles, and diamonds in order to show the "almost automatic" activity of the competent reader. Reading, in this model seems to be very much a thinking, problem-solving, conceptual reasoning task of the kind discussed above. However, Goodman (1969) sees it differently and comments: semantic information revealed by reading miscues. It is unwarranted to conclude from this that

He (the reader) concentrates his total prior experience and learning on the task, drawing on his experiences and the concepts he has attained, as well as the language competence he has achieved. In this process thought and language interrelate, but they are not the same. Reading can be described as a psycholinguistic process in which meaning is decoded from a linguistic medium of communication rather than a thinking or linguistic process. (p.15)

Getting meaning from print, in Goodman's view, is an almost identical process to getting meaning from speech. The only difference

is the necessity to develop "an alternate parallel mode of doing it", i.e., through the eye rather than the ear (Goodman, 1975, p.627). For this reason he believes that "learning to extract meaning from print is no more cognitively difficult than learning to comprehend speech" (Cambourne, 1976-1977, p.635). Thus, understanding speech and understanding print are best conceived as psycholinguistic rather than thinking activities.

Goodman seems to insist upon this because of the "almost automatic" nature of reading. Thinking takes place upon the basis of reading. In one of his very brief references to thinking he states that although language and thought are interactive in reading, "at some point thought processes leap out and away from the message of the writer". The interaction involves "cycles of reading, reflective thinking, flights of fancy and then more reading" (Goodman, 1970, p.484). Thus, gaining the message (reading) is not so much a thinking activity for Goodman; thinking is something which may follow reading.

However, Goodman's data are limited to his linguistic analysis of the graph<sup>o</sup>phonic, syntactic and semantic information revealed by reading miscues. It is unwarranted to conclude from this that understanding speech and understanding print are almost identical processes. As Mosenthal has suggested;

To validate his own theory of comprehension he must determine what concomitant cognitive variables influence the comprehender's ability to employ linguistic skills. In other words, Goodman needs to assess the extent to which linguistic competence exists as a function of other higher-order cognitive processes. (1976-77, p.60)

A major question to be asked in this present study is whether reading involves cognitive capacities which are distinct from language competence. It is the contention of this study that learning to understand print involves thinking processes which are not subsumed by the "psycholinguistic" variables Goodman suggests.

The naturalistic study of oral reading by Marie Clay (1972) has led to a further important conceptualisation of reading which is distinct from that of Goodman but like it in important respects. In support of her perceptual learning view, which sees reading as the "patterning of complex behaviour", she reviews evidence from an Auckland study of seven year old children's oral reading and concludes,

"psycholinguistic" activity while Clay believes it is best described

as These findings seem to indicate that high progress readers are gathering cues from meaning, grammar, letter-sound relationships and cross-relating these in an active process of search and check. The average and low progress readers use fewer types of cues, make less effort to relate these, and do this processing less accurately and more slowly. (Clay, 1972, p.124).

The child's willingness to search and to choose between alternatives is, for Clay, a critical element in successful reading.

"The child who gives up searching becomes the problem reader." (1972) This again seems to imply that reading is centrally a reasoning process. Clay, however, does not come to this conclusion. Early reading, she believes is better described as a perceptual learning task (personal communication, 1977). Thus, in summarising her longitudinal study of five year old children's reading she comments,ly be seen as denoting thought processes. Thorndike's (1917) description of reading as reasoning is strikingly similar to these.

Adequate learning must proceed in the direction of more and more receptiveness to visual perception cues which must eventually dominate the process. (1967, p.29)

Furthermore, because the processing must happen so quickly, it is not likely to be explained adequately in relation to the child's concrete operational thinking, she believes. It is controlled by the "down-stream" cognitive processes rather than the "up-stream" or executive level. Thus, although both Goodman's and Clay's views seem to imply a reasoning, problem solving activity, neither give any significant place to the contribution of thinking in learning to read. Each seems to accept that the processing of print is too quick for thought to be its basis. Goodman asserts instead that it is a "psycholinguistic" activity while Clay believes it is best described as perceptual learning. The question of automatic processing or cognitive processing is a very important one which goes to the heart of an understanding of the nature of reading and requires closer examination.

#### Automatic Versus Cognitive Processing

Goodman may well be right in assuming that much competent reading does not involve thinking (reflecting) but that does not mean that learning to read is not a thinking task nor does it mean that thinking capacity is not critically important for competent reading. Descriptions of children reading provided by Smith, Goodman, and Clay which give such prominence to "selecting", "predicting", "choosing", must surely be seen as denoting thought processes. Thorndike's (1917) description of reading as reasoning is strikingly similar to these.

This implies that conceptual reasoning is not only required to understand the concepts such as "letter", and "word" but is essential to the process involved in getting meaning from print. Furthermore, even if much reading behaviour is automatic, there is still the capacity and frequently the need, during reading, to pause, check and reassess i.e., to think. Although thought is not always called upon, it is a necessary component for learning to read and is required, to greater and lesser degrees, in even the most competent reading. And it is this capacity for reflection that the automatic response depends upon for its development and for its verification.

A concept suggested by Sheldon White (1965, 1970) from his review of research into learning in middle childhood helps to explain the relationship of automatic and reasoning processes in reading. He proposes that competing responses are "temporally stacked" i.e., "different responses become maximally 'ready' in different time zones after the stimulus has initiated the hunt for a response" (1965, p.189). After examining a number of studies upon the issue he proposes that this temporal stacking mechanism can be explained by two zones:

a zone of automation and a zone of decision. If, through prolonged training, a response is drilled in to a particular cue, it is possible that such a response becomes established in an automatic system which has privileged, short-latency access to response selection. If the subject senses novelty and/or an unpleasant event, he inhibits the automated system and switches to the decision system for determination of response. (1965, p.194)

The automatic zone or "associative level" of response is laid down early in development while the "decision zone" or "cognitive layer"

begins or is most marked in the age period from five to seven years. Both layers are available to adults, there being a "law of least mental effort" under which adults revert to the associative level if they feel safely able to do so. White suggests that responses developed and practised at the cognitive level may be claimed by the associative level of response. and research evidence upon the nature of concept formation and how that is related to reading.

Competent reading seems to be a classic example of this two-layer response capacity. The associative level has "claimed" the responses developed by the cognitive system. Reading takes place at the associative layer while the cognitive layer interprets the content of the reading material. Suddenly an unfamiliar construction is not recognised and the associative process breaks down. Reasoning is called upon to make sense of the print and the interpretation of the content is interrupted while this takes place. If this explanation is correct, reading is essentially a thinking process. The extensive evidence cited above gives support for this interpretation. White refers to a factor analysis of longitudinal intelligence test data by Hofstaetter (1954) which indicates that, from age 5 onwards (about the time children are learning to read), a factor III, "provisional action", "planning" and "abstract behaviour" (present earlier but overshadowed), rises to account for a majority of the variance. This factor seems to be very much like the reasoning capacities we saw differentiate good and poor readers and seems rather like Piaget's concrete operations. al task) it is difficult to interpret the studies further since terms are often understood in different ways from one stud. The predominance of automatic processing in adult or competent readers is therefore not the critical test of whether thinking is crucial in reading. There is need rather to examine the learning-to-

read process. White's conclusion that years five to seven see a new cognitive level emerge is instructive. During those years reading is successfully begun for most Western children. Perhaps this new level of cognitive functioning is involved in learning to read. To assess this suggestion and to further the argument of this thesis it is first necessary to consider theories and research evidence upon the nature of concept formation and how that is related to reading.

### Origins of Conceptual Reasoning as it Relates to Reading

From the evidence presented upon good and poor reader differences in strategy usage and in cognitive style, from studies of specific reading concepts and from an examination of children's oral reading, it is clear that conceptual reasoning is a critical element in successful reading. These studies also give some clues to the specific nature of this reasoning. Oaken, Wiener and Cromer (1971) suggest it is the structuring of printed input; Kress (1956) found it to be capacity to hypothesise and infer; Braun (1968), to abstract and generalise; Vernon (1957), to analyse and synthesise; Wirtenberg and Faw (1975), that it is ability to generalise from one circumstance to another; Serafica and Sigel (1970), to integrate and form logical links; Francis (1973), to grasp complex reading concepts.

Although there is much in common amongst these findings (viz., reading is a conceptual task) it is difficult to interpret the studies further since terms are often understood in different ways from one study to another and some of the details seem contradictory. Vernon, for example, found that poor readers were deficient in analysis while Serafika and Sigel assert that poor readers were able to analyse as

well as good readers. An explanation of the origins of concept forming ability is needed. What is the developmental course of conceptual reasoning?

Margaret Donaldson (1978) argues that the awareness of language  
 There are two main schools of thought which seek to explain the basis of concept formation. One emphasises language as the means whereby the world is represented, e.g., the Wisconsin Model (Klausmeier and Hooper, 1974); the other, Piagetian Theory, emphasises logico-mathematical processes as the means of internal structuring of experience. In the first, the learning environment is predominant and developmental continuity is stressed. In the second, internal equilibration is given prominence and stage progression is stressed. In many regards the two theories seem incompatible, e.g., in their views of stage progression or reinforcement. It is also possible that the two make complementary contributions to an explanation of conceptual reasoning.

### Language and Reading

The nature of reading as a language processing task suggests that a strong link exists between speaking and hearing oral language on the one hand and writing and reading printed language on the other. There is no dispute that the child's oral competence is important for successful reading. The critical question is how important is oral language for learning to read? The Wisconsin model argues that language plays a critical part in concept formation. The increasing volume of research (reviewed earlier) which has shown that the development of specific concepts of reading is related to success in

and normal readers in 2nd and 6th grades to identify and/or to reprod-

early reading, suggests that language is highly important for reading progress.

Margaret Donaldson (1978) argues that the awareness of language which reading requires and the reading activity itself, enable children to treat language in some degree of abstraction from context. "Awareness typically develops when something gives us pause ... and we stop to consider the possibilities of acting which are before us." (p.94) The notions of awareness and of choice are thus closely bound together. "We heighten our awareness of what is actual by considering what is possible." (p.94) The control of mental processes implicit in the exercise of choice is a critical element in the development of the highest levels of mental activity and it is suggested that the language awareness and language usage called upon in reading is an important source of impetus for the full realisation of intellectual functioning. Language competence, which, in this view, is regarded as the moving force behind intellectual development, is likely to be a principal explanation of the concept formation called upon by reading. For Kenneth Goodman (1970), a highly developed language competence is the most important resource children bring to the task of learning to read.

An example of research which seems to support this contention is provided by studies of Vellutino and colleagues of perceptual and language factors in regard to reading reversals. For instance, Vellutino, Smith, Steger and Kaman (1975) concluded that poor readers were different from normal readers because of a malfunction of verbal mediation rather than because of optical distortion. They asked poor and normal readers in 2nd and 6th grades to identify and/or to reprod-

uce stimuli (words, scrambled letters, numbers, geometric designs) orally and graphically. Results of an earlier study with older children (9 to 15 years) were confirmed when poor readers were able to reproduce stimuli in graphic form as well as the normal readers but were not as competent as them in verbal encoding. The authors surmise that poor readers learn a great deal about the visual (and visual-motor) properties of words in print but have "difficultly in integrating their visual and verbal counterparts". Reversals they suggest, are thus more a language than a perceptual problem. An alternative explanation of the data could be that verbal mediation is basically a mental process and, if this is so, thinking may be the fundamental weakness of the poor readers. The authors' conclusion, however, provides an example of a language process explanation for learning to read. The present study will seek to assess the relative place of language competence and operativity in an explanation of conceptual processes in reading. While the importance of language competence for reading is well accepted, there is far less agreement about the part that operativity might play in learning to read and evidence upon this question will be considered in some detail.

Operational Thought and Reading

Operational thought in Piaget's theory is a major landmark in the emerging human capacity to make sense of the world because it denotes the emergence of a far more powerful and efficient conceptual process in the human life cycle. In this view reading is highly reliant on the stage related cognitive development of the young child. To assess conservation of length the children were asked to compare lengths of straight and curved pieces of Play Doh and to explain the reasons for their answers. Conservation of number was measured asking

For Piaget a concept is an internalised action. In early childhood, concepts derive from sensory-motor actions, while in middle childhood they are also based upon logical groupings or mental operations. The child of 6 or 7 learning to read is passing from "sensory-motor intelligence" to "conceptual intelligence". The difference lies in the capacity for reversible operations which allow a simultaneous representation of experience and so free the child from the limitations of space and time. It may not be by chance that children show an ability to learn to read at 6 or 7 years, the time when operational thought emerges. If reading is the conceptual activity this study has asserted, there is a need to clarify the conceptual foundations upon which it is built. If Piaget's view of cognitive development in middle childhood is valid, we may well expect the operational capacity to relate to reading progress. Studies which have examined the three infralogical operations, conservation, classification and seriation and a related capacity, perceptual exploration, in their relationship to reading, will be reviewed.

Conservation. Of the studies that have examined concrete operations and reading (or reading readiness), most research has focussed on conservation. Waller (1977), who drew together the results of some ten studies, found that, overall, correlations were low to moderate, ranging from .17 to .44 but most commonly from .25 to .35. Kaufman and Kaufman (1972), who found the highest correlation, studied 80 children whose conservation of length and number (inter alia) were measured in Kindergarten and whose reading (Stanford Achievement Test) was measured 16 months later in first grade. To assess conservation of length the children were asked to compare lengths of straight and curved pieces of Play Doh and to explain the reasons for their answers. Conservation of number was measured <sup>by</sup> asking

the child to demonstrate knowledge of rudimentary adding and subtracting (with objects); identity conservation (whether the number of candies stays the same when poured from a plate to a glass); and equivalence conservation (whether two equal rows of objects remain equal after one row undergoes shape transformation). Conservation of length correlated .30 with reading while conservation of number correlated .44. This latter correlation is the largest reported in the literature. However, close scrutiny shows that it is not based upon a valid measure of conservation since adding and subtracting involve the unit concept which requires a co-ordination of both classification and seriation.

In summarising the evidence, Waller (1977) concluded:

Thus, although there is some relationship between conservation and reading, from the above results it should be clear that there generally is at least a low positive correlation between performance on a variety of tests of reading and reading readiness on the one hand, and measures of level of cognitive development as regards concrete operations (specifically conservation) on the other. These results have been observed using a number of different measures of reading, with both males and females, and across a range of social statuses. (p.14)

#### Classification and Seriation. Studies of classification and

In an important study not included in the Waller review, Lunzer, Dolan and Wilkinson (1976) administered a battery of 28 tests of operational thought, language and memory to a sample of 183 Kindergarten children of three different social levels; from privileged, intermediate and underprivileged areas. Twelve months later they administered two reading tests (Schonell Word Recognition, Neale Comprehension). The validity problem of the Kaufman and Kaufman study seems to have been overcome since the conservation of number test

included 1 for 1 correspondence but no adding or subtracting. Conservation of length asked children to assess the equivalence of equal and unequal rods and pieces of string in parallel alignment, displaced or rearranged. The multiple correlation of all predictors with Schonell Word Reading, was .65 and with Neale Comprehension was .54. Although conservation of number and length correlated at moderate levels with reading (Schonell), .31 and .25 respectively (personal communication, 1977), when conservation was dropped from the battery the multiple R changed very little. It was concluded therefore, that conservation did not contribute significantly over and above other operative and learning measures towards the prediction of reading.

Thus, although there is some relationship between conservation and reading, it is only at a low to moderate level and the variance which it controls is also controlled by classification and seriation which overshadow it. More research attention, therefore, ought to be directed towards classification and seriation in relation to reading.

Classification and Seriation. Studies of classification and reading have not been as numerous as have been studies of conservation and reading but the correlations reported generally have been somewhat higher, usually in the vicinity of .35 (Waller 1977). Kaufman and Kaufman (1972), for example, measured logical classification by two-way block sorting (colour and shape) class inclusion ("some" and "all") and multiple classification tasks. This correlated .35 with reading (Stanford Achievement Test) assessed 16 months later.

research indicates that seriation is perhaps the most promising of the three Piagetian predictors.

The battery of Piagetian classification measures of Lunzer, Dolan and Wilkinson (1976) included "all and some", class inclusion (unequal partition and nested classification) and intersecting classes (simultaneous classification upon the basis of two criteria). These correlated at levels of .43, .32 and .54 respectively with reading (Schonell). In classification of intersecting classes the child's incorrect responses were corrected and subsequent items allowed the child to profit by earlier experience. Lunzer, (in personal communication, 1977) writes "If you pressed me to comment upon the interaction task as a predictor, I would possibly venture that it combined operativity with a fair amount of learning. But one should be chary about making such fine grade distinctions post hoc!" In the multiple regression analysis Lunzer grouped classification with seriation upon the basis of an earlier factor analysis. Seriation comprised single seriation (e.g., ordering different sized rods) and multiple seriation (e.g., cylinders varying in shape and size arranged on a 3 x 3 matrix). When classification and seriation were omitted from the multiple correlation, it dropped from .65 to .61 - the largest single effect shown, and one which the covariance F test revealed is significant at the .01 level for the whole sample and for the privileged and under-privileged socio-economic groups. For the intermediate socio-economic level it did not attain significance. A comparison of the effects of classification and seriation shows that single and multiple seriation (which correlated .47 and .39 respectively with reading) were the best representatives of this part of the battery. Classification and seriation have both shown moderate to strong correlations with reading at grade one but this and other research indicates that seriation is perhaps the most promising of the three Piagetian predictors.

Scott (1970) compared results of single seriation given to kindergarten children with their April third grade reading scores as measured by the Iowa Test of Basic Skills. The 151 boy and girl subjects were from lower and middle class backgrounds and included blacks and whites. Seriation was measured with a thirty item test of various size and pattern ordering tasks, matching of two series and an assessment of trial and error versus operational modes of response. A correlation of .50, significant at the .01 level, was found. The relationship was stronger amongst white than amongst black children. Kaufman and Kaufman (1972) asked children to make staircases out of 5 then 9 slats (ranging from 2 to 6 inches long) and then to insert two additional slats into the larger staircase. They were finally asked to count the steps and tell how many steps a doll had climbed. Although this final step appears to confound seriation with classification (since it requires the unit concept), the results of Lunzer, Dolan and Wilkinson (1976) indicate that this may not be important since the two seem to call upon the same capacities (as shown by the factor analysis). This seriation task, when administered to 30 white upper-middle class kindergarten boys and girls, correlated almost as strongly with reading in first class (.55) as did the whole Piagetian battery (.58) and was a stronger correlate of reading than I.Q. (.48, Lorge-Thorndike) or mental age (.51, Lorge-Thorndike). Each arise from sensory-motor activity. It has often been thought that concepts

Taken together, these three studies provide impressive evidence for the existence of an important relationship between seriation and reading. Similar results have been obtained in two different English speaking countries, for both boys and girls, from under-privileged and privileged social groups, with independently constructed predictor measures and different criterion tests. The relationship extended

from the predictor administered in Kindergarten to the criterion in one case some 18 months later, while in another, some 30 months later. Certainly any investigation of the nature of conceptual reasoning as required by learning to read is well advised to include seriation.

Perceptual Exploration. Perceptual exploration, the developmental capacity to perceive a complex visual field, is a Piagetian concept which the evidence suggests is partly related in its development to operational thought and to success in learning to read. Since Piaget's views upon perception are little known it is necessary to consider them (and some supporting studies of Vurpillot and Zaporozhets) as they relate to conceptual ability before examining perception, reasoning and reading.

During early childhood perception is "syncratic" or "global", i.e., the child lacks the ability to synthesise and analyse and so cannot co-ordinate wholes and parts (Piaget, 1969). This is the outcome of an insufficiency of exploratory activity. This activity directs eye movements and determines pauses or centrations during the examination of a figure. Exploration develops with age, requires practice and direction and is related to intelligence which in part directs its functioning. Perceptions and concepts each arise from sensory-motor activity. It has often been thought that concepts derive from perceptual activities. Piaget (1969, p. 333ff) does not believe this is so. Perceptual activity is never self-sufficient but is directed by sensory-motor intelligence or representational (operational) intelligence.

how perceptual activities exhibit characteristics of composition which are partially isomorphic with the forms of operational composition at work in the construction of a notion and ....share common filiations with early stages of sensory-motor activities. (Piaget, 1969, p.311f)

especially for the relationship of perception to mental processes.

There is no dualism of experience (i.e., perception) and deduction, he argues, since experience is a progressive structuring (not a recording) and deduction is a co-ordination of operations. Thus the difference between perception and reasoning is only in the degree of mental activity involved (Piaget, 1969).

In an authoritative recent statement upon perceptual development in children, Vurpillot (1976) reviews the evidence upon perceptual identification of wholes and parts. What is perceived, she concludes, will be determined by the perceptual organisation of the field and the cognitive structures of the perceiver, as Piaget has asserted. The capacity to see both parts and wholes in an ambiguous figure seems to depend upon the emerging cognitive operations.

It is this double role of a single unit, a role analagous to that taken by a common element in related classes, that children appear to be incapable of appreciating before the age of about 7. Up to that age-level a detail of a figure can constitute either an individualised and identified structure or a part of another structure, also individualised and identified - but it cannot take both roles at the same time. (Vurpillot, 1976, p.147)

The age of 7, Vurpillot emphasises, is only an approximate indication, "a mean around which the dispersion is very great." Demonstration of this capacity can be earlier (or later) depending upon such things as whether the task involves differentiation or identification, whether the contours are continuous or broken and upon

children aged four to eleven years there was an increase with age in ability to perform these tasks and to benefit from training. The

how familiar and meaningful is the content. Zaporozhets' review of Soviet research into haptic perception (in Cole and Maltzman, 1969) gives support for the developmental pattern proposed by Vurpillot and especially for the relationship of perception to mental processes. Haptic exploration begins to be more systematic and thorough at 5 to 6 years and at 6 to 7 years becomes adult-like with systematic exploration of all the contours of a shape.

These findings would seem to confirm that it is only by age 5 that a system of strictly perceptual-cognitive functions begins to develop, the characteristic feature being extensive movements that are carried out consecutively by the receptor apparatus (Zaporozhets, p.96).

This research supports the view that important aspects of perception gain significant impetus from the changes in mental function which take place during middle childhood. If perceptual exploration is "partially isomorphic" with the mental operations and is, to an important degree, directed by them it would not be surprising if it contributed to the conceptual reasoning which the foregoing discussion has suggested is central to learning to read. Several empirical studies have suggested this.

A series of studies upon perceptual exploration (Piaget uses the term "activity", Elkind, "regulation") and reading have been conducted by Elkind and his co-workers (1975) who developed a set of pictorial items to monitor perceptual ambiguity (one figure capable of two interpretations) and perceptual integration (independent items forming a whole) in part replicating the work of Dworetzki (1939, cited in Vurpillot, 1976). In cross sectional and experimental research with children aged four to eleven years there was an increase with age in ability to perform these tasks and to benefit from training. The

results are interpreted to confirm the assertion of Piaget that perceptual development is a constructive process which shows critical change during middle childhood and is related to the structures of the intellect. group's mean score improvement was only 0.67 from 15.79 to

16.26 in word recognition and 1.41 from 8.14 to 9.55 in comprehension

Working amongst children with the perceptual exploration tests Elkind was struck by the apparent relationship of perceptual capacity and reading competence. Investigation of this showed that decentration of perception (going beyond the initially salient feature of a complex visual field) was significantly related to reading (Elkind, Horn and Schneider, 1965) and further research (Elkind, Larson and Van Doorninck, 1965) revealed that perceptual regulations act, in part, independently of general intelligence in this relationship. To test the hypothesis that children would improve in reading if given training in perceptual regulations, 60 inner-city second grade negro pupils were given instruction for three half hour lessons a week for 15 weeks in two groups matched for perceptual activity and reading achievement (Elkind and Deblinger, 1969). The control group read orally around the class from a basic reader and did vocabulary, grammar and comprehension exercises provided in the teacher manual. The experimental subjects who were trained with a set of non-spoken exercises to stimulate perceptual regulations, improved in their recognition of words and word forms significantly more than did the controls. Comprehension showed no significant difference between the groups. support for his view of the perceptual-cognitive process in

reading can be found in some work of Kolers (1975). Kolers initially

Some caution is needed in interpreting this study. On the one hand the group instruction given to the controls does not represent a very efficient teaching pattern. No particular account of individual

pupil reading needs was taken since pupils read aloud while others followed and general exercises were done from the board. An examination of the results bears out the inefficiency of the methods. The control group's mean score improvement was only 0.57 from 15.79 to 16.26 in word recognition and 1.41 from 8.14 to 9.55 in comprehension which represents very little progress after a fifteen week course of lessons. On the other hand the experimental group's instruction may have provided some reading experience since it includes exercises such as using jumbled words and singular-plural pairs. The difference between the two groups could be explained by their different reading experiences rather than by the training in perceptual exploration. The case for a causal relationship between perceptual exploration and reading progress is yet to be established. A specific focus on subjects scoring low in regulations and in reading seems to be required and more effective teaching strategies and lesson patterns need to be used. Stricter control across the treatment groups over factors such as level of motivation and format of lessons can be exercised, despite the use of ecologically valid setting, the school classroom. However, Elkind's series of studies has added greatly to the developmental explication of perception and suggest that perceptual exploration, directed in part by operational thought, is a capacity called upon in learning to read.

Although there has been no independent replication of Elkind's work, support for his view of the perceptual-cognitive process in reading can be found in some work of Kolers (1975). Kolers initially demonstrated that it is possible to distinguish experimentally the processing of the graphemic aspects of a sentence from the interpreting of the message embodied in those graphemes. Next he compared

matched groups of good and poor readers (with mean age 12.1) upon their ability to encode semantic and graphemic features of sentences. Contrary to some expectations, his results gave no support for the view that impaired reading is the result of a general impairment of language skills. The two groups did not differ in grammatical usage, in memory of what was read or in speed reading improvement. The good readers were better than the poor readers "in their ability to analyse and remember graphemic patterns". Kolars remarks that poor readers' difficulty seems to have a perceptual basis but "at a more cognitive level of performance than is usually measured by tests of visual function....This vague middle ground clearly requires better specification" (p.290). There seems to be a remarkable parallel between this and Elkind's work on perceptual exploration in reading. It seems to be this same "vague middle ground" that Elkind is exploring.

The evidence reviewed in this section suggests that perceptual exploration is a perceptual-cognitive function related to success in reading. The precise relationship of perceptual exploration and operativity (as seriation) in regard to reading requires empirical investigation.

#### Operational Thought and Reading - explaining the link

The empirical evidence reviewed indicates that there is a significant relationship between operativity, especially seriation and perceptual exploration, and reading. It might well be wondered, however, how the processes involved in operativity, as measured through picture observation and object manipulation tasks, are linked to those

involved in a language activity, reading? At first glance it seems to be a rather unlikely predictive combination.

An answer may begin to emerge in regard to perceptual exploration by considering the grapho-phonetic cues children use as they recognise words. The general configuration of letters will obviously be an important cue for many words; "Elephant" and "rhinoceros", for example, have gross features which make them readily distinguished from "ant" and "flea". But there are limits to this strategy. Finer discriminations are required to distinguish "giant" and "great", "house" and "home", and in this, perceptual decentration seems to play an important role.

The parts of words young children used in recognition were studied by Marchbanks and Levin (1965) with a sample of kindergarten and first grade pupils. It was found that the first letter was most important for word recognition, the last letter the next in importance and the letters in between were given least consideration. It seems that children whose perceptual exploration is little developed are more likely to be held by the salient aspects of the word, e.g., the first letter, and will take account of less dominant parts of it with more difficulty. In a similar way, children's perceptual exploration seems to be implicated in their processing of words in a sentence. The child whose perception is centred on the salient words or phrases in a passage, e.g., the first words or best known words, is likely to have difficulty allowing each word to take the weight it was intended to have by the meaning of the sentence.

Attaining the concept of units of print seems to be, in essence, the same process as attaining the concept of a unit of number. If this is so, it would draw upon serial ordering capacity.

A further dimension of the explanation for the link between perceptual exploration and reading is suggested by considering the process a child must use in learning and using decoding skills. Elkind (1975) has argued that the concept of units of reading, e.g., of letters, sounds, words, must be constructed before phonics can be used effectively and that these depend upon perceptual regulations. The child must recognise that a single letter, e.g., "t", can be represented in several different ways - upper or lower case and in various type forms and that "when used in a word one and the same letter can be associated with different sounds (t in to and in the) and one and the same sound can be represented by different letters (sun, son)". The child is thus faced by "problems analogous to those he meets in dealing with figure-ground reversals and schematization of part and whole" (Elkind, 1975, p.540).

Seriation may be seen in many aspects of reading. Piaget (1967) has argued that the unit concept develops as seriation and classification combine. He explains the emergence of the unit of number in terms of operational thought.

A whole number is in effect a collection of equal units, a class whose subclasses are rendered equivalent by the suppression of their qualities. At the same time, it is an ordered series, a seriation of the relations of order. Its dual cardinal and ordinal nature thus results from a fusion of the logical systems of nesting and seriation, which explains why true number concepts appear at the same time as the qualitative operations. (p.53)

Attaining the concept of units of print seems to be, in essence, the same process as attaining the concept of a unit of number. If this is so, it would draw upon serial ordering capacity.

Serialiation also seems to be called upon at other points of the reading task. Reversal of letters, e.g., reading "b" for "d", depends upon the child recognising that the order of the parts makes the critical difference (until learning to read the orientation of objects has not altered their identity). The order of letters within words is the means of distinguishing many frequently confused words such as "saw" and "was". Furthermore, although the sequence of words is usually no necessary cue to their individual recognition, it is a vital cue to the overall meaning, e.g., the "blind Venetian" and the "venetian blind", is he "running for a train", or "training for a run". In addition, not only must the order of print (in space) be grasped but it must be matched with the order of speech (in time). Perhaps the most complex serialiation of all is the multi-dimensional evaluation, one against the other, of all the many parts of a printed message to understand the mind of another person revealed there.

It may, therefore, be seen that a closer examination of the tasks involved in the operativity measures and in reading reveals that the link between the two is not as unlikely as it might at first appear but possesses considerable plausibility.

#### SUMMARY AND RESEARCH IMPLICATIONS

In recognition that reading involves "many of the most intricate workings of the human mind" (Huey, 1908), many recent theoretical models of learning to read have gone beyond behaviourist conceptions with their emphasis upon observable responses and instructional sequence and have sought to examine the learner's internal processing. Psycholinguistic views of Goodman (1970), and Smith (1971) argue that

reading is a decision making activity in which minimal language cues are utilised to determine meaning. Information processing models typically describe the internal mechanisms of attention, perception and memory called upon during reading (e.g., La Berge and Samuels, 1976). The present study proposes a cognitive theory of learning to read in which it is argued that the decision-making processes of the psycholinguistic model and the co-ordination of cognitive activity implicit in information processing views demand an explanation in terms of higher mental processes. It is contended that any explanation of learning to read which overlooks the executive functions of the mind fails to take account of the central and most critical activities of the learner. decision-making process (Goodman, 1969) or as a perceptual search-and-check operation (Clay, 1972) in

It is further argued that, since reading is not a unitary task learnt in a short time but a complex integration of many learnings over a lengthy period of time and a period during which the young child is usually experiencing major changes in his cognitive system, an explanation of learning to read in terms of the child's development is called for. A wide range of evidence from diverse theoretical and practical perspectives provides strong support for a cognitive developmental view of reading. Studies of the strategy usage of good and poor readers have demonstrated - both at the level of letter synthesis to form syllables and words and at the level of word integration to form phrases and extended discourse - that good readers impose structure upon print in a significantly more effective way than do poor readers (Golinkoff, 1976; Ryan, 1979). More precise specification of this strategic operation is suggested by studies of cognitive style in good and poor readers. Poor readers were unable to handle hypotheses and inferences and lacked the conceptual reasoning

capacities possessed by good readers (Serafica and Sigel, 1970).

Another strand of evidence which supports the view proposed and clarifies the nature of the cognitive components of early reading is the study of the young child's concepts of print. The beginning reader's concepts of the nature and purpose of print have shown a consistent and positive relationship to progress in reading. Metacognitive insight into the task seems to be an important aspect of the conceptual reasoning required as a child learns to read.

The naturalistic study of oral reading has led to the description of reading as a psycholinguistic decision-making process (Goodman, 1969) or as a perceptual search-and-check operation (Clay, 1972) in which language cueing systems are used to determine meaning. Although this seems to imply a conceptual reasoning activity, it has been explained as language learning (Goodman, 1969) or as a perceptual task (Clay, 1972) because, it seems, in each case, the automatic processing of reading is believed to be too fast for thought to be its basis. This is an important objection to the cognitive theory proposed here since competent reading clearly does involve a predominance of automatic activity in which thinking plays no apparent part. However, even the most competent reader must occasionally stop to puzzle over and reason about the meaning of a word or passage and certainly must possess that reasoning ability irrespective of how frequently it is called upon. The learning-to-read process is thus likely to be a more revealing place to look for knowledge of the underlying nature of reading and here the evidence gives strong support for the critical importance of conceptual reasoning for reading.

Further explication of the relationships of the automatic and higher order processes in reading is suggested by the reviews of White (1965, 1970) in which he argues that there are two response levels, an automatic or associative level and a decision or cognitive level, which have different developmental histories. The associative level, which can claim responses learnt at the cognitive level, is well established in early childhood but the cognitive level begins or develops markedly in the 5 to 7 age period. Reading seems to be a prime example of this two layered response capacity with much learning initially taking place in the decision zone, being claimed and used by the associative zone but able to be checked at the decision zone as necessary.

It is at about the same time a child learns to read, that White (1965, 1970) notes there is a beginning of, or a marked upsurge in the capacity to use the cognitive level of response, and also during the 5 to 7 age period that Piaget claims there is a major qualitative change in the child's capacity for conceptual reasoning, the concrete operational stage. Piaget's theory and related research provide further explication of the nature of conceptual reasoning which has been shown to have such importance in learning to read. An alternative, perhaps complementary, explanation of both conceptual development and reading progress is expressed in terms of the child's language competence (Donaldson, 1978).

In the series of studies to be reported and discussed, answers will In studies of the three Piagetian infra-logical operations, conservation, classification and seriation, single seriation has exhibited the strongest and most consistent relationship to reading, with both boys and girls from a variety of social class groups assessed

with different predictor and criterion measures (Waller, 1977). There is also evidence that perceptual exploration, the capacity to go beyond the more obvious interpretation of a complex field, is partly isomorphic with logical operations and significantly related to learning to read (Elkind, 1975). At first sight it may seem surprising that a language activity, reading, should relate in this way to picture interpretation and object manipulation tasks. Perceptual exploration seems to be called upon as children need to take account of the less salient parts of the print such as the end or middle of words to determine the meaning (Marchbanks and Levin, 1965) and when they need to know that a letter can be represented by several different graphic shapes or that one letter can represent several different sounds (Elkind, 1975). Seriation seems to be called upon at many points in the reading process, such as when children simultaneously seriate and classify to gain the concept of a unit of print (Piaget, 1967) or when they give different relative weightings to the various parts of a printed message to attain the author's meaning. Above all, both perceptual exploration and seriation seem to be implicated in the conceptual process which it has been argued is the essence of reading. However, the final test of this claim is an empirical one and several major foci for worthwhile further investigation emerge from the need to establish and clarify the cognitive developmental theory of reading proposed.

In the series of studies to be reported and discussed, answers will be sought to the following questions:

1. Will multiple seriation and perceptual regulation, as aspects of conceptual reasoning make separate significant contributions to the variance in reading?

#### STUDY 1. CONCEPTUAL REASONING,

2. Will these two indices of conceptual reasoning show a relationship to reading which is separate from the influence of measures of oral language?

3. Will conceptual reasoning (operativity) exert a causal influence on the beginning reader's awareness of the units of print?

4. Do operativity and oral language develop during the first five years at school in different ways from each other?

5. How do their developmental patterns interrelate with the development of reading during those years?

6. Is operativity a necessary cause of learning to read?

middle childhood (Inhelder and Piaget, 1964). As already discussed,

CHAPTER TWO: Others have investigated the relationship between cognitive operations as identified by Piaget and reading performance. These studies indicate that

STUDY 1. CONCEPTUAL REASONING,  
ORAL LANGUAGE AND READING IN GRADE 4

A battery of Piagetian tests was administered by Lunzer, Dolan and Wilkinson (1976) to grade 1 children soon after they began school and the scores obtained were compared with their word recognition

During the first few years of school the child's higher order processes undergo dramatic development (White, 1965, 1970). The cognitive developmental view of reading which is the basis for this study predicts that these reasoning processes exert a critical influence on learning to read and that this effect may be distinguished from the influence that oral language may have on reading. Although there has been widespread recognition of the importance of oral language in reading during the past decade, there has been little direct study of the part played by reasoning in early reading. It is here contended that this underrates the importance of the mental structuring task children must perform as they learn to read and that any theory of reading which omits the non-language cognitive capacities is incomplete.

30 item size and pattern ordering test, found that, when administered in kindergarten, it predicted

A first concern of the study is how to conceptualize and assess reasoning in a way which gives an index of any effects it might have independent of language skill. The most comprehensive theory of cognitive development, Piaget's, suggests that a number of infra-logical groupings increasingly support the reasoning processes in

middle childhood (Inhelder and Piaget, 1964). As already discussed, some researchers have investigated the relationship between cognitive operations as identified by Piaget and reading performance. These studies indicate that, of the logical operations, classification and seriation possess the strongest relationship to reading.

A battery of Piagetian tests was administered by Lunzer, Dolan and Wilkinson (1976) to grade 1 children soon after they began school and the scores obtained were compared with their word recognition (Schonell) at the end of grade 2. Factor analysis of the Piagetian measures isolated conservation as one variable and classification and seriation (subsequently named "operativity") as another. Operativity correlated .57 with word recognition, with seriation making the strongest contribution towards this. Single seriation (arranging rods in a stair pattern) correlated .45 and multiple seriation (arranging shapes on 3 x 3 matrices) correlated .39. Operativity, and seriation in particular, therefore, appears to be related to word recognition and the result suggests the importance of cognitive operations in the reading process.

Other studies also have examined single seriation in relation to reading. Scott (1970), who used a 30 item size and pattern ordering test, found that, when administered in Kindergarten, it predicted third grade reading results (Iowa Test of Basic Skills) with a correlation of .50. Kaufman and Kaufman (1972), who administered a Piagetian battery of tests in Kindergarten, found that seriation (making a stair from rods) correlated .55 with reading at the end of grade 1, while the whole battery correlated .58. Reviewing these studies Waller (1977)

comments, "clearly these are impressive correlations and seriation is a reasonable place to start for any researcher interested in Piagetian foundations of reading" (p.15).

#### Hypothesis 1: The two components of operativity, perceptual

This is fully consonant with the theoretical rationale presented earlier which has argued that reading is a concept forming task and that seriation is a critical aspect of that task involved throughout the reading process. There are thus strong grounds for using seriation as an index of operational processes in this study.

the two exists and suggests that they may be part of a causal vortex

Perceptual activity or perceptual regulation may also be related to reading performance. Perceptual regulation refers to the capacity to explore a complex visual field so that simple parts are integrated into more complex wholes, and less salient as well as more salient components are taken into account. This capacity undergoes major development in the 5 to 8 year period (Piaget 1969; Vurpillot, 1976). Elkind (1976) has argued that perceptual regulation is called upon to examine systematically the visually complex field of the printed page in reading. The link between perceptual regulation and operativity is difficult to explicate precisely (Vurpillot, 1976) and there has been very little empirical work which has examined the relationship of the two. Piaget (1969) has proposed that perceptual activity is "partially isomorphic" with operational thought and is in part directed by it. However, no study has examined the relationship of seriation and perceptual regulations in regard to reading progress.

The conceptual model of this study predicts that two operative tasks, serial ordering and perceptual activity, are both involved in the cognitive processes required in learning to read. Thus the first is for

assessing this question, a vocabulary test (Peabody Picture Vocabulary

hypothesis is concerned with the link between perceptual exploration and seriation and their relationship to reading performance. These

measures represent a range of language performance including vocabulary

Hypothesis 1. The two components of operativity, perceptual regulation and seriation, each make a significant contribution to the variance in reading.

Although a substantial correlation between higher order mental

processes and reading indicates that an important relationship between the two exists and suggests that they may be part of a causal vortex

it is not sufficient to establish the parsimony of an explanation of reading in terms of the higher mental processes. There may be other

more powerful means of explanation, i.e., simpler and better established variables may explain differences in reading capacity and provide a better basis for improved learning and teaching.

A major current explanation of learning to read holds that it is a language learning task which draws upon the same processes as learning to speak. Oral language capacity is so clearly important to the child's success in reading that any cognitive theory of learning to read must ask whether the process might be described more parsimoniously in terms of the child's language. Indeed, Goodman believes that the most important ability a child brings to the reading task is his oral competence (1970). Perhaps the conceptual processes of reading are language based rather than the product of intellectual activity in some way distinct from language. (National Council for Education

Research, 1973).

To monitor language development and to provide some basis for assessing this question, a vocabulary test (Peabody Picture Vocabulary

Test) and a grammatic prediction test (Grammatic Closure from the Illinois Test of Psycholinguistic Abilities) were chosen. These measures represent a range of language performance including vocabulary knowledge and grammatic construction and cover both language production and reception activities. The Grammatic Closure test, for example, asks the child to complete a spoken sentence orally, on the basis of a picture clue. The second hypothesis of the study, then, is concerned with the relative explanatory power of the language variables, vocabulary and grammatic prediction, and the operative variables, seriation and perceptual regulation, in regard to reading.

Hypothesis 2. Operativity, represented by seriation and perceptual regulation, contributes separately from language, represented by vocabulary and grammatic prediction, to the variance in reading.

#### METHOD

##### Instruments

Measures of reading, language and operativity were needed to test the hypotheses.

1. Reading was assessed by two tests; the St. Lucia Graded Word Reading Test (Andrews, 1969), which is a revision of the widely used Schonell Graded Word Reading Test, and the Reading Comprehension scale of the Progressive Achievement Tests (Australian Council for Education Research, 1973).

2. Language was measured by a vocabulary test, the Peabody Picture Vocabulary Test (Dunn, 1959) and the Grammatical Closure subtest of the Illinois Test of Psycholinguistic Abilities (Kirk, McCarthy and Kirk, 1968).  
 3. Operativity was assessed using the Multiple Seriation Test developed for this project and by the Perceptual Regulations Test (Elkind, 1975).

Measures of the cognitive variables, seriation and perceptual regulations, are not as widely used or as well established as are the tests of language. Since the traits they measure are predicted to be undergoing developmental change during middle childhood, it is necessary to choose tests that match the developmental status of the subjects. To ensure that the tests were appropriate, some preliminary development and research was required.

It was decided to conduct this study with grade four children as subjects. By that grade level, it could be assumed that seriation, perceptual exploration and reading had become relatively stable characteristics and thus the relationships between them were likely to be more distinct.

#### Development of a Test of Seriation

Inhelder and Piaget's work with single seriation (Inhelder and Piaget, 1964) indicates that, by age 6, the greater proportion of children in a European sample could successfully order a series of 10 rods either by a trial and error process or operationally. In a

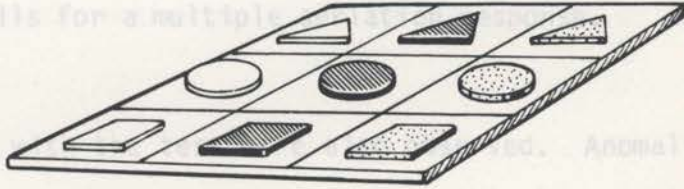
rather sketchy and incomplete discussion of multiple seriation, they indicate that children do not begin to show competence before 7 or 8 years. The task involved ordering 16 or 49 leaves which differed in size on one dimension and in intensity of colour on the other. Lunzer (1970), from a cross-sectional study of Piagetian measures, indicates that single seriation is typically attained by seven years of age and that multiple seriation is attained by a majority of subjects by 9 years.

The Multiple Seriation Test used by Lunzer and Dolan (1977) was first employed in a pilot study but was found unsuitable for several reasons. It was devised by Mackay, Fraser and Ross (1970) for a study of the Harvard and Genevan approaches to cognitive development and was an adaptation of one used by Bruner and Kenney (Bruner, Olver and Greenfield, 1966). Mackay, Fraser and Ross presented subjects with a 3 x 3 matrix board upon which they have, in turn, to arrange three sets of objects (Figure 2.1). For task A, the objects to be placed along one dimension of the matrix vary in shape (squares, circles and triangles) while colour is constant and on the other dimension, colour varies (blue, red and yellow) while shape is constant. For task B, height varies (cylinders) while colour is constant and colour varies (blue, red and yellow) while height is constant. In task C, height (cylinders) varies while diameter is constant and diameter varies while height is constant (Mackay, Fraser and Ross, 1970, p.788).

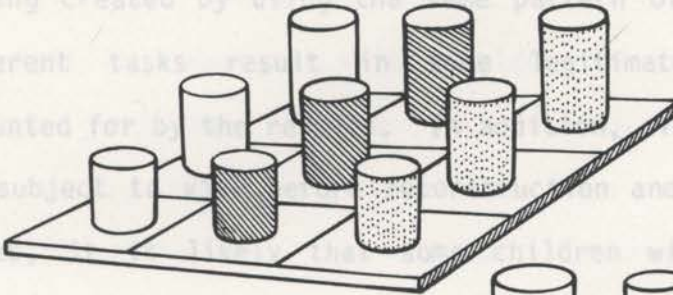
of the study. Firstly, the test is not a true measure of multiple seriation. Only task C involves a genuine multiplication of serial relationships. Task A requires cross classification such that, when the first four pieces are put down, the other pieces must be matched across the board. There is no inherent serial order in either dimension. Task B asks for seriation along one dimension (height) and

colour matching (but not seriation) along the other and is a simple serial matching activity. Task C requires the co-ordination of varying heights on one dimension with varying diameters on the other and is therefore a multiplication of two series. Thus, only one of the three tasks calls for a multiple

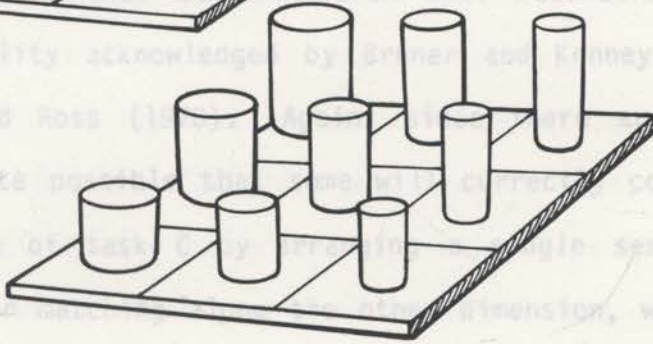
A.



B.



C.



**Figure 2.1.** Earlier Multiple Seriation Test. A. Shape varies, colour constant; colour varies, shape constant. B. Height varies, colour constant; colour varies, height constant. C. Height varies, diameter constant; diameter varies, height constant.

Several difficulties were found with this test and with aspects of the study. Firstly, the test is not a true measure of multiple seriation. Only task C involves a genuine multiplication of serial relationships. Task A requires cross classification such that, when the first four pieces are put down, the other pieces must be matched across the board. There is no inherent serial order in either dimension. Task B asks for seriation along one dimension (height) and

colour matching (but not seriation) along the other and is a simple serial matching activity. Task C requires the co-ordination of varying heights on one dimension with varying diameters on the other and is therefore a multiplication of two series. Thus, only one of the three tasks calls for a multiple seriation response, which overcame these difficulties.

Other problems with the test were also observed. Anomalies in the scoring created by using the same pattern of scores over the three different tasks result in some legitimate responses not being accounted for by the results. In addition, since task A is set up for the subject to view before reconstruction and since it has only nine pieces, it is likely that some children will reconstruct it from memory, a possibility acknowledged by Bruner and Kenney (1966) and Mackay, Fraser and Ross (1970). Again, since there are only nine pieces, it is quite possible that some will correctly construct the multiple seriation of task C by arranging a single series in one dimension and, when matching along the other dimension, will use the correct serial order by chance. No check step is included to prevent a chance correct response being given a full score. Furthermore, Inhelder and Piaget (1964) in their work emphasize the difference between trial and error and operational multiple seriation; the former involves "redundant comparisons" which the latter does not. The test devised by Mackay, Fraser and Ross and used by Lunzer and Dolan makes no distinction between these two qualities of correct placement. Since, however, the subjects used by Lunzer and Dolan were aged 5.6 to 6.0 years and thus surely preoperational on multiple seriation, the distinction between a trial and error and an operational response is probably not significant for that sample.

The test is thus clearly unsuitable for the present study. With considerable modification, it may be used with 5 or 6 year olds, since cross matching and multiple classification seem closely related and perhaps prerequisites of multiple seriation. However, it was necessary to construct another multiple seriation test which overcame these difficulties.

As a final criticism, Mackay, Fraser and Ross' assumption that this test is comparable with Inhelder and Piaget's 7 x 7 or 4 x 4 multiple seriation task is very dubious. Inhelder and Piaget's evidence is, indeed, very weak and their data reporting is quite incomplete. However, they do not state that double seriation is present in the average 7 to 8 year old as Mackay, Fraser and Ross claim (1970, p. 789), but say that the two dimensional seriation starts to emerge at 7 to 8 years (Inhelder and Piaget, 1964, p.27). The challenge to Piaget's theory by Mackay, Fraser and Ross upon the basis that their three tasks show considerable differences in level of difficulty does not stand up to close scrutiny. Inhelder and Piaget do say, of single and multiple classification and seriation, that "all four structures become operational at roughly the same period" (1964, p. 279) but this must surely be interpreted as referring to this general middle childhood period of about 6 to 9 years in contrast to, say, 26 to 29 years or even 2 to 5 years. Inhelder and Piaget have suggested that single seriation emerges at 6 or 7 and multiple seriation begins at 7 or 8 years. Their vagueness on this point is, however, inevitable as their oldest reported subject is only 8.6 years of age and their research on the issue is clearly incomplete. To provide a more valid test of multiple seriation and to avoid the

difficulties of the Mackay, Fraser and Ross measure, it was decided to construct a test which remained closer to Inhelder and Piaget's original work.

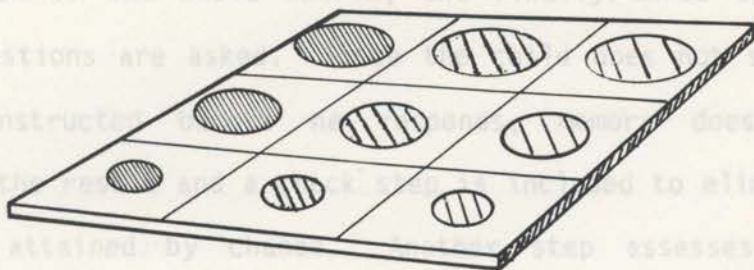
A further important consideration in constructing a test which assesses spontaneous responses is that success will depend in part upon the availability of the structures being tested as well as upon their presence. Research into Piagetian variables has shown a latency of response capacity that can be revealed by retesting a week later (Danner and Day, 1977; Stone and Day, 1978). Responses not available under some cueing conditions may become available under more favourable ones. Although this issue deserves to be the basis for a more extensive investigation, this study sought to provide some opportunity for latent response capacities to be manifest by providing a prompt when the subject is wrong ("Yes, that's a good try. Can you improve upon it?") and a replacement procedure. In the replacement procedure, the child is shown the completed matrix, then is asked to replace pieces taken off as he watches and, finally, is asked to complete the whole task.

Two tasks comprise the test (Figure 2.2). The first, on a 3 x 3 board, requires circles differing in size and density of colour (light, mid and dark blue) to be arranged spontaneously ("where they belong") and then requires a choice on the basis of two dimensions simultaneously combined ("which piece is bigger and darker than this one?").

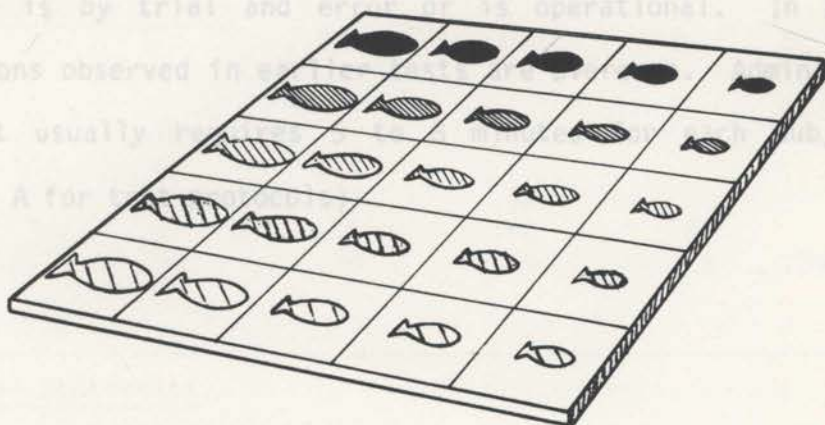
The second test, on a 5 x 5 board, first asks children spontaneously to construct a matrix (by simultaneously arranging fish

from bigger to smaller and from darker to lighter). Next, a replacement procedure (of 4, 8, 12 pieces) is employed, then reproduction of the whole matrix, and finally, three two-dimensional

A.



B.



Reliability of the Test. There has been some questioning of

Figure 2.2. Multiple Seriation Test. A. size varies, colour constant, size constant, depth of colour varies. B. size constant, depth of colour varies; size varies, depth of colour constant. Children have to place the pieces on the board simultaneously using two cues; size (bigger-smaller) and density of colour (darker-lighter).

Two tasks comprise the test (Figure 2.2). The first, on a 3 x 3 board, requires circles differing in size and density of colour (light, mid and dark blue) to be arranged spontaneously ("where they belong") and then requires a choice on the basis of two dimensions simultaneously combined ("which piece is bigger and darker than this one?").

The second task, on a 5 x 5 board, first asks children spontaneously to construct a matrix (by simultaneously arranging fish

from bigger to smaller and from darker to lighter). Next, a replacement procedure (of 4, 8, 12 pieces) is employed, then reproduction of the whole matrix, and finally, three two-dimensional choice questions are asked. Since the child does not see the 3 x 3 matrix constructed before he responds, memory does not unduly influence the result and a check step is included to eliminate correct responses attained by chance. Another step assesses whether the response is by trial and error or is operational. In these ways, limitations observed in earlier tests are overcome. Administration of the test usually requires 5 to 8 minutes for each subject. (See Appendix A for test protocols)

Mean  $r = .738$

#### Item-Total Statistics

Reliability of the Test. There has been some questioning of whether Piagetian measures, originally used in an informal clinical situation, can be objectively administered and demonstrated as reliable.

The critical point for establishing objectivity is in tester capacity to judge whether the basis of a response is trial and error or operational thought since the arrangement of the pieces is the same for each answer. A trial and error response involves "redundant comparisons", while an operational one does not. A tester and an observer independently scored data for 20 nine- and ten-year-old subjects, a task involving 80 decisions (4 for each subject) of whether a response was operational or trial and error. Agreement was found in 71 of the 80 cases (89%) which was considered an index of adequate

inter-judge reliability. Additional data pertaining to the reliability of the multiple seriation Test (for 49 girls and 51 boys in Grade 4) are presented in Table 2.1.

Table 2.1. Reliability Data for Multiple Seriation Test

N=100, Mean = 15.57 SD = 4.77

Inter Item Correlations

	1	2	3	4	5	6
1						
2	.19					
3	.48	.25				
4	.31	.34	.56			
5	.37	.19	.63	.54		
6	.38	.38	.44	.28	.35	

Mean  $r = .38$

Item-Total Statistics

	Scale Mean if item deleted	Scale Variance if item deleted	Corrected Item-Total Correlation	Alpha if item deleted
1	13.23	15.19	.51	.72
2	13.66	21.50	.35	.77
3	11.62	11.01	.70	.67
4	12.42	17.36	.56	.71
5	13.42	17.78	.63	.71
6	13.51	16.64	.49	.73

Alpha = .76

Correlations among the six items of the test were generally moderate, ranging from .19 to .63. Corrected item-total correlations ranged from .35 to .70 and the alpha reliability of the measure was .76. The reliability of the test was thus considered to be satisfactory and this phase of the study indicates that a Piagetian measure of multiple seriation can be administered objectively and provide reliable data for grade 4 primary pupils.

## Suitability of the Perceptual Regulations Test

Of the various measures used to assess the child's increasing perceptual control, Elkind's Perceptual Regulations Test seems to have had the most use and to be suitable for the present study (See Appendix B). The test is in two parts, with seven items of Perceptual Integration (which require the child to identify parts and wholes made from those parts, e.g., pieces of fruit making an animal) and seven items of Perceptual Ambiguity (which require the child to identify an obvious and a less obvious form in the same figure, e.g., a tree and a swan). The drawings are capable of nearly infinite variations of difficulty level. Elkind's studies (Elkind, Kogler and Go, 1964; Elkind and Scott, 1962;) indicate that the greatest change in perceptual regulation occurred in the 6 to 8 year period and suggests that this perceptual exploration is relatively stable at 9 years. However, are the age limits established by Elkind a function of the difficulty level of the test items? Perhaps a more difficult test would show a mastery of perceptual regulations at a later age. In other words, is there a genuine developmental surge in perceptual exploration during middle childhood or are the response levels the result of the difficulty of the input material? To examine this question and to help determine the time when perceptual exploration becomes stable, a new set of stimulus pictures was devised. As in Elkind's original materials, they were divided into two parts; 7 items of Perceptual Integration and 7 items testing Perceptual Ambiguity. However, in the new form of the test (see Figure 2.3), the items were deliberately made more difficult, as comparison of the tests shows. (See Appendix C for complete test with protocols)

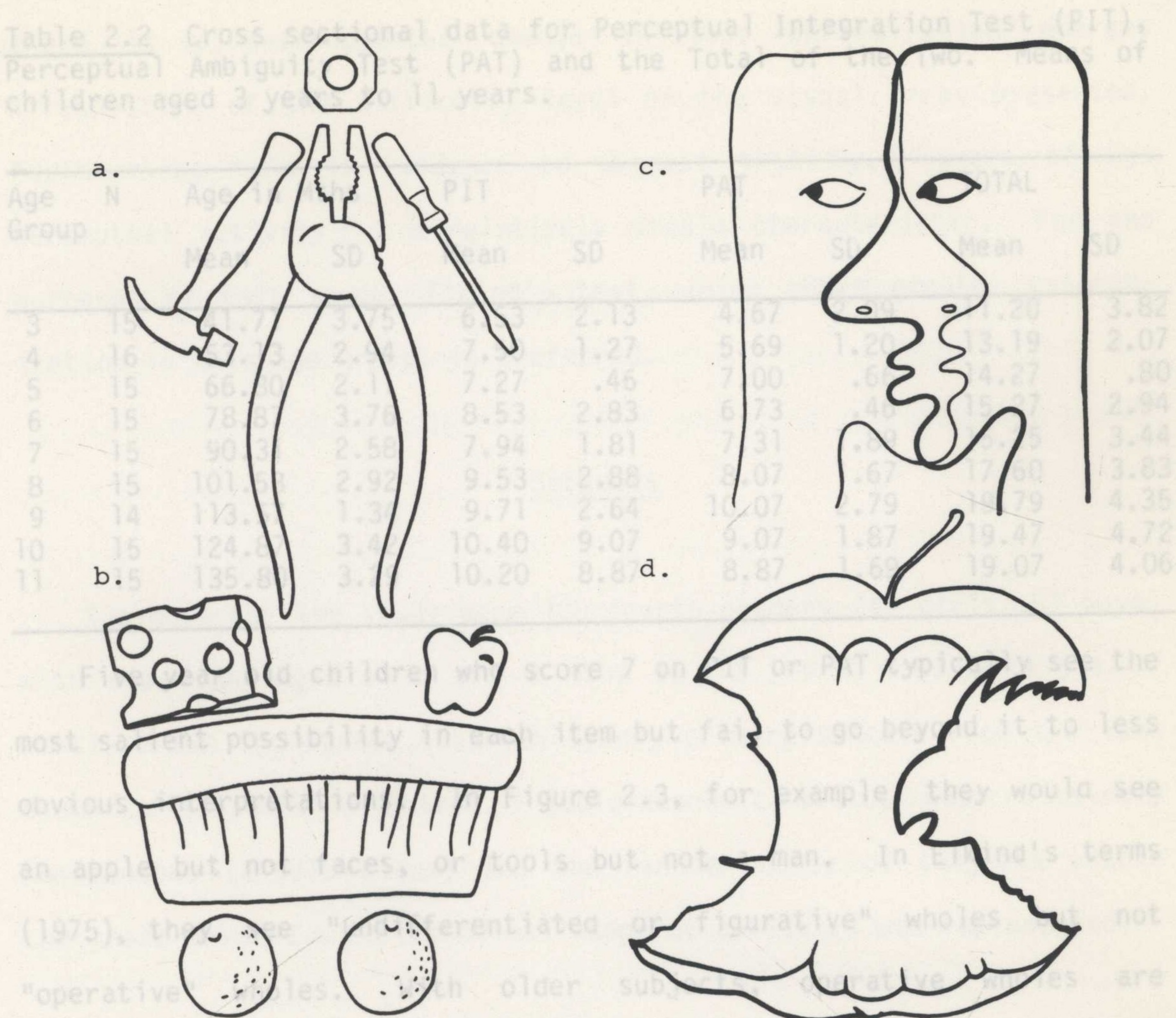


Figure 2.3 Sample Items from the New Perceptual Regulations Test Devised for this study; Perceptual Integration Test (PIT) a and b. Perceptual Ambiguity Test (PAT) c and d.

This new test was administered to a sample of 136 children aged 3 to 11 years by trained research assistants naive to the purposes of the study. The reliability (coefficient alpha) of the new measure, .86 for Perceptual Integration, .75 for Perceptual Ambiguity and .87 for the total test, was deemed satisfactory. A summary of means and standard deviations is provided in Table 2.2. The means are markedly lower than for Elkind's test (Elkind, Kogler and Go, 1964; Elkind and Scott, 1962) because the test is harder. However, there is a gradual increase in scores with age and a tendency to plateau at 5, 6 and 7 years, with a distinct levelling of the increase after 9 years of age.

Table 2.2 Cross sectional data for Perceptual Integration Test (PIT), Perceptual Ambiguity Test (PAT) and the Total of the Two. Means of children aged 3 years to 11 years.

Age Group	N	Age in Mths		PIT		PAT		TOTAL	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
3	15	41.71	3.75	6.53	2.13	4.67	2.09	11.20	3.82
4	16	53.13	2.94	7.50	1.27	5.69	1.20	13.19	2.07
5	15	66.80	2.11	7.27	.46	7.00	.66	14.27	.80
6	15	78.87	3.76	8.53	2.83	6.73	.46	15.27	2.94
7	15	90.31	2.58	7.94	1.81	7.31	1.89	15.25	3.44
8	15	101.53	2.92	9.53	2.88	8.07	1.67	17.60	3.83
9	14	113.57	1.34	9.71	2.64	10.07	2.79	19.79	4.35
10	15	124.87	3.42	10.40	9.07	9.07	1.87	19.47	4.72
11	15	135.80	3.29	10.20	8.87	8.87	1.69	19.07	4.06

Five year old children who score 7 on PIT or PAT typically see the most salient possibility in each item but fail to go beyond it to less obvious interpretations. In Figure 2.3, for example, they would see an apple but not faces, or tools but not a man. In Elkind's terms (1975), they see "undifferentiated or figurative" wholes but not "operative" wholes. With older subjects, operative wholes are described but the greater difficulty of the test items means that scores do not increase as much as they did for Elkind's original items. Elkind's test provides greater differentiation in the 7 to 11 age group. The correlation of the two parts of the test, which was .57, suggests that, although related, the two parts complement each other as predictors.

In conclusion, it is clear that, despite the greater difficulty of the test, children showed marked improvement in their ability to go beyond the most salient impression of a complex visual field and see operative wholes during the 5 to 9 year period. That the same trend of increase occurs despite the lower means, confirms the view that

there is a developmental change in this period which emerges irrespective of the difficulty level of the visual array presented. Furthermore, this is evidence to suggest that by 9 years of age, perceptual activity is a relatively stable characteristic. For the purposes of this study, Elkind's test, which shows greater discrimination in this age group, is preferred. (Im and Tuccy, 1976). This is well suited for comparing the effects of groups of predictor variables upon a criterion.

### Subjects

Subjects for the study were 100 fourth-graders (49 girls, 51 boys) with ages ranging from 8 yrs 9 mths to 10 yrs 7 mths (M=9 yrs. 7 mths), drawn from three suburban Sydney primary schools from the same district (Sutherland Shire). Socio-economic status was relatively homogeneous (middle class) and the random choice of subjects within the grade ensured that the normal range of abilities was represented.

	Boys (n= 51)			Girls (n = 49)			TOTAL (n = 100)		
	Mean	SD	Skew	Mean	SD	Skew	Mean	SD	Skew
<u>Measurement Procedure</u>									
Age in mths	108.78	4.16	-.36	109.00	4.85	.92	108.89	4.50	.42
*Word Recognition	44.04	13.95	.45	49.52	14.88	.13	46.70	14.50	.30
*Reading Comprehension	16.96	7.70	.22	20.18	8.56	.09	18.54	8.26	.20
Integration	15.86	4.90	-.47	15.98	4.07	-.47	15.92	4.49	-.48
Ambiguity	12.43	2.98	.01	13.55	3.13	.13	12.98	3.09	.10
Regulations	27.90	6.99	-.14	29.35	6.36	-.17	28.61	6.70	-.18
Seriation	15.14	4.46	-.41	16.31	4.82	-.56	15.72	4.65	-.45
Closure	29.71	2.21	-.57	30.39	1.87	-1.23	30.04	2.07	-.86

All tests were administered in June and July, 1978. The group test, Reading Comprehension, was administered to approximately 30 subjects at a time by the researcher and an assistant in the classroom. Desks were arranged in rows and screens were used to prevent copying. The individual tests, Word Recognition, Perceptual Regulations, Grammatic Closure and Vocabulary, were administered by a team of undergraduate research assistants trained by demonstration and practice until a criterion level of competence determined by the researcher was attained (usually after 4 or 6 practice administrations). Multiple seriation was administered by the researcher who

was deliberately kept ignorant of the subjects' reading scores. boys and girls except in reading.

#### Analysis of Data

Means, standard deviations and simple correlations were computed using SPSS programmes (Nie, Hull, Jenkins Steinbrenner and Bent, 1970). The SPSS Supplement Regression was used for the backward regression procedures (Cohen, Foster, Helm and Tuccy, 1976). This is well suited for comparing the effects of groups of predictor variables upon a criterion.

The simple correlations of all measures are presented in Table 4.

The two parts of Perceptual RESULTS is (PR), Perceptual Integration (PIT) and Perceptual Ambiguity (PAT) are shown with the total in the

The means, standard deviations and skew of all tests for boys, for girls and for the total sample are shown in Table 2.3. An analysis was also made of set differences for all the measures.

Table 2.3. Means, Standard Deviations and Skew of All Measures.

	Boys (n= 51)			Girls (n = 49)			TOTAL (n = 100)		
	Mean	SD	Skew	Mean	SD	Skew	Mean	SD	Skew
Age inMths	108.78	4.18	-.36	109.00	4.85	.92	108.89	4.50	.42
*Word Recognition	44.04	13.95	.45	49.52	14.88	.13	46.70	14.50	.30
*Reading Comprehension	16.96	7.70	.22	20.18	8.56	.09	18.54	8.26	.20
Perceptual Integration	15.86	4.90	-.47	15.98	4.07	-.47	15.92	4.49	-.48
Perceptual Ambiguity	12.43	2.98	.01	13.55	3.13	.13	12.98	3.09	.10
Regulations	27.90	6.99	-.14	29.35	6.36	-.17	28.61	6.70	-.18
Total Multiple Seriation	15.14	4.46	-.41	16.31	4.82	-.56	15.72	4.65	-.45
Grammatical Closure	29.71	2.21	-.57	30.39	1.87	-1.23	30.04	2.07	-.86
Vocabulary	84.18	9.22	2.05	81.78	7.86	.34	83.00	8.63	1.43

\*  $p < .05$  for the difference between boys and girls

There are no significant differences in means between boys and girls except in reading where for both word recognition and comprehension, girls scored significantly higher than boys ( $p < .05$ ). The skew of the distributions was not considered sufficient to warrant any adjustment of results except for Peabody Picture Vocabulary Test which was recoded on a stanine scale before the correlations and multiple regressions were computed.

The simple correlations of all measures are presented in Table 4. The two parts of Perceptual Regulations (PR), Perceptual Integration (PIT) and Perceptual Ambiguity (PAT) are shown with the total in the same table.

Table 2.4 Intercorrelations of All Variables

Boys' (n=51) and Girls' (n = 49) results are shown below the diagonal and those of the whole sample (n=100) above it.

	Word Rec	Comp	PIT	PAT	PR	MSer	GrCl	Vocab
Word Recognition		<u>.74</u>	<u>.33</u>	<u>.37</u>	<u>.42</u>	<u>.49</u>	<u>.51</u>	<u>.45</u>
Comprehension B	.67							
Comprehension G	<u>.78</u>		<u>.36</u>	<u>.36</u>	<u>.43</u>	<u>.56</u>	<u>.55</u>	<u>.46</u>
Perceptual Integration B	.33	.30						
Perceptual Integration G	<u>.36</u>	<u>.46</u>		<u>.47</u>	<u>.91</u>	<u>.33</u>	<u>.18</u>	<u>.26</u>
Perceptual Ambiguity B	.24	.16	.49					
Perceptual Ambiguity G	<u>.43</u>	<u>.49</u>	<u>.48</u>		<u>.76</u>	<u>.37</u>	<u>.17</u>	<u>.13</u>
Perceptual Reg. Total B	.37	.31	.92	.70				
Perceptual Reg. Total G	<u>.45</u>	<u>.55</u>	<u>.90</u>	<u>.81</u>		<u>.41</u>	<u>.24</u>	<u>.25</u>
Multiple Seriation B	.52	.52	.54	.43	.59			
Multiple Seriation G	<u>.43</u>	<u>.58</u>	<u>.08</u>	<u>.27</u>	<u>.19</u>		<u>.44</u>	<u>.24</u>
Grammatical Closure B	.53	.45	.13	.05	.18	.39		
Grammatical Closure G	<u>.45</u>	<u>.64</u>	<u>.26</u>	<u>.27</u>	<u>.30</u>	<u>.48</u>		<u>.30</u>
Vocabulary B	<u>.42</u>	<u>.53</u>	<u>.24</u>	<u>.11</u>	<u>.24</u>	<u>.35</u>	.41	
Vocabulary G	<u>.54</u>	<u>.47</u>	<u>.29</u>	<u>.20</u>	<u>.29</u>	<u>.18</u>	<u>.23</u>	

Word Recognition (St. Lucia) and Reading Comprehension (Progressive Achievement Test) are quite highly correlated (.74) despite the different methods of measurement involved (individual oral response vs group pencil and paper). They seem to be measuring similar, closely related, capacities. The two parts of the Perceptual Regulations test, PIT and PAT, are correlated more strongly with one another (.47) than with any other measure. Of the other independent variables, Perceptual Regulations is more closely related to the other measure of operativity, Multiple Seriation (.41), than to the language variables (.24 and .25). The construct validity of Multiple Seriation is strengthened by its relationship to the better established Piagetian variable, Perceptual Regulations. This gives empirical support for the grouping of Perceptual Regulations and Multiple Seriation as one block in the regression analysis.

Vocabulary (PPVT), which is moderately correlated with all independent variables, is most strongly related to grammatic prediction (.30), its parallel language measure. This gives support for grouping the two language measures as one block in the regression analysis. Grammatic Closure and Multiple Seriation share considerable common variance, being more strongly correlated (.44) than either is with its operative or language pairing (.41, .30). There seems to be considerable overlap of operativity and language. Yet the variance each shares with the dependent variables is, in every case, greater than their common variance and so, at first glance, each is independent to some degree in its relationship to reading.

Grammatic				.00
Closure	.26	.00	.23	.00
Vocabulary	.22	.02	.26	.00

The separate correlations of scores for boys and girls are all positive and significant and do not seem to reveal any marked pattern of difference (Table 2.4). It has been found that each predictor contributes significantly to the variance with reading and the grouping of both predictor pairs to form operativity and oral language is given support. However, the construct validity of all independent variables and their relationships require further analysis and especially longitudinal testing.

A multiple regression analysis was used to test the independence of the contribution of each predictor and of each predictor grouping to reading. The beta weights for the multiple regression of criterion variables on all predictor variables are shown on Table 2.5.

Table 2.5 Beta Weights for the Regression on Perceptual Regulations, Multiple Seriation, Grammatic Closure and Peabody Picture Vocabulary Test of Word Recognition (St. Lucia) and Reading Comprehension (Paragraph Understanding Test) (All variables entered simultaneously.)

	Word Recognition		Reading Comprehension	
	$\beta$	Sig of F to enter or remove	$\beta$	Sig of F to enter or remove
Perceptual Regulations	.20	.02	.18	.03
Multiple Seriation	.28	.00	.30	.00
Grammatic Closure	.26	.00	.29	.00
Vocabulary	.22	.02	.26	.00

The effects of omitting operativity and Language from the full regression equation are shown in Table 2.6.

Table 2.6 Regression of Word Recognition and Reading Comprehension on Operativity (Perceptual Regulations and Multiple Seriation) and Language (Grammatical Closure and Vocabulary) Measures Showing the Effects of Omitting Operativity and Language from the Equation.

	Word Recognition	Reading Comprehension
Total R	.67	.72
R <sup>2</sup>	.45	.52
Adj R <sup>2</sup>	.42	.50
R of Language with Operativity forced out	.59 <sup>xx</sup>	.63 <sup>xx</sup>
R of Operativity with Language forced out	.54 <sup>xx</sup>	.61 <sup>xx</sup>

Note. xx ( $p < .01$ ) = significance of omitting the variable from the full model. Adj R<sup>2</sup> = R<sup>2</sup> adjusted to eliminate any chance effects which may inflate the value.

Hypothesis one, that the operativity measures, Perceptual Regulations and Seriation, each make a significant independent contribution to the variance in reading is borne out by the regression data. From Table 2.5 it may be discerned that, when all variables are entered into the equation with Word Recognition, the beta weight of Perceptual Regulations is .20 ( $p < .05$ ) and of Multiple Seriation is .28 ( $p < .01$ ). When all variables are entered with Comprehension, the beta weight of Perceptual Regulations is .18 ( $p < .05$ ) and of Multiple Seriation is .30 ( $p < .01$ ). Perceptual Regulations and Multiple Seriation thus seem to measure distinct (though related) variables that might be described as "operativity". Similarly the language variables, Vocabulary and Grammatical Closure, also make distinct and significant contributions to the regression on both reading measures (Table 2.5) and seem to be a suitable choice of measures to represent language effects.

The multiple regressions of Operativity on Word Recognition and Reading Comprehension are .54 and .61 respectively (Table 2.6), and thus operativity controls 29% of the variance in Word Recognition and 36% of the variance in Comprehension. It may, therefore, be seen that operativity bears a substantial relationship to reading in this sample of nine year olds and may be an important explanatory variable. But it might be objected that this relationship is better explained by intelligence as assessed by an I.Q. test. A non-reading test of intelligence is required to assess this possibility. The results in Table 2.5 show that a commonly used non-reading measure of intelligence, Peabody Picture Vocabulary Test has a lower beta value to enter the equations (.22, .26) than just one of the reasoning measures, multiple Seriation (.28, .30). It clearly controls less variance than does operativity and, at least for this measure of I Q, the contribution of operativity to reading is distinct from intelligence.

The results give empirical support for the construct validity of operativity. The final question to be asked of the data arises from hypothesis two, whether the effects of operativity on reading may be separated from the effects of oral language on reading. This hypothesis is supported by the multiple regression analysis. The programme first entered all variables into the equations which produced a multiple correlation with Word Recognition of .67 and with Comprehension of .72. The two variables grouped as operativity (Perceptual Regulations and Multiple Seriation) were then forced out of the equation reducing the multiple correlation from .67 to .59 ( $P < .01$ ) for Word Recognition and from .72 to .63 for Reading Comprehension ( $P < .01$ ). The significant reduction in each case indicates that, although operativity and

language share common variance with reading, a considerable part of the variance in reading is explained by operativity independent of language. The two language variables were also forced out of the full equation and the multiple correlation was reduced from .67 to .54 ( $P < .01$ ) with Word Recognition and from .72 to .61 ( $P < .01$ ) with Comprehension. Language explains a considerable portion of the variance in reading which operativity does not explain.

In regard to the cognitive theory of reading being investigated, the data does not allow any comment on the relative effects of operativity and oral language on reading since their separate contributions are nearly equal (though partially independent) and there can be little doubt that these relationships are complex.

rights, even with all four variables in the regression equation, are significant. This suggests that the newly emerging higher order mental processes of middle childhood play an important role in reading achievement. It is doubtful that this can be explained as a reflection of general

#### DISCUSSION

The results give empirical support for the construct validity of operativity (Perceptual Regulations and Seriation) and language (Grammatical Closure and Vocabulary) as predictor variables of reading. Although all are intercorrelated, Perceptual Regulations is more strongly related to its operativity partner, Seriation, than it is to either of the language variables. Vocabulary is more strongly related to its language partner, Grammatical Closure, than it is to either of the operativity variables. Each measure contributes significantly to the variance in reading. The strength of the relationship between Seriation and Grammatical Closure ( $r = .44$ ) indicates a significant degree of overlap in mental and language functioning. This is the more interesting because the two tasks contrast sharply; Grammatical

Closure requiring oral sentence completion from stimulus drawings, Multiple Seriation requiring the placement of objects on a form board. Although the results indicate that each makes a distinct contribution to the variance in reading, this correlation means that the separation of their effects in multiple regression is more difficult and requires some caution. considerable care about interpreting these results in causal terms. A correlation in itself is a des. In regard to the cognitive theory of reading being investigated, the data accord with the hypotheses advanced. The first hypothesis, that the two components of operativity, perceptual regulations and seriation, each make significant independent contributions to the variance in reading, is supported, since their beta weights, even with all four variables in the regression equation, are significant. This suggests that the newly emerging higher order mental processes of middle childhood play an important role in reading achievement. It is doubtful that this can be explained as a reflection of general intelligence in the sense of an I.Q., score since one commonly used non-reading test of I.Q. (Peabody Picture Vocabulary Test) does not control as much of the variance as does operativity. causal directions in the relationships.

The most important finding of this study is concerned with hypothesis two, that conceptual reasoning contributes to the variance in reading separately from oral language. This is supported. The executive functions of the mind, conceptual reasoning, as defined by operativity are involved in reading at grade four in a way which is partly distinct from language. Oral language is clearly an important underlying process called upon in reading but in itself it does not seem to be an adequate explanation of reading. At least with this

sample and on the basis of these measures, reading is an intellectual activity which in some degree is distinct from language. Thus it is possible that the higher mental processes may be a necessary although not a sufficient explanation of reading.

There is, however, need for considerable care about interpreting these results in causal terms. A correlation in itself is a descriptive statistic and conveys no information about the causal direction of an association. Nevertheless, a correlation does help identify promising variables which deserve further study in an attempt to establish causal relationships. Perhaps operativity is an important cause of reading success or perhaps the child's reading has been a stimulus to the development of operative processes. The perceptual activity of exploring words and sentences and the ordering of sounds, words, phrases and sentences into a meaningful whole may well develop higher levels of perceptual regulation and multiple seriation. Perhaps a certain level of operativity is called for at first after which there is an interaction of developmental influence. Longitudinal study is required to illuminate the causal directions in the relationships.

The reading task seems to call for this breaking down of wholes into parts and combining component units into a comprehensive

The specific responses of some children seem to give insight into qualitative aspects of the developmental process and suggest how evidence suggests that poor readers do not perform this perceptual regulation and multiple seriation may be involved in the reading task. In an informal preliminary trial of the Perceptual

Integration Test a nine year old poor reader was presented the item in which pieces of fruit are arranged to form an animal (See Appendix B, PIT Item 3). He looked intently and reported seeing fruit only.

Although adults and most nine year olds easily see fruit and an animal, he failed to report the integrated whole even when prompted. "Do you see anything about the way they are arranged?" "Sort of one after the other like that," he responded moving his finger across the animal configuration. "And do they make anything when they are one after the other like that?" He screwed up his face and shook his head. "No just fruits, one after the other like that", pointing with his finger again. Adults tend to assume that school children perceive the same visual world that they do. Vurpillot (1976) draws upon a wide range of evidence to show that this assumption is often wrong. Not until the 6 to 8 year period does the child's perceptual construction of the world lose much of its earlier rigidity. The child can now break down wholes into smaller parts, can abstract certain of their features and focus on one part while disregarding the others.

Equally, different perceptual units can be combined, each one serving as a whole to the smaller units of which it is composed and, at the same time, as a component part of the comprehensive structure. (Vurpillot, 1976, p. 31)

The reading task seems to call for this breaking down of wholes into parts and combining component units into a comprehensive structure, e.g., letters into words, words into sentences. The

The qualitative differences in children's responses to multiple evidence suggests that poor readers do not perform this perceptual activity as well as good readers. Those who scored highest typically surveyed the pieces set out on the table in random order and instantly

Another child, an 8 year old, was presented with a perceptual ambiguity item in which negative and positive aspects of a drawing form different images; the outline of the leaves of a tree make four

face profiles (See Appendix B, PAT Item 3). He saw the tree, then with some doubt said, "A face." When asked where the face was, he slowly ran his finger around the outline of the most obvious profile and then on to the next, his face lighting up in recognition as he announced, "Aha.... another face". His finger continued to follow the outline...."Four faces". It seemed that his finger had guided his eyes to do something more mature perception would do unaided. Up to the age of about 7, Vurpillot (1976) reports, the child's perceptual exploration of a complex field continues to become more systematic and effective. It is the intellectual processes which guide and limit the scope of perceptual exploration being themselves in turn affected by it, since perceptual exploration provides much of the substance of intellectual activity (Vurpillot, 1976, p.276).

In reading, the child seems to be called upon to shift his perceptual and mental focus from one possibility to another in a way analogous to the positive and negative perceptual switch required in this kind of item. For example, one letter or combination of letters often represents two or more sound possibilities such as, "a" in "cat" and "away" or the same speech sound is represented by different letters, "no" and "know", "sun" and "son".

The qualitative differences in children's responses to multiple seriation are also instructive. Those who scored highest typically surveyed the pieces set out on the table in random order and instantly seemed to recognise the relationship of the two dimensions. They then usually chose the biggest and darkest pieces for the top corner and systematically placed all the colour in order across the board before

beginning with the next colour and so, with no hesitation or redundant comparisons, completed the whole matrix. They recognised that the two dimensional problem of the placement of the pieces is resolved by simultaneously performing the two seriations. It is as though their mental construction of the final pattern is so strong that there is no need for perceptual checking as they place the pieces on the board, i.e., in Piaget's terms, they are "operational" in this task. Most children, however, respond to greater or lesser degrees in a trial and error fashion, comparing and adjusting the placement of pieces. Some endlessly move pieces around the board, not seeming to understand the relationships of the task at all and never getting it right.

Reading seems to be the creation of a very complex seriation of meaning well described by E.L. Thorndike in 1917 when he argued that reading is a very elaborate procedure which involves; a weighing of each of many elements in a sentence, their organisation in the proper relations one to another, the selection of certain of their connotations and the rejection of others, and the co-operation of many forces to determine final response (p.323). The bases for this elaborate seriation are the concepts, rules and principles which enable the grapho-phonetic, syntactic and semantic cues to be applied to the printed page.

This is rather like the activity which the child performs to solve the multiple seriation puzzle described above. Pieces are selected according to the overall conception of the problem, then checked and confirmed, typically by trial-and-error processes, to determine the solution. Reading, then, is a multi-dimensional seriation of language

in which a wide array of cues interact and are transformed to produce a message which is not the sum of the parts but a multiple of them all. This conception of reading is consonant with Goodman's description developed from his psycholinguistic theory and his study of oral reading miscues.

It seems unlikely in view of the considerable and significant

contribution of reading. Reading printed words then is a spiral of predict, sample, select, guess and confirm activities....The proficient reader uses the least amount of information to make the best possible first guesses...No single cue or system of cues in fact is useful in reading unless it is processed in its relationship to all other cues in a natural language setting. (Goodman, 1973, p. 295)

A study of this kind is that conclusions must be drawn upon the basis of

one. In multiple seriation, the child who is able to form a strong mental construction of the whole, i.e., is "operational", does not need to check perceptually where each individual part should go. This seems to explain Kolers' conclusion (Kolers, 1969) from an analysis of adult reading errors that "reading is only incidentally visual". Adults (and competent children) have become "operational" in their performance of the multi-dimensional seriation of reading and so use a minimum of perceptual cues.

One specific effect of a one-testing study is that a lesser level of In sum, the study does provide evidence for the cognitive developmental view that higher mental processes are partly distinct from oral language in their relationship with reading. However, there are limitations which must qualify the conclusions and which suggest aspects of the work requiring further investigation.

comparatively little use. Although their validity and reliability is

sat. One limitation of the study is the restricted number of operative and language tests used as independent variables. Although each

measure has demonstrated its explanatory value and so justified its inclusion, no data of this kind can ever be complete. However, the choice of variables has been made upon the basis of careful theoretical and empirical analysis and those used seem to be the most suitable for the task. That other measures would alter the findings significantly seems unlikely in view of the considerable and significant contribution each makes independently to the variance in reading. Replication of the results is nevertheless required. *ear period is the increased effect of metalinguistic and metacognitive processes on learn*

A further limitation upon the interpretation of findings in a study of this kind is that conclusions must be drawn upon the basis of one measurement of variables and an examination of an extended pattern of relationships is not possible. Data collection at one observation period can never afford the insight into process that the examination of trends over many testings gives. Longitudinal study of these variables is required to allow something of the dynamic and complexity of developmental change to be revealed in order to find not only 'who ends up where' but also 'how they got there'.

One specific effect of a one-testing study is that a lesser level of construct validity can be ascribed to the variables, especially those that depend on less well-established tests. The strength of the relationships found depends critically on the strength of the measures used. This is especially important for the cognitive variables Perceptual Regulation and Multiple Seriation which have had comparatively little use. Although their validity and reliability is satisfactory in this study, are they reliable and valid with extended testing over a number of years? Do they show the dramatic change it

is expected they will in the 5 to 8 years period when applied to the same children over that time, i.e., in a longitudinal rather than a cross-sectional study? What will the pattern of relationships over an extended time period show about the dynamics of the development of language, reasoning and reading? These questions are investigated in a study spanning five years reported in Chapter 4.

One aspect of the changes during the 5 to 8 year period is the increased effect of metalinguistic and metacognitive processes on learning. Awareness of the nature of language seems to play a prominent part in early reading. This is commonly interpreted as an aspect of the influence of language on reading but it may also be an effect of higher reasoning processes. This issue is the subject of the next study.

cross his name, "PETER", printed on his playgroup painting and pronounced, "Pe-ter, Gor-don Mey-ers", he showed considerable awareness of the functions and purposes of written language. He realised that print provides clues for reading and that components of his printed name in some way represent speech sounds. However, the nature of the units of which print is composed and the one-to-one correspondence of their visual and auditory elements were yet to be grasped. This chapter will review theory and research on attaining concepts of the units of print and will present evidence which tests a cognitive developmental view of this task.

The units of print are a particularly difficult constellation of concepts for the child to grasp. Even after a year's reading instruction school beginners did not reliably distinguish a word, a letter and a sentence (Reid, 1966; Downing, 1970). Part of the difficulty of

CHAPTER THREESTUDY 2. COGNITIVE DEVELOPMENT AND UNITS OF PRINTIN EARLY READING

Print is composed of basic units such as letters, syllables, words, and sentences. Forming concepts of the units of print seems to be an aspect of the young child's language awareness which is critical in learning to read. When three years old Peter ran his finger haphazardly across his name, "PETER", printed on his playgroup painting and pronounced, "Pe-ter, Gor-don Mey-ers", he showed considerable awareness of the functions and purposes of written language. He realised that print provides clues for reading and that components of his printed name in some way represent speech sounds. However, the nature of the units of which print is composed and the one-to-one correspondence of their visual and auditory elements were yet to be grasped. This chapter will review theory and research on attaining concepts of the units of print and will present evidence which tests a cognitive developmental view of this task.

The units of print are a particularly difficult constellation of concepts for the child to grasp. Even after a year's reading instruction school beginners did not reliably distinguish a word, a letter and a sentence (Reid, 1966; Downing, 1970). Part of the difficulty of

the task seems to be that the unit of reading, chameleon-like, takes so many different forms in different situations. Sometimes the unit might be a letter, or a group of letters, while at other times it might be a word or a phrase or a sentence. Furthermore, the phonemic elements of speech are particularly difficult to identify. Although spoken words have acoustic peaks which help the child form syllables (Peter did this quite well), there are no acoustic criteria for distinguishing phonemes (Liberman, Shankweiler, Fischer and Carter, 1974) and, even when the phonemic elements of speech have been identified, there is the problem of ambiguity in their representation. There is no simple correspondence of phoneme and grapheme. In addition, the alphabetic system requires the child to manipulate meaningless units at a time when the child's focus in regard to language is upon its communication purpose.

that reading calls for an awareness of language developed initially,

Thus, the elusive nature of the unit itself, the difficulty of identifying its phonemic elements, the ambiguity inherent in its representation and its meaninglessness for the communication oriented child, suggests that to appreciate the units of print is a demanding cognitive task which calls for mental flexibility of a high order. It is the contention of this study that it calls for the most advanced level of conceptual reasoning the child can produce and that the basis of the failure of many children to understand the units of print is their, as yet, inadequate reasoning capacity.

#### Language Acquisition

According to Nattigly (1972), speech is a primary linguistic activity while reading is a secondary linguistic activity dependent on

## EXPLAINING THE RELATIONSHIP BETWEEN LANGUAGE AWARENESS AND READING

primary linguistic activity which is critical in beginning reading is

Since manipulating and making sense of print is likely to require an appreciation of its units, it is not surprising that a wide range of language awareness tasks have exhibited a considerable relationship with reading in a number of different studies (Ehri, 1975, 1976; Fox and Routh, 1980; Francis, 1973; Liberman, 1973; Liberman and Shankweiler, 1977; Snowling, 1980). There is little controversy over the existence of an important relationship between reading and language awareness, but there is, however, considerable controversy over the explanation for that relationship. Three major hypotheses merit close examination. One hypothesis, developed from linguistic theory (Mattingly, 1972, 1979), proposes that the same underlying language acquisition processes are used in learning to speak and to read but that reading calls for an awareness of language developed initially, at least, by enriched experience with oral language. A second hypothesis is an information processing view (Ehri, 1979) which suggests that the relationship is the direct result of specific experience of print, i.e., learning to read produces language insights. A third hypothesis, a cognitive developmental view favoured in this study, proposes that the child's developing reasoning capacities support both language awareness and learning to read in a way not required as the child learned to speak. rhymes which would help to keep active psychological mechanisms that are necessary for learning to read.

### Language Acquisition

According to Mattingly (1972), speech is a primary linguistic activity while reading is a secondary linguistic activity dependent on

the learner's awareness of the primary activity. The aspect of that primary linguistic activity which is critical in beginning reading is awareness of, or "having access to", the appropriate units of one's morpho-phonemic representation (Mattingly, 1979, p.14). Mattingly argues that, although the same biologically based language acquisition processes are used to learn both speaking and listening as well as reading and writing, the need for this access accounts for the greater difficulty involved in reading and writing. Linguistic awareness is acquired as an extension of the early grammatical development which supports speaking and listening. Some children learn just enough for their oral language acquisition, others learn much more. Those who continue actively acquiring language gain knowledge of the morpho-phonemic nature of words and, finding print a fresh source of data, learn to read quickly and easily as they nourish their linguistic curiosity on this new mode of language. Those whose active language learning faltered before beginning to read and whose linguistic awareness is thus "dormant" are likely to find learning to read difficult and unrewarding and their progress is likely to be poor. It would be desirable, Mattingly contends, that there be "no awkward interval" between learning to speak and learning to read (1979). This is not a demand for early reading instruction but for pre-school linguistic stimulation beyond speaking and listening by activities such as word-games, story telling and rhymes which would help to keep active psychological mechanisms that are necessary for learning to read.

There have been a few studies of pre-school children's language awareness (e.g. Hiebert, 1980, 1981) but none seem to have traced its

relationship to reading progress. There is, however, a large range of both correlational and training studies, reviewed by Golinkoff (1978) and Rozin and Gleitman (1977), which attest to the importance of the relationship of language awareness (especially phonemic awareness) and reading amongst school aged children. In some more recent studies it has been found that severely retarded readers, in contrast to normal readers, could not perform phonemic analysis (Fox and Routh, 1980), could not use the surface code (rhyme) to assist memory (Byrne and Shea, 1979), could not do an auditory oddity task or provide a matched rhyming word (Bradley and Bryant, 1978) and could not match appropriate graphemes and phonemes (Snowling, 1980).

Despite this very general suggestive support, the language acquisition hypothesis has several limitations. First, the account of how linguistic awareness is acquired as a nonfunctional precursor to reading is unconvincing. Since morphophonemic knowledge is not needed in speaking and listening, it is unlikely to be acquired before reading is begun because language is not learned independently of its functions (Halliday, 1973). MacGinitie (1979), responding to Mattingly's view, noted the weakness of an explanation which proposes that the child attains non-functional grammatic knowledge and commented that, in this view, "the human propensity to acquire grammar beyond the point of functional value has been rescued from the extinctive fate of other sabretoothed characteristics by the invention of writing. It seems unlikely." (p. 4).

Second, the cultural influence on learning to read is underrated by this account. Mattingly has convincingly argued for the existence

of important differences in the nature of primary and secondary language activity. A critical cause of these differences is the effect of the cultural invention, orthography. This seems to imply significant differences in the learning conditions of the primary and secondary language activities. The discussion of these conditions, however, which proposes the same learning processes for both, does not do justice to the differences established. For example, it is maintained that learning to read will be motivated by the same linguistic curiosity that motivated oral language acquisition. No account is taken of social effects which seem likely to influence a cultural skill, reading, rather differently and much more than they did a more biologically based skill, listening (Waterhouse, 1980). The explanations of the nature of reading and of the way it is learnt do not sit together very comfortably and the effect of social influences on learning to read are largely overlooked.

Third, the account is very difficult to subject to empirical testing. Although there is evidence of a very general kind which seems to support some of its main contentions, their formulation as yet lacks specific testable hypotheses. Is the existence of oral language learning mechanisms a necessary but not a sufficient condition for the acquisition of linguistic awareness? How do the language learning mechanisms relate to other processes, e.g., perception, memory, which have long been considered important to reading? Studies with school beginners have suggested that print awareness typically develops as a result of reading instruction (Neils,

1986). Despite these limitations, the language acquisition hypothesis has served an important seminal role in current reading theory. The delin-

eation of primary and secondary linguistic activity and the concept of linguistic awareness as an explanation of the difference between the two and of difficulties in learning to read, has drawn together much recent knowledge in a fairly coherent and plausible way. The theory, however, as Mattingly acknowledges, is largely conjecture and needs to be developed considerably and tested empirically before it can be used as a firm basis for classroom practice.

the way children spell words influenced the way they segmented words into phonemes and Ehri and Wilce conclude that word Information Processing influence on phonemic awareness. In summing up the print experience view, Ehri (1979)

While the language acquisition hypothesis gives little place to social influence in learning to read, an information processing view gives a much greater place to social effects. Language insights are gained as a direct result of experience with print, usually in learning to read (Ehri, 1979). It is a knowledge-based rather than a mechanism-based explanation. The orientation of this perspective is towards the detailed interpretation of empirical data rather than towards broad theoretical proposals. The general concept, linguistic awareness, is avoided and instead, content specific insights, e.g., about words or about phonemes, are studied. They are viewed as bearing no necessary relationship to one another.

independently of it within a narrow chronological range. To assert that something is a

A range of evidence indicates that learning to read is commonly a critical variable in the development of word and phoneme awareness. Interview studies with school beginners have suggested that print awareness typically develops as a result of reading instruction (Reid, 1966; Downing, 1971/1972; Francis, 1973). Ehri (1976) found that, of

written word cannot be a sufficient cause of print awareness. This is

two age-matched Kindergarten groups, readers had a considerable advantage over pre-readers on a task requiring word awareness and were not significantly different from older Grade 1 readers. This is interpreted to mean that reading ability, rather than age and its correlates, is the critical factor in accounting for word consciousness. Additional evidence for this view is provided by the finding (Ehri and Wilce, 1980) that the way children spelt words influenced the way they segmented words into phonemes and Ehri and Wilce conclude that word learning has a causal influence on phonemic awareness. In summing up the print experience view, Ehri (1979) states that, as the results with beginning readers are correlational and since there are some children with a well developed word consciousness before learning to read, experience with print is "not a necessary condition for acquiring lexical awareness" but only a sufficient condition" (p. 84). While the illiterate subjects were unable to delete or add a phone (a single sound) at the beginning of non- There is, however, a difficulty with this conclusion. Whether children of the same age and grade are readers or non-readers may well be influenced by their underlying general cognitive or language development. No control was maintained for these factors which are indeed correlates of age but which act quite independently of it within a narrow chronological range. To assert that something is a "sufficient" condition implies that it is, in itself, enough to produce the result. No other conditions are required if that condition exists. If, however, a certain level of cognitive development is necessary in addition to the child's experience of print to produce an understanding of its units, then experience of the written word cannot be a sufficient cause of print awareness. This is

an example of the problem of causality in developmental data raised by Wohlwill (1973). If there are 'normal developmental processes' which have a momentum of their own independent of specifiable external agents or conditions, it is only possible to isolate necessary not sufficient causes of developmental or developmentally related variables. Whether there are important general developmental influences on language awareness is the subject of this study. The possibility that they exert a significant influence has not been excluded by Ehri's data or by the other studies surveyed.

One study which sought to test the print experience and cognitive development hypotheses of phonemic awareness compared literate and illiterate adults from a poor agricultural area of Portugal who were similar in childhood experiences and environment (Morais, Cary, Alegria and Bertelson, 1979). While the illiterate subjects were unable to delete or add a phone (a single sound) at the beginning of non-words and fared little better adding a phone to words, the literate subjects had little trouble with either task. Ability to manipulate beginning sounds of words is not attained spontaneously as a result of general cognitive development and any incidental experience of print they may have had (this is not documented). The experience of print in learning to read seems to have produced that capacity. This conclusion, however, does not rule out cognitive development as an important influence, since specific instruction may have no effect before a certain level of cognitive development is attained. The question of whether reading experience is a sufficient cause of language awareness requires a comparison of groups which are equated for reading achievement, not age. The numerous studies which

have found that backward readers have low language awareness by contrast with normal readers of the same age and intellectual level (Rozin and Gleitman, 1977; Golinkoff, 1978), confound language awareness and reading experience. Poor readers' lower language awareness may be due to their limited experience with reading by comparison with that of normal readers. Do children who are at a similar level of reading possess a similar degree of print awareness? Similarities and differences in groups of words, e.g., "beo, rec, fed, had". Snowling (1980) tested this hypothesis by asking normal and backward readers matched for reading and IQ levels (but not for chronological age), to say whether visually presented nonsense words e.g., dorn - dron, sint - snit, were the same or different. Retarded readers were significantly poorer than normal readers, indicating that, despite having had about as much experience of reading, they were less able to use phonemic segmentation. This is evidence against the view that reading experience is a sufficient cause of phonemic awareness. There seem to be other factors of great importance for its development. The data suggest that the retarded readers perform in a qualitatively different way to the normal readers. Normal readers show a distinct developmental trend in visual-auditory matching but retarded readers show no significant changes with reading age. Retarded readers reach the same reading level as normal readers with far less capacity for phoneme segmentation. Finding it difficult to decode unfamiliar words, it seems they depend more on other methods e.g., sight vocabulary. Snowling interprets this in terms of Vellutino's verbal deficit hypothesis (Vellutino, 1977) but it could well imply a cognitive processing deficit. Retarded readers are able to operate at the "associative" level (White, 1965, 1970) to learn that

whole words as part of sight vocabulary but have great difficulty operating at the "decision" or "reasoning" level required to master phonemic awareness tasks which are mentally much more demanding. A similar mental organizing deficiency has been shown in a phonemic differentiation task by retarded readers who were also matched with normals for reading level and I.Q. but not age (Bradley and Bryant, 1978). The normal readers were far superior in discerning phonemic similarities and differences in groups of words, e.g., "bed, red, fed, had," and in producing a rhyming word. As in the Snowling study (1980), there was a clear developmental trend evident for the normal readers but no such trend was shown by the backward group.

Both studies are subject to the limitation of being based upon cross-sectional data but the suggestion is clear. Normal readers develop a phonemic awareness which poor readers, who are at the same reading level, do not develop. These abilities do not appear to be the result of experience with written language since the groups were matched for reading level. Indeed, in regard to the quantity of time spent with print, the older backward readers have probably had much more. A plausible explanation is that there are different processing capacities brought to the learning situation which have a profound effect on phonemic and word awareness learning. This is the contention of the cognitive developmental view. Cognitive Development a study which analysed qualitative differences in error patterns of Kindergarten and Grade 1 resp. This explanation claims that an underlying cognitive developmental capacity is called upon by both language awareness and by reading that

learning to speak and listen did not require. It does not deny the involvement of the child's language acquisition processes in language awareness and in reading. Nor does it believe that print experience and instruction are of little importance for language awareness. To the contrary, they are seen as critical for reading progress. Instruction, however, exerts an effect in the degree to which its structure, timing and content match the child's developmental status. In themselves, oral language mechanisms and print experience are inadequate explanations of the relationship between language awareness and learning to read. This view was suggested by Williams (1979) in a response to the language acquisition theory of Mattingly.

It seems to me more reasonable to assume that every "normal" human being has enough of whatever it takes to learn to speak and listen, and that there is some other capacity, not equally distributed among all people, that (when environmental conditions permit) leads to facile reading acquisition and reading performance (a cognitive, non-linguistic ability, perhaps?). (p. 4)

The extent of individual differences across groups of children who have had the same amount of schooling (Calfee, Lindamood and Lindamood, 1973) implies the importance of factors other than instruction and print experience. The difference between the language awareness of good and poor readers matched for reading and IQ (Bradley and Bryant, 1978; Snowling, 1980) indicates that reading competence does not explain these individual differences in language awareness. The nature of these factors is suggested by a study which analysed qualitative differences in error patterns of Kindergarten and Grade I responses to a word awareness test (Holden, 1977). The subjects had to detect which word had been added to the second of two orally pre-

sented sentences when the word added made a homophone change meaning, e.g., "John leaves after dinner", "John rakes leaves after dinner". They showed a developmental trend from larger unit responses (sentences or incorrect sentences) in Kindergarten to smaller unit responses (the homophonous word or a phrase containing it) in Grade I. This move from global to more discrete error units is not readily explained by memory improvement nor by specific experience or instruction since no one instructs response errors. A developmental pattern in analysis of utterance from global to discrete with a later emergence of the ability to differentiate words from the semantic matrix seems to exist. The data, however, suffer from being cross-sectional and the interval of one year does not seem well chosen when the greatest change over that period is in the number of correct responses (43% to 85%), which can tell nothing about the qualitative changes being studied. A finer grained examination of the ability starting during kindergarten and followed for a year or so with measures four or six months apart would provide a more convincing demonstration of this developmental change. Although Ehri (1979) interprets the increase in correct responses to show the effect of print experience, it is not possible to isolate the effects of instruction and cognitive development in this improvement. Probably both are operating. However, the qualitative change in error patterns suggests a developmental component in the child's emerging lexical awareness.

Corroboration of this finding is provided by the two studies of phonemic awareness (Bradley and Bryant, 1978; Snowling, 1980) in which print experience is controlled by matching normal and backward

readers on reading achievement. Both found that normal readers underwent a developmental change towards use of phonemic awareness while backward readers did not. These developmental patterns, taken together with Holden's evidence (Holden, 1977) for a developmental component in lexical awareness, suggests that language awareness is a capacity influenced, not only by instruction, but also by underlying developmental change. This is fully consonant with a cognitive developmental viewpoint but whether the development can be explained as an expression of the simple to complex organisation of the task or also as an expression of the child's underlying mental structures, requires further evidence. Some means of identifying possible underlying reasoning capacities is needed to give a basis for this investigation. The most comprehensive current developmental theory of cognition, that of Jean Piaget, provides a starting point.

Perceptual regulation, which refers to the ability to see Piaget's explanation of the emergence of a unit of number in terms of operative thought (Piaget, 1967) may provide an important clue to understanding the child's conception of units of print.

reading suggest that cognitive development is an important underlying capability.

A whole number is in effect a collection of equal units, a class whose subclasses are rendered equivalent by the suppression of their qualities. At the same time, it is an ordered series, a seriation of the relations of order. Its dual cardinal and ordinal nature thus results from a fusion of the logical systems of nesting and seriation, which explains why true number concepts appear at the same time as the qualitative operations. (p.53)

MacGinitie (1973) examined the relationship of word awareness to a battery of measures including operativity (single seriation), 10 and

To gain the concept of a unit of print, children seem to need to do several things simultaneously. They must classify, for example, all letters as having something in common despite their evident differences.

They must also recognise that these letters participate in some complex form of serial relationship to one another, e.g., T before o before m in the boy's name. As well as doing these with both the spoken and written forms of the letters, the child must also match these two elements in a one-to-one correspondence. Although attaining the concept of units of print is more complex than gaining the unit of number (Elkind, 1974), it seems to possess basic similarities and does appear at about the same time as operational thought.

Studies of Piagetian operations and reading have shown low to moderate correlations of conservation and classification with reading but a stronger relationship of seriation with reading (Waller, 1977). Another aspect of operativity, perceptual regulation, has also displayed a significant and consistent relationship with reading (Elkind, 1976). Perceptual regulation, which refers to the ability to see beyond the more salient aspect of a complex visual field, is also claimed by Elkind to underlie linguistic awareness. The findings in regard to the relationship of seriation and perceptual regulation to reading suggest that cognitive development is an important underlying capability for learning to read and for language awareness.

Two studies support this suggestion, the first, with school aged subjects and the second, with pre-school children. Holden and MacGinitie (1973) examined the relationship of word awareness to a battery of measures including operativity (single seriation), IQ and readiness skills in 50 kindergarten and 50 first grade subjects. The strongest predictor of word awareness for the whole sample was age ( $r = .57$ ) which also shared heavy common factor loadings with word aware-

ness while no other variables loaded heavily on more than one factor. This relationship, reflected in the marked superiority of Grade I over Kindergarten pupils and a rapid increase in word awareness at about age six, is clearly not to be attributed to age per se (Ehri, 1976). Yet its interpretation is difficult. Although it is likely that experience of print through reading instruction begun in Grade I is a major influence as Ehri (1979) claims, the substantial relationship between seriation and word awareness suggests that cognitive development may also be important. Kindergarten seriation correlated .48 with word awareness and the combined Kindergarten and Grade I correlation of the two was .46 despite a relatively low reliability of .54. When corrected for reliability, the combined scores correlation was .68. Comparison with word awareness in its correlation with IQ, .54, and in its correlation with Gates - MacGinitie Readiness Skills test, .60, both well established predictors of school tasks whose reliabilities can be expected to be greater than that of seriation, indicates that operativity cannot be dismissed lightly as an influence in the development of word awareness. Its basis in a wide ranging developmental theory, in contrast to the pragmatic basis of IQ and readiness, gives it a potential explanatory power which those measures lack. Cognitive development as well as reading instruction may be the basis of the marked improvement in word awareness detected at about six years of age. the relationship needs to be clarified. Above all, the use of cross-sectional data is a severe limitation in the study of development. However, the data present a difficulty for this interpretation. The cross-tabulation of word awareness and seriation, in which half of those low in seriation are high in word awareness, suggests that operational competence is not necessary for word awareness. This effect,

however, is almost entirely confined to Grade I pupils where 68% are assessed as low in single seriation, a task which has been found to be mastered by the majority of children in Western society by age 7 (Elkind, 1964b; Inhelder and Piaget, 1964; Lunzer, 1970; Nixon, 1971). Since the average age of Holden and MacGinitie's subjects is 7 years 2 months, the high-low cut off point of 27 (maximum 30) seems too stringent. There must therefore be some reserve about the conclusion drawn from this cross-tabulation, that language awareness precedes seriation operativity. The Kindergarten cross-tabulation provides a somewhat more dependable guide to the relationship. Hence, despite the rather high cut off point for seriation, 78% of those low in seriation are also low in word awareness. In this comparison, few children achieve a high level of awareness without high seriation. the interpretation, cognitive development must be seen as an explanatory var In sum, the relationship between word awareness and seriation found by Holden and MacGinitie suggests that cognitive development may provide an underlying capacity which enables the child to benefit from print experience during reading instruction. Individual differences in word awareness after a year or two of reading instruction may partly be caused by differences in conceptual reasoning ability. However, the evidence is as yet inconclusive and needs corroboration and extension. No control has been exercised for the influence of oral language and the direction of the relationship needs to be clarified. Above all, the use of cross-sectional data is a severe limitation in the study of developmental phenomena, since change is not directly studied but can only be inferred. and backward readers, matched for reading level (e.g., Snowling, 1980). Qualitative differences in the reading of these two groups and developmental progress in awareness and reading by the

Hiebert (1980, 1981), who studied preschooler's print awareness and its relationship to operativity (including seriation), oral language and home experience, found that operativity made a unique contribution to print awareness. The best predictor model for the measures of print awareness was a combination of operativity, home teaching and vocabulary which accounted for 56% of the variance. Although it is claimed that linguistic and cognitive variables seem "inextricably interwoven" (Hiebert, 1980, p. 321) in the development of print awareness, this is not a conclusion based on the data presented. Hiebert's regression procedure shows that the major influence on print awareness comes from operativity and that each of the three variables contributes independently of the other two. Within the limits which regression procedures impose upon the interpretation, cognitive development must be seen as an explanatory variable of considerable consequence for awareness of print. *regard to developmental variables based on cross-sectional data, however, are sub* Finally, it is necessary to summarise this cognitive developmental view of language awareness to provide a basis from which hypotheses can be developed for empirical investigation. Although experience of print (especially reading instruction) is of great importance for the development of linguistic insight, wide individual differences in the language awareness of those who have had similar print experience indicates that other factors are also highly important in its development. Print experience does not seem to be a sufficient condition for the development of language awareness. Striking differences exist between normal and backward readers, matched for reading level (e.g., Snowling, 1980). Qualitative differences in the reading of these two groups and developmental progress in awareness and reading by the

normal but not the backward readers suggests that a developmental effect important to language awareness is at work. Furthermore, changes in word awareness resulting in errors not readily explained as a result of improved memory or of instructional experience (Holden, 1977) also suggests that a developmental factor is operating. Studies of Piagetian variables which have shown a moderate to strong correlation of operativity (especially seriation) and reading indicate that these conceptual reasoning capacities may provide a basis for the study of the influence of cognitive development on language awareness.

Investigated was concerned with the extent of the effect of *op*. Thus, the developmental change evident in the qualitative analysis of pupil responses and the relationship of Piagetian variables to linguistic insight provides the basis of a substantial case that cognitive development is an important underlying factor in the attainment of several aspects of language awareness. Findings in regard to developmental variables based on cross-sectional data, however, are subject to a severe limitation. Static observations, insensitive to the dynamics of change, are likely to confound growth with individual differences and to assume that inter-individual differences are stable over time. Longitudinal research, the "lifeblood of developmental psychology" (McCall, 1977), is vitally important for an understanding of the relationship between the development of the cultural skill, reading, and the more biologically based capacities of thought and language. This is especially so since the more biologically based skills are not unitary phenomena but complex jigsaws of varied components and control mechanisms, and the cultural skills may be so flexibly achieved as to have different components and arrangements in

different individuals (Waterhouse, 1980). ent correlations of seriation and word awareness in Kindergarten (.48) and in Grade 1 (.26) found by Holden and MacGinitie

#### AN EMPIRICAL INVESTIGATION

ere may be changing patterns of relationship from year to year between predictor and dependent variables. A study was undertaken to overcome the limitations of cross-sectional data and to extend present findings by a longitudinal examination of the relationship of conceptual reasoning (operativity), oral language, print awareness and reading during the first three school years (Kindergarten, Grade 1 and Grade 2). The hypothesis investigated was concerned with the extent of the effect of operativity on awareness of units of print. Its influence was compared with the effects of competing explanatory variables, oral language and reading experience. The hypothesis states that the effects of operativity on print awareness are partly distinct from the effects of oral language and reading ability and that operativity exerts a causal influence on print awareness. subjects (69 boys and 79 girls) with a mean age of 5 years 10 months and a standard deviation of 3 months. To test this hypothesis it was first necessary to examine the relationships within and between the several variable groupings. The evidence for multiple mental abilities which develop in different ways with greater and lesser degrees of continuity and consistency (Bayley, 1970), suggests that there may be varying patterns shown within the abilities under study. These varying developmental patterns may have important implications for attaining an awareness of units of print and for learning to read. Language capacities have been found to be more developmentally consistent than reasoning processes which could be expected to undergo important developmental change in the age period. The study, devised for this study, sought to assess the child's appreciation of

of the study, 5 to 7 years. The different correlations of seriation and word awareness in Kindergarten (.48) and in Grade 1 (.26) found by Holden and MacGinitie (1973) suggests that there may be changing patterns of relationship from year to year between predictor and dependent variables. However, the lack of previous research makes it impossible to formulate specific predictions of how these inter-relationships may change with time. This preliminary exploration prepared for an examination of the overall pattern of effects as expressed in the hypothesis.

#### Method

##### Sample

The subjects were selected by chance procedures from kindergarten entrants to three adjacent public schools in a homogeneous middle-class southern area of Sydney. The average age was 5 years 10 months. In the first year the sample consisted of 148 subjects (69 boys and 79 girls) with a mean age of 5 years 10 months and a standard deviation of 3 months. In the second and third years, by following pupils to their new schools as far as possible, the sample size was kept at 142 and 137 respectively.

##### Materials

The various measuring instruments used were as follows. Reading was assessed with a group comprehension measure, the Paragraph Understanding Test (Hall and Pacey, 1978) and with an individual test, the St Lucia Graded Word Reading Test (Andrews, 1969) both devised for use in Australian schools. The Units of Print Test, a group measure devised for this study, sought to assess the child's appreciation of

the units of which print is composed. It presented a series of examples of letters, numbers, words or sentences with distractors and asked the child to nominate, for example, which one was a letter. In this way, the child's knowledge of the correspondence between the written and the spoken forms of the items was tested. One problem which became apparent in pilot testing of an early version of the measure was the possibility of confounding reading ability with print awareness. To avoid this difficulty, words and sentences were made as simple as possible and the test was given after at least a full year of reading instruction. As in the previous study, two tasks, adapted from Piaget's work, were used as indices of operativity, seriation and perceptual regulation. Seriation was measured in a two part test assessing single seriation (Lunzer, Dolan and Wilkinson, 1976), and multiple seriation (Watson, 1979). Perceptual regulation was measured with the Perceptual Ambiguity Test developed by Elkind and Scott (1962) which tests whether the child can look beyond the most salient aspect of an ambiguous line drawing. Two aspects of oral language, vocabulary and grammatic prediction, were tested. The Grammatic Closure test from the Illinois Test of Psycholinguistic Abilities was used to measure syntactic prediction (Kirk, McCarthy and Kirk, 1968) and the Peabody Picture Vocabulary Test (Dunn, 1959) was used to assess lexical knowledge.

#### Procedures by Campbell and Fiske (1959).

The operativity and oral language tasks were administered at the end of Kindergarten and Grade 1 by a team of undergraduate research assistants trained until a criterion level of competence was attained. Each measure was administered by a different tester or group of

testers. The language awareness and reading measures were given at the end of Grade 1 and Grade 2 by the researcher and an assistant to groups of some 25 subjects seated in rows in a classroom and separated by screens. Precautions were taken to avoid contamination of results by ensuring that no tester administered individual criterion and predictor measures to the same child.

### Data Analysis

Internal consistency, as assessed by Cronbach's coefficient alpha, was used as an index of reliability for all measures and was calculated on the basis of the responses of the full sample (Goldstein, 1979).

The computations were made with the commercially prepared SPSS programmes (Hull and Nie, 1981; Nie, Hull, Jenkins, Steinbrenner and Bent, 1975). The correlation table was arranged partly in the form of a MTMM (Multitrait-multimethod) matrix (Campbell and Fiske, 1959) with time difference replacing method difference. The diagonals underlined (Table 3.1) represent stability values for the predictor and dependent variables. Comparison of these values and those with different traits assessed at different times (the square blocks surrounding the diagonals) and with different traits assessed at the same time (values in triangles immediately above or to the right of the square blocks) gives an indication of divergent validity in a way similar to that suggested by Campbell and Fiske (1959).

### Relationships Within Variable Groupings

Path analysis, a method for representing and attaching quantitative estimates to a theoretically structured model, was used to examine the relationships between the language variables. Examination of the language variables, presented in Table 3.1. Examination of the language variables, grammatic prediction and vocabulary, reveals a consistently strong reliability and, a high stability (.69, .60).

to assess the pattern of causal effects within the data (Kerlinger and Pedhazur, 1973; Wolfle, 1980). Recursive equation models (with no feedback loops) were drawn up and standardised regression coefficients were used to estimate the values of the path relationships. Associations shown in the path analysis were decomposed using Duncan's fundamental theorem (Wolfle, 1980) to allow an assessment of the extent of direct, indirect and spurious effects. Although there are limits to causal attribution on the basis of path analysis (Rogosa, 1979), the difficulty of applying experimental methods to the study of developmental variables (Wohlwill, 1973) suggests that the technique is a highly suitable one for this study.

### Results

The issue of central concern, as discussed earlier, was the relationship of operativity, oral language and reading to awareness of print. The predictive efficiency of the variables was assessed in several stages. First, the relationships within variable groupings were gauged by inspection of a simple correlation matrix. Second, the prediction of dependent variables was evaluated from the correlation matrix and from cross tabulation of some promising relationships. Third, the pattern of causal effects was examined using path analysis.

#### Relationships Within Variable Groupings

The Pearson correlations for predictor and dependent variables are presented in Table 3.1. Examination of the language variables, grammatic prediction and vocabulary, reveals a consistently strong reliability and, a high stability (.69, .60).

Table 3.1 Correlation Matrix of all Variables

Kindergarten				Grade 1				Grade 2					
PR	Ser	GrPr	Voc	PR	Ser	GrPr	Voc	UOP	RC	WR	UOP	RC	WR
<b>Kindergarten</b>													
PR	(64)												
Ser	10	(80)											
GPr	20	13	(97)										
Voc	23	04	43	(90)									
<b>Grade 1</b>													
PR	29	27	23	07	(79)								
Ser	27	46	12	10	14	(79)							
GPr	28	34	69	41	31	33	(99)						
Voc	35	14	47	60	07	12	54	(99)					
UOP	13	48	15	12	30	37	39	19	(99)				
RC	19	28	24	20	26	35	44	25	45	(96)			
WR	21	31	28	07	18	28	46	07	39	50	(95)		
<b>Grade 2</b>													
UOP	28	37	09	10	23	20	31	07	47	25	34	(98)	
RC	19	28	31	09	30	35	45	18	46	57	57	27	(95)
WR	24	33	26	10	23	22	47	14	37	52	85	34	62 (95)

Note: Reliability co-efficients (Cronbach's alpha) are shown in parentheses. Stability co-efficients are underlined. Decimal points are omitted for ease of presentation. PR = Perceptual Regulation, Ser = Seriation, GPr = Grammatic Prediction, Voc = Vocabulary, UOP = Units of Print, RC = Reading Comprehension, WR = Word Recognition

The application of Campbell and Fiske's (1959) divergent validity criteria (that require lower correlations between unrelated constructs) indicates that both language variables possess sound discriminant validity. Furthermore, although distinct from each other, the two are also quite closely and consistently related, correlating with each other (.43, .41, .47, .54) more strongly than they do with any other variables.

The operativity variables, perceptual regulation and seriation, are not as reliable or as stable as the language measures. The reliability of perceptual regulation moves from rather low (.64) to moderate (.79), thus limiting its predictive potential. The low stability coefficient (.29) is likely to be, in part, a reflection of this but may also (as would be predicted) indicate a surge of developmental change in this period and considerable individual differences in the development of this capacity (McCall, 1977). Discriminant validity is fair with the stability coefficient exceeding 10 out of the 12 values in the comparison of its correlations with other constructs. Seriation is a more reliable (.80, .79) and more stable (.46) measure. The stability again seems, in part, to reflect individual differences of development shown by considerable rank order change over this time period. Seriation also shows sound construct validity with its stability value exceeding all 12 relevant comparison values. The relationship of the two operativity measures in these data gives little basis for their combination but evidence shows that only a slight relationship between operative tasks can be expected before these capacities have settled more firmly into the response repertoire (Arlin, 1981; Flavell, 1977; Tomlinson-Keasey, Eisert, Kahle, Hardy-Brown, and Keasey, 1979).

The cross-tabulation of Kindergarten Seriation with Grade 1 Units of Units of Print shows high reliability (.98, .99), moderate stability (.47) and sound discriminant validity. The two reading measures, which show strong reliability and stability (especially Word Recognition) and a satisfactory discriminant validity, are closely related and their combination as a composite reading measure seems well justified. Seriation, while, of those low in Units of Print, 87%

Prediction of Dependent Variables

The kindergarten language variables, although highly reliable, reveal little relationship to Units of Print, either at Grade 1 (.15, .12) or at Grade 2 (.09, .10) but Grade 1 language predicts Units of Print more strongly (Table 3.1). By contrast, Seriation, despite its lower reliability, is the strongest Kindergarten predictor of Units of Print with a correlation of .48 at Grade 1 and .37 at Grade 2. The predictive strength of Seriation at Grade 1 is lower but still significant (.37, .20). Perceptual Regulation displays a mainly significant but rather low relationship with Units of Print. To some degree this is influenced by its low reliability, but it contributes much less than Seriation to the prediction of print awareness and reading.

		Grade 1			Grade 2		
		Low	Mid	High	Low	Mid	High
Ser.	Low	22 (76)	7 (24)	29 (20)	4 (100)	0 (0)	4 (3)
	Mid	32 (26)	50 (74)	82 (22)	26 (37)	24 (63)	50 (62)
	Total	62	80	142	62	79	141

To provide a further estimate of the importance of Seriation for Units of Print, the relationship was examined more closely by cross-tabulation of these variables. Seriation, which showed a tendency to cluster at three points on the Kindergarten distribution, was broken into three levels, and Units of Print was broken into two, as shown in Table 3.2.

The cross-tabulation of Kindergarten Seriation with Grade 1 Units of Print shows that high seriation has a strong tendency to go with high print awareness a year later (74% of those high in Seriation are high in Units of Print) and that low seriation is strongly associated with low print awareness a year later (76% of those low in Seriation are low in Units of Print). Of those high in Units of Print, 91% were mid or high in Seriation, while, of those low in Units of Print, 87%

were low or mid in seriation. Although the support is not complete, since there is no empty cell, this suggests that attainment of at least a moderate level of seriation may be necessary for gaining a high level of print awareness. Yet, since a large proportion of those at a mid level in Seriation are still low in Units of Print, a moderate level of Seriation is not a sufficient condition for attaining high print awareness. Other factors apparently also have an important effect.

Table 3.2 Cross tabulation of Units of Print and Seriation

		Units of Print Grade 1					Units of Print Grade 1		
		Low	High	Total			Low	High	Total
Ser. Kinder.	Low	22 (76)	7 (24)	29 (20)	Low	4 (100)	0 (0)	4 (3)	
	Mid	32 (39)	50 (61)	82 (58)	Ser. Gr. 1	26 (52)	24 (48)	50 (35)	
	High	8 (26)	23 (74)	31 (22)	High	32 (37)	55 (63)	87 (62)	
	Total	62 (44)	80 (56)	142 (100)	Total	62 (44)	79 (56)	141 (100)	

Cut-off points for Seriation (maximum 43) are 18 and 34. Cut-off point for Units of Print (maximum 24) is 18. Percentage values are shown in parentheses. Within the matrix are the row percentage. Beside the matrix are Seriation subgroup percentages. Below are units of Print subgroup percentages.

These contentions are supported by the cross-tabulation of Grade 1 Seriation with Grade 1 Units of Print. Of the 29 children low in Seriation at the end of Kindergarten, only 4 remain low at the end of Grade 1, all of whom are also low in Units of Print. (An examination of the result sheets showed that all four were part of the original 22 in the "low-low" cell). However, it may be observed that high Seriation

does not necessarily produce high Units of Print, since, of those low in Units of Print, 52% are high in Seriation. A moderate level of Seriation seems to be a necessary but not a sufficient condition for a high level of Units of Print. Although pre-school children have been shown to possess some degree of print awareness (Hiebert, 1981); this

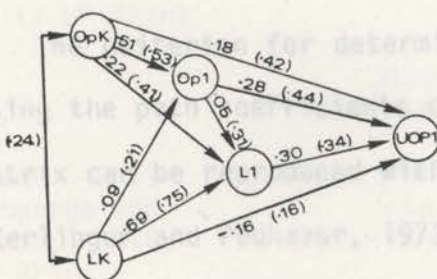
### Pattern of Effects

The path analysis has two analytic goals, each concerned with linking the data to reveal the pattern of its longitudinal relationships; first, to assess the relative effects of operativity and oral language on print awareness and second, to evaluate the effect of reading achievement on print awareness in relation to operativity and oral language. This will allow longitudinal testing of the hypothesis that operational thinking is causally implicated in the development of an awareness of the units of print.

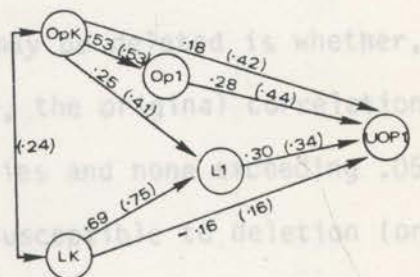
The first analytic goal is addressed by the path diagrams shown in Figure 3.1. The greater strength of the path OpK to L1 than the path LK to Op1 seems to support this; however, several path

Figure 3.1. Path Analysis Showing Effects of Kindergarten and Grade 1 Operativity and of Kindergarten and Grade 1 Oral Language on Grade 1 Units of Print.

A. Full model



B. Reduced model



Note: Single headed arrows show the direction of effect. Strength of effect is shown by the path coefficients on each arrow. Simple correlations (total associations) are shown in parentheses. Double headed arrow joins two exogenous variables.

Units of Print at the end of Grade 1 is considered to be dependent on operational thought and oral language in Kindergarten and Grade 1 directly, and, for the Kindergarten measures, indirectly through the Grade 1 measures (Figure 1A). Although pre-school children have been shown to possess some degree of print awareness (Hiebert, 1981), this has not included the ability to distinguish reliably between the various units of print, an insight which children typically develop in their first year of formal reading instruction (Downing, 1971-72; Francis, 1973; Reid, 1966). Thus, it is assumed that the more fundamental cognitive abilities, thinking and language, possess temporal and causal precedence over the more culturally specific capacity, awareness of units of print at Grade 1. Another assumption of the model (Figure 3.1A) is that the causal flow between Op1 and L1 moves from Op1 to L1, since there is evidence that new language capacities developed at 6 or 7 years are under the influence of logical operations (Beilin, 1975; Sinclair-de-Zwart, 1969; Tenezakis, 1975). The greater strength of the path OpK to L1 than the path LK to Op1 seems to support this. However, several path coefficients including Op1 to L1, do not attain significance and may thus be subject to deletion in model trimming.

The criterion for determining if paths may be deleted is whether, using the path coefficients of the new model, the original correlation matrix can be reproduced with few discrepancies and none exceeding .05 (Kerlinger and Pedhazur, 1973). All paths susceptible to deletion (on the basis of their failing to meet the .05 level of significance) were tested in this way and it was found that the paths Op1 to L1, LK to Op1 could be deleted with few discrepancies from the original

Lost in Model trimming

correlations and none greater than .02. As a precaution, the assumption of the opposite causal direction for the two variables, L1 and Op1, was made and tested. Again the path could be deleted from the model without substantial alteration to the correlation matrix. The omission of path LK to Op1 in the more parsimonious model (Figure 3.1B) is in accord with the hypothesis that operativity exerts an influence distinct, in part, from that of oral language.

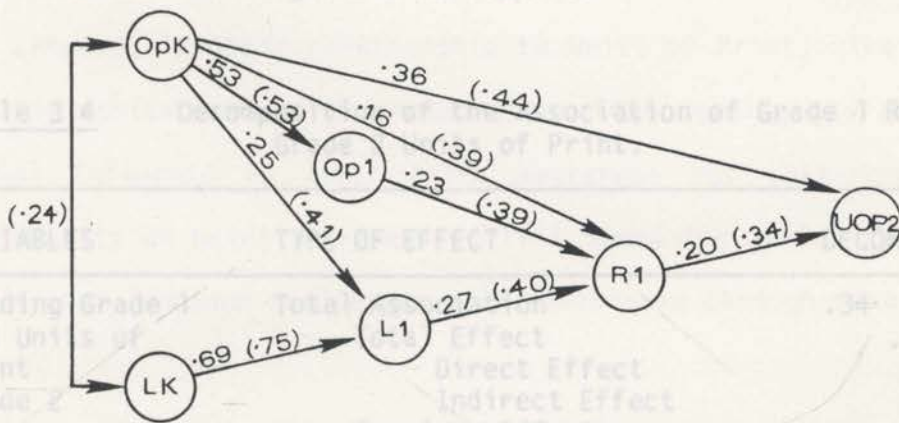
Table 3.3 Decomposition of Associations of Kindergarten and Grade 1 Operativity and of Kindergarten and Grade 1 Oral Language with Grade 1 Units of Print.

Variables	Type of Effect	Decomposition
Kindergarten Operativity and Grade 1 Units of Print	Total Association	.42
	Total Effect	.41
	Direct Effect	.18
	Indirect Effect	.23
	Through OP 1	.15
	Through L 1	.08
	Joint Association	.01
Grade 1 Operativity and Grade 1 Units of Print	Total Association	.44
	Total Effect	.28
	Direct Effect	.28
	Indirect Effect	--
	Spurious Effects	.14
	By Op K	.10
	By Op K through L 1	.04
	Joint Association	.01
	Lost in Model trimming	.01
Kindergarten Oral Language and Grade 1 Units of Print	Total Association	.16
	Total Effect	.05
	Direct Effect	-.16
	Indirect Effects	.21
	Through L 1	.21
	Joint Association	.10
	Lost in Model trimming	.01
Grade 1 Oral Language and Grade 1 Units of Print	Total Association	.34
	Total Effect	.30
	Direct Effect	.30
	Indirect Effect	--
	Spurious Effects	-.02
	By Op K	.05
	By Op K through Op 1	.04
	By LK	-.11
	Joint Association	.04
	Lost in Model trimming	.02

The decomposition of the associations of the predictor variables with Units of Print Grade 1 (Table 3.3), reveals the strength of the total effect of operativity (.41 and .28) by comparison with that of oral language (.05 and .30). This is especially marked in Kindergarten where it is interesting to note that the indirect effects of operativity (through Grade 1 Operativity and Language) are greater than its direct effects. If Kindergarten Operativity were left out, undue importance would be attached to the effects of Grade 1 Operativity and Oral Language; the total association of Grade 1 Operativity with Units of Print is reduced by 32% (.14), and of Grade 1 Language with Units of Print, by 27% (.09), due to the spurious influence of Kindergarten Operativity. Kindergarten Language seems to be acting as a suppressor variable in its considerable indirect influence on Units of Print through Grade 1 Language. This is, in part, offset by the positive indirect effect of Kindergarten Operativity on Units of Print through Grade 1 Language. The moderate zero-order relationship of Grade 1 Language and Units of Print is influenced by counter balancing spurious effects which would not be noticed without the present decomposition. Again the importance of Kindergarten Operativity for Units of Print is made clear. Its longitudinal direct effects seem to operate independently of the effects of oral language and its longitudinal indirect effects seem to operate, in part, through oral language. The direct effects of oral language, although weak in Kindergarten, are much stronger and about the same as those of operativity in Grade I. Thus, both operativity and oral language, in accord with the hypothesis, exert independent effects upon Units of Print. The model, however, takes no account of reading ability which is developing rapidly at this time and is likely

to be an important explanatory variable. Perhaps, as Ehri claims (1979), it is even an alternate hypothesis to explain the development of language awareness, e.g., experience of print, as shown by reading ability is a sufficient condition for acquiring lexical insight. To provide a test of the impact of reading ability, a reading achievement measure is added in the next model (Figure 3.2).

Figure 3.2. Path Analysis Showing Effects of Kindergarten and Grade 1 Operativity, Kindergarten and Grade 1 Oral Language and Grade 1 Reading on Grade 2 Units of Print.



Single headed arrows show the direction of effect. Strength of effect is shown by the path coefficients on each arrow. Simple correlations (total associations) are shown in parentheses. Double headed arrow joins two exogenous variables.

For this model, Units of Print was measured one year later in Grade 2 and Grade 1 Reading results were used in an attempt to overcome the problem of feedback loops in a recursive equation model (Wolfle, 1980). The assumptions of these additions to the earlier model are that reading has an effect on later awareness of print and that Grade 1 Reading follows Kindergarten and Grade 1 Operativity and Language.

The total effect of operativity ( $OpK + Op1$ ) is .12 or 35% of the variance of Reading Grade 1 and Units of Print Grade 2. If

This is justified on the grounds that the earlier established abilities are more likely to influence the newly developing capacity, reading, rather than the other way around, at least in its beginning. Grade 1 Units of Print is likely to be exerting an effect but is omitted to avoid feedback loops as any interaction with Grade 1 Reading cannot be analysed in this model. Any effect it might have, however, would be likely to reduce the present model's estimation of the effect of Grade 1 Reading. If the analysis is consistent with the cognitive developmental hypothesis without Grade 1 Units of Print, its inclusion would strengthen that support.

Table 3.4 Decomposition of the Association of Grade 1 Reading with Grade 2 Units of Print.

VARIABLES	TYPE OF EFFECT	DECOMPOSITION
Reading Grade 1 and Units of Print Grade 2	Total Association	.34
	Total Effect	.20
	Direct Effect	.20
	Indirect Effect	--
	Spurious Effects	.12
	By OpK	.06
	By OpK through Op1	.04
	By OpK through L1	.02
	Joint Association	.02

The model, which has been trimmed in a similar way to the previous understanding of the units of print. These effects operate over and one, shows that Kindergarten Operativity has a direct effect on Grade 2 Units of Print over and above the effect of Reading. In addition, the decomposition of the relationship of Grade 1 Reading and Grade 2 Units of Print (Table 3.4) reveals that 41% of that association is spuriously caused by operativity and language. In this spurious effect the total effect of operativity (OpK + Op1) is .12 or 35% of the variance of Reading Grade 1 and Units of Print Grade 2. If

operativity were omitted, the effect of reading on print awareness would have been markedly larger and an undue importance attached to a spurious component.

In sum, the path analysis gives support for the interpretation that both operativity and oral language have a causal effect on Units of Print and that each is partly distinct from the other in this effect. Operativity at Kindergarten plays a dominant causal role both one year and two years later in its relationship with print awareness. It also exerts a causal influence on Grade 1 Operativity and Language in their relationship to Units of Print. The addition of reading achievement to the model shows that reading has an additional causal influence on later print awareness but that the effect of operativity on print awareness is felt above the influence of reading, while oral language influences print awareness through reading.

#### Discussion

The principal finding of this study is that the conceptual reasoning (operativity) of the five to seven year old beginning reader seems to have direct and indirect causal effects on the child's understanding of the units of print. These effects operate over and above the influence of oral language and the influence of reading ability. Both oral language and reading seem to make important contributions towards the emergence of language insights but no explanation of print awareness seems adequate which overlooks the impact of the child's underlying cognitive development.

### Establishing a Causal Interpretation

The validity of the causal interpretation of the data requires careful consideration especially since causality has commonly been seen as attributable only on the basis of experimental results. There is, however, considerable doubt about the suitability of experimental methods to establish causality in developmental phenomena (Baltes and Nesselroade, 1979; Wohlwill, 1973). Granted that there are "normal developmental processes", which have a momentum of their own, involved in important variables of this study, simple cause-and-effect analysis limited to the activity of an externally imposed condition (i.e., an experimental manipulation) is inadequate and causal modelling procedures are called for.

There are three conditions for establishing causality from path analysis; first, two phenomena must show reliable covariation, second, one must be demonstrated to have temporal precedence, and third, the possibility that both variables are jointly dependent on some other determinant(s) must be excluded. These conditions, in regard to the present data, will be discussed in turn.

The simple correlation of Kindergarten Seriation and Grade 1 Units of Print, .48, in this study is remarkably similar to the relationship found by Holden and MacGinitie (1973) between Kindergarten word awareness and single Seriation, .48, and that found by Hiebert (1980) between pre-schoolers' logical reasoning (including seriation) and five different indices of print awareness in which the correlations ranged from .47 to .60. With three somewhat different measures of operativity and several different indices of language awareness, admin-

istered independently by different researchers in America and Australia to pre-school and beginning school pupils, there is a very close similarity of result. Further verification of this is desirable but the relationship seems to be a consistent one and cannot be ignored in the explanation of language awareness. further check of this was made

with a sub-group, a class of 31 pupils, selected because it had been taught. The temporal precedence of Kindergarten operativity over Grade 1 Units of Print depends less on the earlier assessment of operativity than on the finding from three studies that, before formal reading instruction, children were unable to distinguish reliably between print units such as a word, a letter, a number ( Downing, 1971/72; Francis, 1973; Reid, 1966). The more fundamental cognitive processes are assumed to have precedence over the more culturally specific capacity, awareness of print.

Reading achievement is sometimes considered, with good reason, to be The exclusion of other possible determinants, underlying both operativity and oral language, is critical for the causal interpretation of this path analysis. The control of oral language mechanisms is provided by the design of the study. Although the measures are not complete or absolute indices of oral language (or of operativity), there are sound theoretical and empirical grounds for their choice and the data indicate that they possess good reliability and construct validity. The results show that operativity influences print awareness quite independently of oral language at Kindergarten and thus language seems unlikely to provide a sufficient causal explanation. change the results or other underlying causes could be discovered. However, within the context of the measures employed, the Another proposed alternative explanation, print experience (Ehri,

1979) is controlled in two ways; first, by comparing subjects who have had very similar teaching exposure and second, by monitoring reading ability. Although all subjects have had the same number of years of schooling, there is a wide range (from 4 to 23 out of 24) of scores in Grade 1 Units of Print. A further check of this was made with a sub-group, a class of 31 pupils, selected because it had been taught by the same method and with similar materials. From it, any pupil with less than 85% attendance was excluded. The range for Grade 1 Units of Print was 7 to 23. This, in full accord with the findings of wide individual differences in other studies (e.g., Calfee, Lindamood and Lindamood, 1973), suggests that factors other than print experience are important and that print experience is not likely to be a common underlying determinant of operativity and print awareness.

Reading achievement is sometimes considered, with good reason, to be a better guide to print experience than teaching exposure. The path analysis, however, shows that operativity has an effect on print awareness distinct from that of reading achievement and it is concluded that experience of print in terms of reading progress, as measured in this study, is excluded as a general underlying determiner.

Although a case can thus be made for the exclusion of oral language mechanisms and print experience as causal effects underlying operativity and awareness of the units of print, no such exclusion process can ever be complete. More powerful measures of these variables could be found to change the results or other underlying causes could be discovered. However, within the context of the measures employed, the middle class sample and the limits of present theoretical understand-

ings, the data support the conclusion that operativity has a causal effect on the child's knowledge of the units of print. conceptual level and providing training where there are weaknesses, which will be considered

### A Cognitive Developmental Theory

The results are consistent with a cognitive developmental explanation of the units of print. The five and six year old's emerging operational capacity, unformed when he or she learned to speak, is of great importance for gaining print awareness and learning to read. This does not mean, however, that understanding the units of print is gained spontaneously in the course of cognitive development or that development and print experience are competing explanations of linguistic insight. Although Piaget's concrete operations may well be attained as a result of the need to survive (Elkind, 1975), knowledge of the units of print does not appear to emerge in this way since illiterate adults, who might reasonably be thought to have achieved concrete operations, could not segment speech while literate adults, matched in background and experience, could (Morais et al, 1979). Specific experience of print, typically in reading instruction, is also highly important (Ehri, 1976; Francis, 1973). Since print is a comparatively recent and rather complex cultural invention (Rozin and Gleitman, 1977), it is not surprising that the learner usually requires at least some deliberate social initiation. his name and some classroom

These findings are, therefore, in accord with an interactive theory of learning to read. How well a child learns will depend largely on the success of the match between the teaching - its content, structure and strategies - and the developmental status of the child - his cognitive developmental view consonant with the results of this study

tive, language, and motivational state. There are important practical implications flowing from this on determining conceptual level and providing training where there are weaknesses, which will be considered in a later section.

One question which this raises is the causal direction of the relationship between language awareness and reading. The present recursive path analysis does not allow an assessment of this question but the assumption that speech is a primary linguistic activity with a strong biological basis (Mattingly, 1972) suggests that language awareness may possess causal precedence over the secondary activity, reading, as Mattingly assumes. Yet the importance of experience of print (especially reading instruction) for its development (Ehri, 1979) suggests that reading and language awareness may interact. Perhaps some minimal appreciation of the nature of the task is required for reading to begin, e.g., that print conveys a linguistic message, after which reading starts to exert a feedback effect on language awareness. It is clear that linguistic awareness is no unitary concept but possesses many levels of meaning and that reading is no unitary learning task but requires the integration of many learnings over an extended period of time. The child may learn a few community signs - "STOP", "Hospital" - and may be taught his name and some classroom labels - "table", "box" - and so gain the insight that speech can be represented by print and that there are such things as words in both speech and print. Upon this is built the next aspect of linguistic insight as learning to read progresses. In this way, reading and linguistic awareness are probably interactive in their effects. The cognitive developmental view consonant with the results of this study

subset of general vocabulary ability, there is only a low correlation

asserts that some degree of cognitive development must first be present to support the learning of both. However, cognition may also be interactive in its relationship with linguistic awareness and reading. As they are learned, the cognitive development which supports that process is, in itself, further stimulated. Children, equal in other regards, who do not learn to read, do not seem to advance as far in their cognitive development as those who do (Greenfield, 1966). This important issue, however, awaits further empirical study.

#### Explaining Some Current Issues

The cognitive developmental view offers insight into three puzzling issues in current research and theory; the low relationship between general vocabulary and print vocabulary, the ease of listening and the difficulty of reading (Lieberman, in Mattingly, 1972) and the bimodal distribution of lexical awareness scores.

In regard to the first issue, Francis (1973) found that the relationship between reading and vocabulary of units of print (.41), continued to be considerable (.34) even when general vocabulary skill was partialled out. She believes this indicates that factors independent of general conceptual ability are involved in learning the print units vocabulary and that these are closely related to reading. The present results afford a similar demonstration. When general vocabulary (PPVT) was partialled out of the correlation of Grade 1 Units of Print and a Grade 1 combined reading value (Word Recognition and Reading Comprehension), the coefficient changed very little (from .49 to .47). Although the vocabulary of print units seems to be a subset of general vocabulary ability, there is only a low correlation

between the two and they are quite independent of one another in their relationship to beginning reading. The present results provide the suggestion that the difference lies in the much greater level of operational thinking which the vocabulary of print units requires. It seems that in the preparation of the Peabody Picture Vocabulary Test, developmentally unstable influences on its items, such as would be exerted by operativity, have been largely omitted. Linguistic awareness, in the form of understanding units of print, seems to be another aspect of language development which, like relational terms (more, less) and co-ordinated structures (tall and thin) (Sinclair-de-Zwart, 1969; Tenezakis, 1975) and the appreciation of riddles (Shultz, 1974; Shultz and Horibe, 1974), is especially dependent on the cognitive changes of middle childhood.

A second issue for which the cognitive developmental view offers an explanation is the conundrum raised by Mattingly, (1972 p.135) of why "listening is easy, reading is hard". The many differences in the learning tasks and the linguistic awareness which Mattingly has argued is needed in reading, seem to require a higher level of cognitive functioning. The data provide support for the suggestion of Williams (1979) that, while every "normal" human being has enough of the capacity required by speaking and listening, there is a non-linguistic cognitive capacity, not equally distributed among the population, needed in learning to read. That capacity, as indicated by the operativity measures of the present study, seems to include aspects of conceptual reasoning or executive functioning. In Sheldon White's terms, it is the "decision zone" or the "cognitive layer" of response which emerges as an important new dimension of ability during middle

childhood (White, 1965) and which the study has shown exerts a decisive causal effect on print awareness. This explanation avoids the considerable difficulties of Mattingly's suggestion that the language learning mechanisms are prepared for reading by the accumulation of non-functional grammatic knowledge during early childhood.

These data also offer a feasible explanation for the third issue; the bimodal distribution of scores shown by different measures of word awareness amongst kindergarten and first grade subjects in several studies (Calfee, Chapman and Venezky; 1972, Ehri, 1979; Holden and MacGinitie, 1973). Ehri notes that a single skill, either possessed or not possessed by the subjects, seems to underlie these tests but looks to further investigation for an explanation. Measures of Piaget's operations have typically shown the "on-off" bimodal distribution similar to these. The distribution of Kindergarten Seriation scores in this study reveals three modal points with 20% of subjects (29) clustered around one of these modes at the lower end of the scale. Of these 29 subjects, 22 (76%) are low in Units of Print (Table 3.2) and, of the four still low in Seriation 12 months later, all are low in Units of Print. Although the Units of Print test does not show a bimodal distribution, due, it seems, to the difficulty range and the number of its component parts, the cross-tabulation indicates a strong relationship between a failure to achieve seriation and low scores on Units of Print. Although there may be other factors at work, seriation seems to be an important ingredient in the explanation of the bimodal distribution of word awareness scores.

others, low in conceptual functioning, need deliberate teacher expla-

### Implications for Teaching

A central implication of the interactive theory proposed here is that good teaching makes a productive match of the child's developmental status, including the level of his or her cognitive processing, with the instructional content and strategy. Like the experimenter in the instructional approach to developmental cognitive research (Belmont and Butterfield, 1977), the teacher too has one critical task - to ascertain the conceptual level of the child and provide instruction in those terms. Sometimes teachers, through shrewd observation of children and a thorough knowledge of the subject, have structured the situation to produce good results. At other times, they have created unintended mismatches and poor learning or even failed outright to promote learning performance. All reading teachers would be helped by a more systematic knowledge of the cognitive processes called on in print awareness and reading. This research gives some insight into these processes and could provide the basis for the adaptation of Hunt's idea of a learning style conceptual level (Hunt, 1975) in terms of reading related cognitive components. Hunt found that pupils with low conceptual levels (dependent on external standards and incapable of generating their own concepts) learnt better with high structure teaching, while those with high conceptual levels (independent in their capacity to generate concepts) did well with either high or low structured teaching. It seems that the low conceptual level pupil lacks a degree of executive control which the teaching approach can make up in a similar way that researchers can serve as the executive for individuals in their experiments (Belmont and Butterfield, 1977). Although many pupils will learn the units of print incidentally, others, low in conceptual functioning, need deliberate teacher explan-

ation of terms and daily instruction, e.g., through game or song, based on the various print units. The success of such programmes as those of Elkonin (1973) and Williams (1980) will depend on the effectiveness of the match between the greater structure they offer, and the learning needs of the children. new mechanisms not required by learning to speak and listen. These new mechanisms involve cognitive

If it is possible to ascertain the conceptual level of the pupil and match instruction to it, perhaps it is also possible to raise a low level of conceptual ability by training and so strengthen print awareness. Does a cognitive developmental based capacity lend itself to this manipulation? There is evidence in the work of Gelman (1969) and Siegler and Liebert (1972) for the contention that 'rigid organisational limits on cognition can no longer stand' (Belmont and Butterfield, 1977) but this does not mean that limits do not exist even though they may be more elastic than originally thought. Specific intervention to stimulate operational development may improve the language awareness and reading of those who lag behind their peers. However, it is likely that a high specificity of effect would be found and therefore the training of seriation tasks directly involved in print awareness and reading is desirable. For this purpose, the recent development of an alphabetical seriation test (Weed and Ryan, 1982) is of interest. More structured teaching of the units of print using concrete materials devised by Elkonin (1973) and adapted for use in English (Ollila, Johnson and Downing, 1974), may provide help especially valuable for those with low conceptual levels.

ConclusionSTUDY 3. COGNITIVE DEVELOPMENT AND LEARNING TO READ

The evidence presented provides support for the view that understanding units of print, as well as drawing on existing language mechanisms, calls on what seems to be new mechanisms not required by learning to speak and listen. These new mechanisms involve cognitive capacities which are part of the higher mental processes whose development gains major new impetus in the 5 to 8 year period. Their causal effects, which are very difficult to uncover with cross-sectional or experimental data, are revealed by this longitudinal study to influence print awareness over and above the effects of oral language and reading achievement. The heavy demands which awareness of print makes on conceptual development seem to be an important reason why learning to comprehend print is harder than learning to comprehend speech.

The review of literature has proposed a cognitive developmental theory. The cognitive developmental perspective consistent with the findings offers valuable guidance for the subtle matching process which is at the heart of good instruction. In doing so, it calls for a more detailed study of the changing mosaic of interaction between the developing characteristics of the children and the instructional patterns used as they gain an understanding of the units of print and learn to read.

Research into strategic tasks in reading comprehension and into children's conceptions of the nature of print, as well as the naturalistic study of reading, all suggest the importance of reasoning processes for learning to read. Furthermore, there is cause to believe

CHAPTER FOURSTUDY 3. COGNITIVE DEVELOPMENT AND LEARNING TO READ:A FIVE YEAR LONGITUDINAL STUDY.

This third study is the central and most extensive investigation of the report. It provides the most powerful test of the main argument drawn from the literature, building on the two studies which have preceded it and testing some of the assumptions which they have made. To provide the setting for this study, the conclusions from the literature and the findings of the two previous investigations will first be presented.

The review of literature has proposed a cognitive developmental theory of learning to read in which the conceptual reasoning capacities that gain important impetus in middle childhood play a major role. Several current models of reading and a wide array of empirical data support this contention. Conceptual reasoning is implicated in the patterning required by information processing models and the decision-making postulated by psycholinguistic explanations. Research into strategic tasks in reading comprehension, and into children's conceptions of the nature of print, as well as the naturalistic study of reading, all suggest the importance of reasoning processes for learning to read. Furthermore, there is cause to believe

experimental method since the cognitive variables involved have been

that these conceptual reasoning processes undergo a critical developmental change during the early school years. Support for this is found in the basic change to the character of learning from associative processing in early childhood to more complex cognitive processing in middle childhood identified by White (1965, 1970), in the developmental theory of Piaget, and in research relating Piaget's theory to reading (e.g., Waller, 1977). The overall purpose of these studies is to investigate the relationship of cognitive development during this period to beginning reading.

The first study (Chapter 2) provided an initial examination of this relationship by investigating the link between aspects of the Piagetian concept, operativity, and reading with 100 grade four children while controlling for the effects of oral language. Operativity, which was indexed by tests of multiple seriation and perceptual regulation, showed a distinct effect upon word recognition and reading comprehension above the influence of oral language as measured by vocabulary and grammatic prediction tests. This confirmed the prediction that reasoning processes are important in reading and indicated that more extensive study of them and of their relationship to reading was warranted. The one time of measurement and the correlational nature of this first study, however, are major limitations which mean that neither developmental nor causal inferences, both necessary to explain the relationships involved, can be drawn unambiguously from it. The second study, therefore, explored developmental and causal inferences using a longitudinal design and the techniques of path analysis. This approach was preferred to the experimental method since the cognitive variables involved have been

found to possess a developmental momentum which is, in part, independent of specifiable external conditions and which is likely to interact with any superimposed treatment and confound the effect (Wohlwill, 1973; Flavell, 1977).

The second investigation was concerned with an aspect of metalinguistic ability, print awareness, and its relationship to cognitive development and reading. Donaldson (1978) has argued that, during the first few years of school, the child typically begins to use language in some degree of abstraction from its primary meaningful context and that this provides a major source of stimulus to intellectual growth. Parallel to this, White (1965) notes that the cognitive changes of middle childhood are associated with an increase in the apparent influence of language on learning and Beilin (1975) suggests that a new capacity to treat the written word as an object emerges after about five years of age.

Thus, the question of the nature of metalinguistic ability provides a test case for a cognitive developmental theory of reading. If linguistic awareness, a language capacity closely involved in early reading (Mattingly, 1972, 1979), is causally dependent on the emerging cognitive reasoning abilities, this would constitute important evidence for a cognitive developmental view of reading. This issue was investigated in a three year longitudinal study of school beginners reported in chapter three.

The child's awareness of the units of print (the index of metalinguistic ability chosen as one closely related to the reading

task) was found in path analysis to be causally related to operativity. This relationship was substantial despite allowance for the effects of oral language and reading ability. Thus, although oral language and reading level (as an index of print experience) each played a part in the emergence of the awareness of units of print, no explanation of the metalinguistic capacity of school beginners seems to be adequate without reference to the newly emerging operative competence. The school child's use of language in some degree of abstraction from context, therefore, depends importantly on a non-language reasoning capacity. These results are consistent with a cognitive developmental view of linguistic awareness which provides plausible explanations of puzzling current issues such as why learning to read and write is much harder than learning to listen and speak and which gives important guidance for instruction. The study considerably strengthens the case, which was argued in the review of literature and was supported by study one, for a cognitive developmental theory of learning to read.

However, because the operativity variables are part of Piagetian developmental theory, it has been assumed that these cognitive influences on reading follow a developmental pattern. Neither study one nor study two afforded an opportunity to assess the nature of this pattern and, since Piagetian theory is currently subject to considerable challenge, it is important that these developmental assumptions be given close empirical scrutiny. In what sense are the cognitive variables developmental? Are they indices of a cognitive structure which shows stage related change? Furthermore, although there is a good basis reported here and elsewhere (Waller, 1977) for

accepting the existence of a relationship between operativity and learning to read, the precise nature of that relationship is difficult to determine. Is operativity a prerequisite, a facilitator or an incidental correlate of reading ability? This difficulty occurs largely because cognitive development and learning to read are not unitary activities but are attained as part of extended processes and one time of sampling the data tells nothing about those processes. Only on the basis of a close examination of the developmental pattern can a more precise delineation of its relationship to the child's emerging reading capability be determined.

#### The Purposes of the Study

Arising from these considerations there are two purposes for the present study: first, to assess the nature of the development of the predictor variables, operativity and oral language and of the criterion variable, reading, during the first five years of school, and second, to examine their interrelationship during this period, in order to test a cognitive developmental theory of learning to read.

#### Developmental Nature of the Constructs Studied

Human development refers to change over time in the characteristics of the subject. Is any variety of change developmental? The answer to this question produces sharp theoretical division. Most would say "no" and require certain specific conditions. Some, however, would tend to say "yes". Something of the range and nature of those theoretical differences needs to be understood.

Earlier work on child development has been concerned with age-related change which has produced a linear model and a unidirectional conception of sequence. However, more recent writings have sought to encompass the greater complexity of human change in evidence and there has emerged a plurality of views which can be categorized along a continuum from strong to weak (Baltes and Nesselroade, 1979). Strong conceptions require many criteria for change to be classified as development, such as irreversible sequence of stages, goal orientation, structure and qualitiveness, as specified, for example, in Piagetian theory. Weak conceptions of development, such as in social learning theory (Bandura, 1971), assume a cumulative model of development and require little more than that change be reliably identified. The differences seem to be partly a reflection of the complexity of human functioning and partly the result of the theoretical commitments of researchers which guide the questions they ask. For the present work it seems unwise to narrow the range of conceptions of development but rather to use theoretical predictions which seem suitable to the class of behaviour under study and then assess the nature of the development as empirically revealed in the light of the theory. A full consideration of this issue is beyond the scope of the present

dis. Operativity, chosen for this study to assess conceptual reasoning, usually is considered to be nearer the strong end of this continuum, while oral language, the other aspect of the predictor set, seems likely to be located nearer the weak end of the continuum. Bayley's findings (Bayley, 1970) of greater stability for verbal than for reasoning tasks over an extensive longitudinal assessment of mental abilities gives general support for this. However, more detailed change in middle childhood. First, is the change abrupt or gradual?

specification is required and is of particular interest in regard to the Piagetian variables. Are they indices of a cognitive structure which participates in stage related change or are they more parsimoniously described as following such change concepts as Brainerd's "measurement sequences" (Brainerd, 1978)? A measurement sequence is determined by the structure of the test and occurs "whenever each item in the sequence consists of the immediately preceding item plus some new things" (Brainerd, 1978, p.176). Brainerd argues that an invariant sequence of development does not provide prima facie evidence for the existence of stage progression, since measurement sequences or other non-organismic explanations may be found which can account for change. change is gradual, there seems less basis for considering it as constituting a stage. However, Piaget's "structure d'ensemble", which proposes a psychological unity with interdependence of the sets of operations linked as logico-mathematical groupings, is very difficult to verify and has been regarded with varying degrees of scepticism by researchers. The forty-one responses following Brainerd's challenge to the stage concept (Brainerd, 1978), provide a lively example. A full consideration of this issue is beyond the scope of the present discussion and is unnecessary since several scholars (Brainerd, 1978; Feldman and Toulmin, 1975; Flavell, 1971; Larsen, 1977; Wohlwill, 1973) have argued it at some length from several different positions along the strong-weak continuum of developmental conceptions. Yet a review of the present position, including a consideration of some recent longitudinal evidence on the matter, is necessary and will be provided by the discussion of three questions in regard to cognitive change in middle childhood. First, is the change abrupt or gradual?

Second, is the change qualitative as well as quantitative? Third, are the subsystems of the hypothesised structure interrelated and, if so, in what way?

In regard to the first question - abrupt or gradual change - there is ample evidence that specific concrete operational tasks do not mushroom overnight but emerge by slow steps (Flavell, 1971) and, from individual to individual, follow different timetables (Almy, Chittenden and Miller, 1966; Almy, Dimitrovsky, Hardeman, Gordis, Chittenden and Elliott, 1970). Thus, gradual rather than abrupt change in operational skills over the middle childhood years is found (Tomlinson-Keasey, et al, 1979). If change is gradual, there seems less basis for considering it as constituting a stage. However, "gradual" is a relative term; change which is gradual over two or three years is rather different from that which is gradual over twenty years or a life time. If behaviour alters in its quality over two or three years, even if that change is gradual, there may be some basis for a stage conception (Ausubel, 1957). This leads into the second question which concerns qualitative change.

In an illuminating essay on the concept of continuity in Western thought, Kagan (1980) has suggested that the predominant assumption of smooth cumulative transitions and of long term change has prevented a recognition of the importance of shorter term change and hence of discontinuities in development. Psychology's linear, unidirectional growth models as applied to cognition are being challenged by evidence which suggests multidirectional patterns. Piaget's theory, for example, which suggests that there will be several qualitative changes

during infancy and childhood has found echo in some recent longitudinal studies. McCall, Appelbaum and Hogarty (1973) reanalysed data from the Fels longitudinal study of IQ in children between two and a half years and seventeen years. Distinguishing between the general level of a person's IQ and his profile contour (developmental inflections in performance), they found major inflections in IQ performance at 6 and 10 years and perhaps at 14 with the change at 6 years being the most compelling. Although psychometric influences (repeated testing and change in the tests) seem to have had some effect, the evidence remained clearly in support of a marked surge in development at about 6 years discontinuous with earlier change. A similar conclusion that there is a qualitative change in learning performance at about the same age has been suggested by White (1965). Earlier discontinuities have been discovered by McCall, Eichorn and Hogarty (1977) in their reanalysis of the Berkeley Growth Study covering the first five years of life and by Uzgiris (1976) in a review of studies of cognitive change during infancy. Similarly, qualitative differences in early adolescence have been found in the study of concepts over the 9 to 13 year period (Nassefat, in Wohlwill, 1973).

There is, therefore, considerable evidence that qualitative as well as quantitative change does take place in the development of human cognition. In the move to concrete operational intelligence it is seen clearly by the difference between the perceptually based response of the typical four year old and the conceptually based response of the typical seven year old to a task such as the conservation of mass. This qualitative difference between responses seems to mark off

different levels and thus give some substance to the concept of stage. However, a number of unrelated qualitative changes would not be sufficient for the title "stage". They must have something in common which ties them together and which provides for economy and consistency of operation. This is assumed to be provided by some underlying mechanism that integrates the range of behaviours into a harmonious functional whole. This leads to the third and most difficult question about change - the interrelationship of the subsystems.

If concurrent emergence is important for the concept of the interdependence of concrete operational components (and Flavell (1971) thinks it is), then the evidence provides little support for this aspect of a stage. The subsystems of operativity seem to emerge rather asynchronously (Flavell, 1971; Tomlinson-Keasey et al, 1979; Arlin, 1981). Flavell suggests that only in the final assembly of the stage is the structure integrated and that transitional periods are marked by the unstable organization of components. Wohlwill (1973) believes that Flavell has "allowed himself to be misled by the pervasiveness of asynchrony" and has adopted a position where the development of "supposedly related concepts occurs in an essentially indeterminate fashion, with only gross correspondence of chronological periods remaining as a hopelessly watered down restatement of the synchrony principle" (p. 239). Flavell (1977) shows some ambivalence over this as evidenced by the comparison of his introductory assertion of the existence of a "complexly organized system of interacting (cognitive) components" (p.4) with his later challenge (p. 249) to an almost identical statement of Wohlwill. Nevertheless, he believes that

stages will not figure importantly in future scientific work on cognition. A subsystems is provided by a recent two year study of Arlin (1981). In Kindergarten and Grade 1 testing of nine operational tasks. Concurrence may well be an unreasonable expectation in the light of the gradualness of development, of measurement confounds such as task specific difficulty levels and the possibility of latency effects (Danner and Day, 1977). The heart of the issue is the inter-relationship of the suggested operative components over the middle childhood years and, in regard to this, some recent evidence suggests that structures become more stable and intercorrelated during that period. Tomlinson-Keasey et al (1979) found that the seriation and numeration of six year olds predicted an increasing range of other operativity tasks measured in four waves of testing at intervals of 4 months, 7 months, 12 months and a further 12 months. These two early Piagetian abilities predicted the other operations more powerfully than did the Metropolitan Readiness Test. Although the authors' causal claims for some relationships on the basis of cross-lagged panel analysis must be regarded with scepticism because of the inadequacy of that method of analysis (Rogosa, 1979), the time precedence built into the design of the study and the relationships found (multiple correlations frequently exceeded .5) suggest that a path analysis applied to the data would uncover important causal patterns. The results show a degree of empirical coherence for the operations tested and afford some validation for the construct of concrete operations not only in its final form, as Flavell suggests, but also at what may be nodal points along the way, as Wohlwill (1973) proposes. family resemblance structure proposed by Feldman and Toulmin (1975) and perhaps a little stronger than the three ring circus (with

Further longitudinal illumination of the relationship within operational subsystems is provided by a recent two year study of Arlin (1981). In Kindergarten and Grade 1 testing of nine operational tasks, Arlin (1981) confirmed the general order of difficulty found by Inhelder, Sinclair and Bovet (1974) but also reported intraindividual differences in the process of acquisition. The coefficients of reproductibility and scalability for a Guttman scalogram analysis of the difficulty order of the nine tasks failed to attain the level required to indicate a valid and truly unidimensional and cumulative scale (Nie et al, 1970). Arlin hypothesises that a linear relationship of the nine variables is much less appropriate than a two or three tier pattern across which integration and consolidation take place. Within a given tier, individual differences in the order of acquisition seem to be the rule rather than the exception. However, this suggestion must be accepted with some caution. Although the data are consistent with it, a much closer study e.g., measurement every 3 or 4 months and use of more finely graduated scales, is needed to confirm the suggestion.

In sum, concrete operations show gradual rather than abrupt change which nevertheless seems to reflect a qualitative difference in functioning from earlier mental activity. Although this change may not show a great degree of concurrence over two, three and four years, there is evidence of coherence and interdependence of its subsystems. The evidence is far from strong enough to support the logico-mathematical stage proposed by Piaget but may be closer to the less exacting family resemblance structure proposed by Feldman and Toulmin (1975) and perhaps a little stronger than the three ring circus (with

some coherence but much that is unrelated) of Flavell (1977). Although the concept of stage in some forms may not fit the data very well, the alternative concept, sequence, seems to fit it less well, failing to account for the demonstrated interdependence of different but analogous concepts or skills. Certainly more longitudinal and finer grained data is needed before the stage concept is abandoned or can be given sufficient support for wider acceptance. At present, it seems well to retain it (with an open mind) as a valuable heuristic - a position Geneva seems to accept (Inhelder, Sinclair and Bovet, 1974).

Arlin (1981) tested 121 children at the end of their kindergarten year. The first hypothesis is thus concerned with the developmental patterns of the predictor variables and states that operativity and oral language follow different developmental paths in the early school years. Operativity shows a degree of developmental surgence as befits stage related change while oral language shows steady continuous change.

Although double seriation was the strongest single predictor, tests from each of the three subgroups

Relationship of Operativity and Reading

reading and it is concluded that all three subsystems must be represented for a satisfactory change. There can be little doubt that a relationship exists between operativity and reading. The results of studies one and two of this report add weight to the evidence in numerous other studies (Waller, 1977) where significant and generally moderate correlations were found between various forms of operativity and a range of reading and reading readiness measures. However, the nature of that relationship requires detailed elucidation.

Two recent studies illustrate this research. Fifteen early readers

(who read without formal instruction) were found (Howes Polk and Goldstein, 1980) to be significantly better in conservation tasks than were fifteen matched non-early readers. The correlation of their operativity (largely conservation) before formal reading instruction and reading after one year of instruction was .38. Thus, although operativity seems to be one of the factors in the successful reading of these subjects, the nature of the relationship is not clear. Is it a causal link and, if so, what is its direction? (1975; Howes Polk and Goldstein, 1980; Lunzer and Dolan, 1977) may suggest that operativity is.

Arlin (1981) tested 121 children at the end of their kindergarten year on nine operativity tasks including some from each of the three operative subgroups, conservation, classification and seriation, and compared their reading 12 months later. The correlations were low to moderate ranging from .16 to .35 but, in a regression process, the operativity measures affected reading significantly above the effect of a reading readiness test. Although double seriation was the strongest single predictor, tests from each of the three subgroups contributed to the best prediction of reading and it is concluded that all three subsystems must be represented for a satisfactory characterization of operative level. There are some limitations to the assessment of operativity in this study, however, which must qualify the results. Neither multiple seriation nor perceptual regulation were included among the operative measures. Both have been shown to be important predictors of reading (Elkind, 1975; Lunzer and Dolan, 1977; Chapter 2, this report), perhaps as strong as, or stronger than, those in the set used by Arlin. In addition, the use of one task in each measure and a narrow scoring range of 0,1 or 0,1,2, does not allow the gradualness of development nor the important

distinction between trial-and-error and operational responses (outlined by Piaget for tasks such as seriation) nor any latency of response, to be reflected in the results. Despite the restriction to the predictive power of the measures which these factors are likely to produce, the existence of a relationship between operativity and reading is evident. However, again the nature of this relationship is not clear. Though the time precedence of operativity in this and several other studies (Dimitrovsky and Almy, 1975; Howes Polk and Goldstein, 1980; Lunzer and Dolan, 1977) may suggest that operativity is a causal factor, data which allows the testing of rival hypotheses (e.g., language learning hypothesis) and the more sophisticated analysis of longitudinal patterns (e.g., using structural models) is required to elucidate possible causal relations. Is operativity causally linked with learning to read? If so, is it a unidirectional or reciprocal relationship? Does it function independently of oral language (commonly held to be critical for reading and intellectual development)? How does an understanding of the units of print (language awareness) which seems to be causally dependent on operativity (Chapter 3), fit into this network of relationships? Is there a changing pattern in the relationship of operativity, oral language, units of print and reading during the first five years of school? If so, what is the nature of that changing pattern? These are the questions which this study will seek to answer. The central concern of the study is with the pattern of relationship between operativity, oral language and reading during the first five years of school. The second hypothesis states that operativity exerts a causal influence on reading which is partly distinct from the effect of oral language.

### Bringing Theory and Method Together

The gradualness of the developmental process of operational capacities is frequently overlooked in their measurement. They are The critical importance of a convergence of theory and methodology makes the longitudinal approach highly suitable for this study. No other method is able to capture the developmental dynamism of cognition and reading during the first few years of school. However, there are several major difficulties in longitudinal research, especially when the method is applied to cognitive developmental variables, that must be faced if it is to be used successfully. Three issues will be considered; first, the need to resolve measurement problems raised by the nature of the developmental variables studied, second, the assessment of the construct validity of these variables by using a reinterpretation of Campbell and Fiske's multitrait-multimethod analysis and third, the application of stability values from that analysis to examine individual differences and qualitative change revealed in the measures.

### Measuring Developmental Capacities

Longitudinal research, concerned as it is to study time-related constancy and change, encounters problems additional to those usually associated with measurement of less changeable capacities. This is especially the case for variables towards the strong end of the developmental continuum such as operativity which, as has been shown above, can be expected to manifest gradual and qualitative change during the 5 to 9 year age period being studied in this project. Difficulties occasioned by the gradual and the qualitative nature of the change will be considered in turn.

The gradualness of the development of concrete operational capacities is frequently overlooked in their measurement. They are commonly scored on a two point scale, operational, (those who can do the task) and non-operational, (those who cannot); or perhaps on a three point scale with transitional as an intermediate category, (e.g., Arlin, 1981; Howes Polk and Goldstein, 1980). However, the gradualness of the emergence of these capacities means that there are likely to be individual differences that produce a range of intermediate levels of response. In seriation, for example, as well as those who can and those who cannot arrange the items in order, there are those who can only do so with the simplest materials such as four different sized stick figures. Others can order 10 rods each 1 cm different in size but fail when the rods are 4 mm different in size. Others correctly order small groups of the rods but fail to relate all 10 rods. Thus, a recognition of the gradualness of development means its measurement must also reflect the gradations of response shown. This implies the determination of a certain order of difficulty for responses and the assignment of score values accordingly. A two or three point scale will overlook a great deal of response variance which may reduce the predictive power of the measure.

latency, the question may need to be repeated a number of times as

Qualitative differences in responses stemming from qualitative change in development can lead to overestimation or underestimation of capacity. An overestimation of capacity can result from failing to distinguish between trial-and-error and operative modes of response to such tasks as seriation (Inhelder and Piaget, 1964). In an operative response to the single seriation task the child realizes the relationship of the rods before he begins to assemble them and so orders them

without redundant comparisons. In a trial-and-error response, the child does not seem to have this mental construction but physically compares and alters the elements in the emerging pattern to complete the array. If no distinction in the score is made between these two qualities of response, an overestimation of the trial-and-error response will result. The problem of distinguishing between the two qualities of response can be minimised by a behavioral definition of the difference and by careful training of testers to discern it. Inter-tester agreement on this distinction was found to be 89% in regard to a multiple seriation task (Chapter 2).

An underestimation of capacity can result from failing to provide for response latency in the structure of the test. One aspect of developmental change revealed by research into Piagetian variables is that a response may be present in the subject before it is spontaneously available for use in a specific situation (Danner and Day, 1977; Stone and Day, 1978). Inhelder, Sinclair and Bovet (1974) seem to be referring to the same issue when they comment that it is sometimes sufficient to ask the right question at the right moment in order to activate dormant mental processes. To allow for response latency, the question may need to be repeated a number of times as Inhelder et al (1974) suggest or, after requiring a spontaneous response, the problem can be repeated in a more structured form so that greater support is given for the correct response. For example, in multiple seriation the subject can be required first, to place all pieces on the matrix (a spontaneous construction) and then, to replace several which the tester has omitted in a reconstruction of the solution, and then again to construct the whole matrix. If the subject

fails in the spontaneous construction through response latency (a capacity present but not available), these next two steps are likely to increase the chance that the response will be elicited. (Piaget, 1969). If this is the case, a steady increase in mean scores can be predicted. These difficulties in diagnosis, springing from individual differences induced by the gradualness and the qualitative nature of development, apply in any one time of testing. There is, however, a further difficulty when developmental capacities are compared from one time to another. Their fundamental nature may be changing during the period in which they are being monitored. If the change is largely unidimensional and quantitative in nature, established measurement techniques seem to be satisfactory to monitor that change over time. Vocabulary development measured by a test such as the Peabody Picture Vocabulary Test seems to be an example. However, when change is not unidimensional and is qualitative in its nature, measurement of that capacity presents a fundamental methodological problem for the researcher. How can such behaviour be measured to allow comparisons over age along a common dimension and yet at the same time reveal the qualitative change taking place (McCall, 1977)? If the nature of the test does not change it may not capture the qualitative behavioral change. If the test does change it may not afford a meaningful comparison with results before the change. Some variables, while changing quantitatively over a lengthy period, also show shorter periods in which there is qualitative change. McCall et al, (1973, 1977) found this in an analysis of patterns of mental change in the data of the Fels Longitudinal Study and the Berkeley Growth Study. In the present study, this seems to be likely for the test of perceptual regulation which is predicted to show gradual change from before the

concrete operational period and beyond it, but, being partially isomorphic with the operational processes and strongly influenced by them, will undergo qualitative change in middle childhood (Piaget, 1969). If this is the case, a steady increase in mean scores can be predicted during middle childhood but a heightened level of individual differences shown by a lower stability is likely as concrete operations influence it.

Other variables such as are measured by operational tasks, e.g., single seriation, seem to show little or no change up to about four or five years of age, then undergo a period of rapid development over two or three years, after which virtually all children can complete the task and there is no more change. However, as shown above, there seems to be greater gradualness than appears on the surface which is related in part to task difficulty factors such as whether the rods are 1 cm or 4 mm different in length. If researchers wish to measure subjects over a five year period on such a dimension, they must vary the form of the test with age, drawing on theoretical considerations to ensure its appropriateness to the particular development of the subjects.

In sum, two different varieties of developmental change have been identified which require somewhat different measurement provisions and which are expected to show different developmental patterns in longitudinal investigation. First, there is development which is continuous, largely showing quantitative differences over time, e.g., vocabulary. Second, there is development which shows qualitative differences during middle childhood, either together with continuous

change, e.g., perceptual regulation or development, which seems to reflect discrete qualitative differences in functioning, e.g., single seriation. In the longitudinal measurement of all varieties of developmental change, construct validity is a critical consideration but, in the measurement of capacities which show qualitative change and which require a change of task in the measurement process, construct validity is even more important. If the form of the test is changing, how can we know that what we are measuring over time is indeed the same thing? This calls for a consideration of how construct validity may be assessed in longitudinal research, an issue raised in the next section. This will be followed by a discussion of a related issue; the validity of the proposed variable groupings to be used in further analysis. After this, the question of how these different patterns of development can be studied empirically will be discussed.

Campbell and Fiske (1959) suggest that four aspects of the multitrait-multimethod matrix bear upon validity. First, the diagonal values (validity coefficients) should be statistically significant and of sufficient size.

Construct Validity: Multitrait-Multitime Analysis

A useful technique for the study of validity is the multitrait-multimethod analysis (MTMM) proposed originally by Campbell and Fiske (1959) and discussed more recently by others such as Sullivan and Feldman (1979). To assess the construct validity of longitudinal data, some reinterpretation of multitrait-multimethod analysis is required. It has been used to study two aspects of validity - convergent validity and divergent validity - and to assess the measurement bias components of results. Convergent validity is indicated when different methods of measuring the same trait are substantially correlated. If different tests are measuring the same

construct, a convergence of results can be expected. Divergent validity is indicated by a lack of correlation among theoretically separate constructs. If similar tests are measuring different constructs, a divergence of results can be expected. To establish the matrix, at least two different measures are used of at least two different traits.

An assumption of the technique is that there are no time-induced differences in the subject's responses. Thus the tests are to be administered at the same time period. If, as in the present data, the assumption of no time effects upon responses does not hold, but instead the purpose is to study those time effects, the nature of the analysis is changed and the interpretation requires modification.

Campbell and Fiske (1959) suggest that four aspects of the multitrait-multimethod matrix bear upon validity. First, the correlations between different measures of the same trait (validity diagonal values) should be statistically significant and of sufficient size to warrant further investigation. Second, each validity value should exceed the correlations between that trait and different traits assessed with different measuring methods. Third, each validity correlation should be greater than those between that trait and other traits assessed by the same measuring method. Fourth, the same pattern of trait correlations should be shown in all the method by trait matrix triangles.

The application of this technique for repeated measures of potentially unstable developmental characteristics requires some rein-

terpretation of these four criteria. For the data of this study, method difference is replaced by time difference; the same method is used to test each variable but with one year between each testing. The data thus produce a multitrait-multitime matrix (MTMT) for analysis. Without different measures of the one variable, methods bias cannot be assessed and the convergent correlations thus indicate stability rather than validity. Assuming there is strong reliability, (internal consistency) substantial correlations in the trait by time diagonals become the basis for the first criterion which now indicates convergent stability. for MTMT as for MTMT.

The nature of this stability coefficient and how it is related to reliability and validity need careful consideration. Reliability and validity, as Campbell and Fiske (1959) point out, can be seen as regions on a continuum. In this context, reliability is agreement between two tests of the same trait using maximally similar methods. Validity is agreement between two tests of a trait using maximally dissimilar methods. Stability seems to occupy the middle ground partly shared by both and partly independent of each. Since the same test is used despite the time separation, the stability value represents a lower limit of reliability. Because of the time interval involved, there are likely to be differences in the nature of the variable being tested. Has it changed beyond recognition or is it sufficiently similar at a later testing to be distinguished from other variables measured in the same time pattern? Thus, the stability value and its comparison with the divergent validity coefficients, give an index of construct validity. In practice, even two different measures of a trait are not entirely independent and relative validity

is always the best that can be attained (Campbell and Fiske, 1959). Although the first criterion of Campbell and Fiske when transposed into a multitrait-multitime analysis is not strictly convergent validity the second and third criteria indicate divergent validity in MTMT. They are concerned with whether the measures are distinct from measures of other related variables over time. Since time-change does not seem to present as severe a test of convergent validity as method-change, the demonstration of construct validity is probably not as strong for MTMT as for MTMM. A fourth criterion can be the basis for testing the validity of these groupings.

The second reinterpreted criterion is that the stability value should exceed the correlations between that trait and different traits measured at different times. On the MTMT matrix, this means that the stability diagonal value should be higher than the values lying in its adjacent column and row in the different-time blocks. In other words, the correlation across time (stability value) should be higher for the same traits than for different traits. and an indication of stable development (given increases in means) during that period. This gives

The third restated criterion from Campbell and Fiske is that the stability value should be greater than the intercorrelations of different traits measured at the same time. From the matrix, a value in the stability diagonal is compared with those in the different-trait, same-time triangles. or the construct validity of the trait, or both, are seriously in doubt.

The fourth criterion restated for MTMT is that the same pattern of correlations should be shown in each of the trait by time triangles. This assumes that, although the magnitude of the values might differ,

their pattern reflects the strength of causal connections among the traits. However, with time changes it is possible that the causal links between variables will change. Indeed, it is a purpose of this study to examine these causal links and their possible changes. Thus the fourth criterion may not indicate construct validity. However, given an acceptable level of reliability and validity for the measures, the fourth criterion may shed light upon any changing causal relationships over time in the data. In studies such as the present one, where variables are being grouped as predictors for further analysis, the relationships implied in this fourth criterion can be the basis for testing the validity of those groupings.

The implications of various result patterns when applying multitrait-multimethod analysis to test construct validity in time sequence data require examination. If the stability coefficients are substantial and consistent and are distinct from the correlations of other variables (criteria 2 and 3), there is some support for the construct validity of the measure and an indication of stable development (given increases in means) during that period. This gives confidence for its use in further analysis. Consistent high stability of a test and increases in the mean show that subjects are developing at about the same rate in that characteristic. If, on the other hand, the stability values for a variable are low and not well distinguished from other values, the instrument or the construct validity of the trait, or both, are seriously in doubt.

In conclusion, the reinterpretation of multitrait-multimethod analysis for testing the construct validity of time sequence data

changes its significance in important ways. Instead of construct validity values, it provides stability coefficients which, although not giving as stringent a test as multitrait-multimethod analysis, can indicate construct validity. These stability values (the lower limits of reliability) are an index of construct validity when compared with the values of other unrelated traits measured at the same time or at different times (Campbell and Fiske's first, second and third criteria).

The pattern of correlations in each of the trait by time triangles (Campbell and Fiske's fourth criterion) can allow a test of the validity of the variable groupings in the present study. This needs more detailed consideration which will be provided in the next section.

#### Validity of Variable Groupings

When two predictor variables are combined as one, it is important but not sufficient to consider the construct validity of each separately. The question of the validity of the grouping must also be investigated. This can be achieved by using multitrait-multitime analysis to ask whether the variables, although distinct, are more strongly related to one another than they are to other variables measured at the same time or at different times. This is a stringent test since it is not assessing different methods of measuring the same variable nor even the same method applied at different times but rather is it testing different (though theoretically related) variables perhaps measured with different methods at the same time and at different times. Although no other example of this test has been

found in the literature that might serve as a precedent, four criteria, based on the multitrait-multitime matrix and, in part, similar to those of Campbell and Fiske, seem appropriate.

The first is whether the correlation of the partners is significant and substantial at same-time and across-time measurement points. Does the strength of their convergence suggest that the validity merits further investigation?

The second criterion concerns the discriminant validity of the grouping as shown by the relationship of variables measured at the same time. Is the correlation of the partners stronger than the correlation of either with other variables measured at that same time? This involves a comparison of values within the same-time triangles adjacent to the matrix diagonal.

The third criterion concerns the discriminant validity as shown by the relationship of variables measured at different times. Is the correlation of a variable with its theoretically determined partner stronger than its correlation with other variables measured at the same time as its partner, i.e., in the same row and column of its matrix box?

The fourth criterion is concerned with whether the relationship of the variable partners across time is greater than the relationship of either of the variables with non-related variables measured at the same time. This means the correlations of partner variables in the different-time boxes will be greater than the values within the same

row or column of corresponding same-time triangles. This is a very stringent criterion to apply to time-lag developmental data since the developmental process is likely to reduce across-time values.

Individual Differences and Qualitative Change

As well as being the basis for assessment of construct validity, the stability value can also have another important use in developmental time-sequence data. It can be an index of developmental change when compared with the other values it takes across time and with the stability pattern of theoretically contrasting variables. In this way, given sound reliability (in the sense of internal consistency), it can provide an assessment of the effects of individual differences in developmental change which may suggest the existence of qualitative as well as quantitative change in the data. It is this possibility which will be discussed in more detail now.

Two different forms of developmental change have been distinguished which seem to reflect greater and lesser degrees of continuity and qualitative change. Some behaviours seem to emerge with continuous quantitative increments throughout childhood, e.g., oral language. Others are likely to reveal the effects of a marked qualitative transformation in middle childhood. Of these, some undergo qualitative change while also showing elements of continuity, e.g., perceptual regulation. Others, such as responses to operative tasks, are first shown in middle childhood, are then mastered by virtually all children during the next two or three years and, in that form, do not change again, i.e., they show discrete, qualitative change.

The problem for the researcher is how these developmental continuities or discontinuities can be distinguished by empirical assessment. Can quantitative data reveal qualitative change? Must not any quantification of qualitative change gloss over and lose the impact of the changing organisational substructure? For example, it is often felt that to quantify Piagetian concepts inevitably forces them into an ill-fitting empiricist mould. If the purpose is to index individual intellectual development, this is the case. Elkind (1981a) has cautioned against the assumption that Piagetian measures are comparable to psychometric assessments and rejects the translation of developmental assessments into psychometric values as a means of indexing mental growth. Developmental assessment records evolving organised wholes or "forms" while psychometric assessment deals with measurement units or "traits". Elkind's suggestion of a two part definition of general intelligence, "g", in terms of "gf", a form component and "gt", a trait component, seems to be a useful response to the call of Wohlwill (1980) for a major reorientation in the assessment of cognitive functioning to replace inadequate linear models. Common longitudinal strategies of examining the stability of variables while ignoring changes in the average performance over ages, However, if the purpose is not individual assessment but the developmental study of change, McCall (1977) has described how qualitative change can be detected in quantitative data. This can be done by distinguishing between developmental function and stability of individual differences in longitudinal data and McCall has illustrated the usefulness of this distinction in his reanalysis of major growth studies (e.g., McCall, Eichorn and Hogarty, 1977). Developmental function refers to the increase or decrease in frequency of a behaviour

across age and may be continuous or discontinuous. The stability of behaviour refers to the degree to which the rank order of individual subjects on a measure corresponds to their rank order on that same measure (or a conceptually equivalent one) assessed at a later time. The correlation of scores across age is presumably an index of individual differences in developmental progression for that capacity. A high correlation indicates that there is little change in the rank order of subjects over the period. A low correlation (with satisfactory test reliability) indicates greater change in rank order and suggests that individual differences in the development of that capacity are considerable. For that capacity it may be a time of very marked developmental ferment and indicate a qualitative change in functioning. As the capacity becomes settled in its development, the stability values are predicted to increase (given substantial variance and reliability). Since correlations are independent of the means of the distributions from which they are calculated, developmental function and stability are potentially independent of one another and each adds importantly to the understanding of developmental change. The common longitudinal strategies of examining the stability of variables while ignoring changes in the average performance over ages, means that such studies are not truly developmental in nature (McCall, 1977). The use of stability as a potential index of qualitative change does not reduce the need for description of the logical substructure of responses. On the contrary, findings obtained in this analysis may underline the importance of providing a "form" component in the representation of intelligence.

2. Operativity exerts a causal influence on reading which is partially distinct from the effect of oral language and from awareness of units of print.

It is in the assessment of changing relationships over time that longitudinal design has overwhelming advantages over cross-sectional research and multitrait-multitime analysis is a valuable technique to study this. It might be wondered, finally, how the same stability value can be used to indicate validity at one moment and developmental change at the next. The difference lies in the comparisons being made with it. Discriminant validity of a trait is indicated by whether its prediction of itself is distinct from its prediction of other traits. The nature of developmental change is indicated by whether its prediction of itself is consistent (given increments in the mean) and by comparison with the levels of stability of other traits.

#### Hypotheses of the Study

Finally, before considering the details of research procedure, the hypotheses need to be stated in terms of the principles of assessment discussed in this section. The first has to do with the differing nature of the development of the predictor variables and the second with their distinct relationships to the criterion.

1. Operativity and oral language, although both increasing rapidly in the early school years, develop in different ways. Operativity shows considerable individual differences in its emergence consistent with developmentally surgent, stage related change. Oral language shows a lesser level of individual differences indicating developmentally steady, continuous change.

2. Operativity exerts a causal influence on reading which is partially distinct from the effect of oral language and from awareness of units of print.

## Method

### Design

The longitudinal design of the study involved five waves of testing at the end of each school year from Kindergarten to Grade 4 as shown in Table 4.1.

Table 4.1. Longitudinal Design of the Study

	Wave 1 Summer 1977	Wave 2 Summer 1978	Wave 3 Summer 1979	Wave 4 Summer 1980	Wave 5 Summer 1981
School Year	Kind.	Gr 1	Gr 2	Gr 3	Gr 4
N - core sample	148	142	136	135	128
N - control sample	-	-	44	-	-
<u>Reading Measures</u>					
Word Recognition		*	*	*	*
Paragraph Understanding		*	*	*	*
GAP (Cloze)				*	*
Progressive Achievement Comprehension					*
<u>Piagetian Measures</u>					
<u>Seriation</u>					
Single Seriation	*	*	*	*	*
Multiple Ser. 3 x 3	*	*	*	*	*
Multiple Ser. 5 x 5	*	*	*	*	*
Perceptual Regulation	*	*	*	*	*
<u>Language Measures</u>					
Picture Vocabulary	*	*	*	*	*
Grammatical Closure	*	*	*	*	*
Units of Print Test		*	*	*	*

### Sample

The original subjects were drawn by chance procedures from three

adjacent public schools in a middle-class southern area of the city of Sydney. In two schools, pupils had been allocated to non-graded classes by chance from enrolment lists. In one of these schools, two of four kindergarten classes (65 out of 101 children) were selected and in the other school, because there were fewer facilities for testing, one of five classes (33 out of 164 children) was selected, in each case after ascertaining the willingness of the teacher to participate in the project. At the third school, pupils had been apportioned to classes on the basis of preliminary skill tests and a different procedure was followed. The 50 children were drawn from all three classes by selecting every second pupil on alphabetical class lists until the sample was complete.

A major problem of longitudinal research is sample wastage during the extended assessment period involved. This was kept to a minimum by following subjects who moved to areas within reasonable proximity to the original schools. At the five annual testing periods the sample size was 148, 142, 136, 135 and 128 respectively. In no one year were more than 6 pupils tested away from their original school. In the first year of testing there were 69 boys and 79 girls with a mean age of 5 years 10 months, while in the last year, there were 54 boys and 74 girls with a mean age of 9 years 10 months. Subjects were lost to the sample largely because of a change in parental work location. The wastage rate over five years is notably low and does not seem to be a significant factor influencing results.

The repeated testing of the same sample over five years introduces the possibility that the testing experience itself will have a signif-

ificant effect on subsequent performance on the tests and thus be an uncontrolled influence on the relationships being studied (Wohlwill, 1973). For example, retest effects of intelligence measures were found to be considerable in a large adolescent sample (Nesselroade and Baltes, 1974). It is often thought that, when testing waves are separated by one year as in the present project, this effect is not likely to be significant. However, in the study of Nesselroade and Baltes (1974) there were significant effects despite a 12 month interval between testing and thus it is desirable to monitor this influence. An ideal technique is to administer all tests to a fresh matched control group at each wave after the first. This, however, presented a demand beyond the resources of the project and so a compromise was struck by enrolling 44 new subjects in the third year of testing (22 girls and 22 boys) from the same socio-economic group who attended a public school 3 km from the nearest core sample school. Average age of the control sample was 8 years by comparison with the core sample average of 7 years 10 months.

### Materials

Piagetian measures. Two indices of operative thinking, Seriation and Reading measures. Two criteria were of particular importance in guiding the choice of reading tests from amongst the many available: suitability for an Australian sample and discriminability across the five year age change of the subjects during the project. An Australian revision of the Schonell Graded Word Reading Test, the St. Lucia Graded Word Reading Test (Andrews, 1969), was chosen to assess word recognition. The test is a well established individual measure consisting of 100 finely graded single content words. The subject

orally reads the words until the cut off point, 10 incorrect responses, is attained. The test has shown good discrimination from grades one to six and consistent high reliability.

Reading comprehension was measured by a test developed for use with children aged six to ten years in New South Wales Schools, the Paragraph Understanding Test (Hall and Pacey, 1978). It is a 20 minute group measure consisting of 33 graded paragraphs each with a multiple choice question. To eliminate the effects of guessing, a cut-off point was applied after subjects scored 8 out of 10 responses wrong. In the fourth and fifth years of the project, an Australian developed cloze test, GAP Reading (McLeod, 1977), was added to provide a wider spectrum of reading measures and allow further assessment of the convergent and divergent validity of the initial measures. In addition, at the fifth year, the Reading Comprehension Test of the Progressive Achievement Tests (Elley and Reid, 1969), a New Zealand test adapted for Australian use, was also administered to all subjects as an additional means of monitoring construct validity.

Piagetian measures. Two indices of operative thinking, Seriation and Perceptual Regulation, were used in this study. Seriation consisted of a three part test; part one, Single Seriation (Lunzer, 1970), part two, Multiple Seriation with 9 pieces on a 3 x 3 matrix board (each described in chapter 3) and part three, Multiple Seriation with 25 pieces on a 5 x 5 matrix board. The first and second parts were administered in all five waves of testing with one exception. This occurred at the fifth testing occasion when Single Seriation, for which the subjects, mostly then over nine years of age, had attained a

ceiling, was omitted. The third part, Multiple Seriation 5 x 5, was found to be too hard and impractical to administer at the first and second waves and was administered in waves three, four and five as an extension of the task difficulty of the measure. The appropriateness of this change in task to match the expected change in capacity was suggested first from the finding (Lunzer, 1970) that a similar seriation task was not attained by more than 50% of subjects until age 9 and was confirmed in trials of the materials.

The 25 piece 5 x 5 matrix multiple seriation task, which followed the 9 piece task, presented the child with 25 fish graded from bigger to smaller on one dimension and from darker to lighter on the other. The pieces were mixed and placed on a table before the child next to the empty 5 x 5 matrix board. The subject was first required to construct the matrix spontaneously ("put the pieces on the board where they belong"). To overcome the problem of underestimation of capacity due to response latency, the instruction was given as many times as was needed, a prompt was provided if the response was incorrect and the task was repeated in a graded series of easier forms in the next step of testing. In this, the tester constructed the whole matrix correctly without comment, then asked the subject to replace 4, 8 and 12 pieces which the tester removed in turn. Next, all the pieces were removed and the child was asked to reproduce the whole matrix. Finally, the subject was shown the board with all but the top row and the left hand column of fish removed and was required simultaneously to co-ordinate the two dimensions of the task by placing three non-adjacent fish correctly on the board. As well as providing for response latency, this graduated presentation, with a maximum score of

for administration at waves 4 and 5.

15, sought to allow for the range of intermediate levels of response capacity which, as shown in earlier discussion, is likely to exist in a sample. The problem of over-estimation through failing to distinguish between trial-and-error and operative responses was attacked by providing higher scores at three parts of the test for operative rather than trial-and-error constructions.

6 Perceptual Regulation, which was assessed by the Perceptual Ambiguity Test developed by Elkind and Scott (1962), provides an indication of how well the child can go beyond the more salient aspects of a complex visual field and perceive other elements of the stimulus. Seven ambiguous line drawings (e.g., two face profiles which, when juxtaposed, make a vase) are presented one at a time to the subject who is asked what he can see. If there is no response the question is asked again until the child replies or says he cannot see anything. If one aspect of the drawing is reported, e.g., two faces, the child is asked can he see anything else. The question is repeated if there is no answer. If the child says "no", the next drawing is presented. One point is scored for each item identified with a maximum of 21 for the seven items.

Language Measures. Oral tests of grammatic prediction (Kirk, McCarthy and Kirk, 1968) and of vocabulary knowledge (Dunn, 1959), as described in chapter 3, were administered and scored following the standard procedures. Language awareness was assessed in waves two and three of the testing with the Units of Print Test developed for the project (chapter 3). Subjects were found to have attained a ceiling on this test after grade two (wave 3) and it was thus inappropriate for administration at waves 4 and 5.

Procedures

Each wave of testing was conducted in two phases, individual tests and group tests. The individual measures were administered mostly in the school library by a team of some ten undergraduate research assistants who were trained by demonstration and supervised rehearsal until a criterion level of competence was achieved (usually after 4 to 6 administrations). To provide greater standardization of procedure, each assistant or group of assistants administered one measure and subjects were moved from test to test. This also ensured that no one testing period was excessively long, that there was a change of posture, tester and activity every few minutes and that results of one test did not contaminate scores on another. The average time of the individual tests ranged from 3 to 8 minutes and the total average time was 25 minutes. In some cases where assistants administered the criterion measure, St. Lucia Word Reading, and also some predictor tests, steps were taken to prevent any influence on results by ensuring that no tester administered both measures to the same child. The use of specialised testers and the variable time taken for the different tests, however, meant that it was not possible to ensure tests were administered in a predetermined order. As a subject completed a test he or she was directed to another tester who was free. The order of administration, thus varied by chance, could influence the results but it seems most unlikely given the minimum generalisation found to take place across cognitive tasks (Brainerd and Allen, 1971) and the lack of any significant effect found (Hooper, Toniolo and Sipple, 1978) when six different presentation orders for Piagetian tasks were compared. The research assistant team did not

remain the same across the five years although the majority continued for three or more years and some for all five years. At the beginning of each testing period, however, there was a time of procedure revision and practice for continuing testers and training for new team members. At all times the researcher worked closely with the team directing and supervising procedures. Steps were taken to ensure that the children knew about the nature of the testing and were relaxed and free of distractions as they responded.

The group measures were administered in a classroom by the researcher and an assistant to some 25 subjects at a time seated in rows of desks with screens positioned to prevent any subject seeing the work of others.

#### Data Analysis

The pervasiveness of measurement error and its potential influence on the interpretation of data (Goldstein, 1979) means that the first analysis needed is one of the reliability of all measures.

Since reliability is specific to the sample and to the particular testing occasion, measurement error variance defined as internal consistency was calculated using Cronbach's coefficient alpha on the basis of the full sample for each value (Goldstein, 1979) using an SPSS programme (Hull and Nie, 1981). Two of the measures with variable ceilings depending on student responses, the Peabody Picture Vocabulary Test and the St. Lucia Graded Word Reading Test, presented problems for the calculation of alpha since it requires equal item

totals for each subject. To overcome this problem three coefficients were calculated for both tests each using a different cut-off point. The first point was that to which every child had completed, the second point was that to which 50% had completed and the third point included all responses of the highest scoring subjects. There was not a great deal of difference between the coefficients calculated in this way and the second cut-off point, which usually produced the lowest coefficient, was used as the most satisfactory basis for calculating reliability in these cases.

Calculation of the means and standard deviations, the t-test of the difference between the core sample and the control sample, the simple correlations for multitrait-multitime analysis and for predictor-criterion relationship and the multiple regression analyses were completed using SPSS computer programmes (Hull and Nie, 1981; Nie et al, 1975).

To allow for the graphical comparison of change over the five year period all means for each measure were reduced to standard scores with a mean of 0 and a standard deviation of 1 before being plotted on graphs. A multitrait-multitime analysis was provided by arranging the simple correlations in a matrix form as suggested by Campbell and Fiske (1959, see earlier discussion) both for all criterion measures and for the reading tests. This allowed an examination of both construct validity and developmental stability.

The relationship between the predictor variable groupings and the criterion variables was studied first using regression coefficients in

a backward regression procedure (Hull and Nie, 1981). All variables were first entered into the equation then the different variable groups, in turn, were omitted. The significance of the drop in the multiple correlation was calculated and used to assess the contribution of that variable group to the regression.

Path analysis was performed to represent and summarise the overall relationship of the predictor and criterion variables and to attach quantitative estimates to causal effects postulated on the basis of the theoretical model. The firm theoretical foundation for the present study, its longitudinal design and the usefulness of determining causal patterns in the relationships makes this form of analysis appropriate (Duncan, 1975; Kerlinger and Pedhazur, 1973; Wolfle, 1980). To handle the complexity of the interrelationships of the multiple variables over a five year period, the raw scores for each year were standardised and the composite measures of operativity, language and reading were computed as the basis for the structural analysis.

Path coefficients were calculated using COSAN (McDonald, 1980), a program developed to analyse covariant structures using maximum likelihood estimation procedures. The goodness of fit of a model was assessed by two methods, the overall chi-square statistic and the distribution of residual correlations.  $\chi^2$  measures the difference between the theoretical model and the observed data. The larger the value of  $\chi^2$ , the greater the difference. As a test of the significance of the difference, a p value is given. When, for example,  $p < .05$ , the difference between the data and the model is significant, i.e.

the data do not fit the theoretical structure. When  $p > .05$  the difference between the data and the model is insignificant and the structure is accepted. This procedure assumes that observations follow multivariate normal distributions. Although it is not possible to test this assumption formally, the continuous nature of the measures, the strength of the scales and the representative nature of the sample make the assumption a reasonable one. The COSAN program which is able to provide path coefficients for the whole model in one computation and gives a residual coefficient matrix for the estimation of fit, is more efficient with a large number of variables than the use of ordinary least squares regression procedures.

### Results

The major focus of the data, as indicated, is on the relationship of operativity and reading during the first five years at school while controlling for the influence of oral language. In addition, the effects of the child's developing awareness of print on these relationships will be examined. Before this is done, however, consideration will be given to the possible effects of repeated measurement and historical time period on the results. It is then proposed to explore the variables' construct validities, and the validities of the proposed variable groups. For this, multitrait-multitime analysis will be used. The nature of developmental change will next be studied, principally by an examination of increments in the means and of the pattern of stability values over the five years. This will lead to some reconsideration of construct validity of the predictor variables. Finally, the relationship of the predictor and criterion

variables will be considered using simple correlations, multiple regression and path analysis. The strength of the conclusions is considerably increased by the multiple comparisons provided by the longitudinal nature of the study which allow general trends in the data, rather than individual salients, to be the basis of such conclusions.

These results, however, indicate that three yearly waves of repeated  
Effects of Repeated Testing

To assess any effects on the core sample of repeated experiences of the same tests, 44 additional subjects, a control sample matched with the original children, were given the full battery of tests in the third wave (Table 4.2). For neither the reading tests nor the Piagetian measures, (Seriation and Perceptual Regulation) were any significant differences between the groups shown. Of the language measures, Units of Print and Grammatical Closure showed no significant differences but in the Peabody

Table 4.2. Effects of Repeated Testing Assessed at Wave Three for All Variables

	MEAN		Sig. of F for the difference
	Core Sample N = 136	Control Sample N = 44	
Word Recognition	34.07	34.64	-
Paragraph Understanding	12.84	11.16	-
Seriation	37.19	36.59	-
Perceptual Regulation	28.15	27.64	-
Vocabulary	71.32	74.96	x
Grammatical Prediction	28.15	27.64	-
Units of Print	19.69	19.93	-

x =  $p < .05$

Picture Vocabulary Test, the control sample, with a mean of 74.96, scored significantly better than the core sample which had a mean of 71.32 ( $p < .05$ ). This difference, in favour of the 44 new subjects, is unlikely to be a depressor effect of testing but perhaps registers a difference in school vocabulary teaching between the two groups. These results, however, indicate that three yearly waves of repeated testing gave no special advantage to the core subjects over those who were new to the tests. It seems that the school program, which involves activities and materials similar to the testing procedures, effectively prepared the children for assessment of this kind and that the additional annual testing of the core subjects made little appreciable difference at least at this third testing wave.

This finding is in accord with results obtained by Hooper, Toniolo and Sipple (1978) who checked repeated testing effects on operativity measures. They enrolled 48 additional subjects (original sample 102) in the second year of testing and found there were no significant differences in the performance of conservation and transitive inference tasks across the two groups. Although resource limitations in the present project have meant that retest effects could not be monitored over all years, this check gives some basis for the assumption that repeated measurement is not a significant influence on the results of the present data.

#### Effects of Historic Time Period

Another potential problem related to sampling is the differential effect of historical time period on development. There is some evidence (Baltes, Cornelius and Nesselroade, 1979) that different birth

cohorts may undergo different experiences that produce significant effects on intellectual development. No attempt was made in this present study to examine possible cohort effects by including other school year cohorts beyond the one selected and this may be a limit to the generality of the findings. However, McCall (1977) feels that this concern is overstated since neither the interrelationship of variables nor the stability of individual differences have been shown to be affected. The speculation of Baltes, Reese and Lipsitt (1980) that historic period influences operate most strongly in adolescence and early adulthood, while normative age-graded influences are dominant in childhood seems feasible and suggests that historic time period effects on the present data may not be great. As McCall, Eichorn and Hogarty (1977) point out, age, year of birth and time of measurement are inevitably confounded and no methodology exists to separate them without making some assumptions. That there is little peculiar effect of birth cohort in this sample seems a reasonable assumption for the interpretation of the data. However, should the results be compared with a cohort which experienced the direct effect of events such as a major war, an economic depression or a change of school admission age, the conclusion may need some qualification.

### Establishing Construct Validity

The reinterpretation of Campbell and Fiske's multitrait-multimethod analysis for longitudinal data provides four criteria which will be applied to the predictor and then to the criterion variables, in turn, to assess construct validity. It can also be extended to yield four other criteria which will be applied to assess the validity of the variable groupings.

Table 4.3. Multitrait - Multitime Matrix of the Predictor Variables over Five Years (Waves)

	WAVE 1				WAVE 2				WAVE 3				WAVE 4				WAVE 5			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
<u>Wave 1</u>																				
1. PR	(64)																			
2. Ser	10	(78)																		
3. GP	20	13	(97)																	
4. Voc	23	04	43	(90)																
<u>Wave 2</u>																				
1. PR	<u>29</u>	27	23	07	(79)															
2. Ser	17	<u>46</u>	13	10	27	(72)														
3. GP	28	34	<u>69</u>	41	31	33	(99)													
4. Voc	35	14	47	<u>60</u>	07	12	54	(99)												
<u>Wave 3</u>																				
1. PR	<u>22</u>	20	15	12	<u>30</u>	16	25	11	(86)											
2. Ser	14	<u>47</u>	15	04	16	<u>44</u>	26	13	23	(97)										
3. GP	19	28	<u>60</u>	31	20	27	<u>68</u>	44	17	26	(99)									
4. Voc	32	17	35	<u>45</u>	19	13	33	<u>64</u>	06	10	30	(94)								
<u>Wave 4</u>																				
1. PR	<u>27</u>	20	27	26	<u>35</u>	20	29	21	<u>65</u>	34	24	18	(77)							
2. Ser	13	<u>39</u>	04	03	01	<u>28</u>	08	-01	17	<u>46</u>	14	08	25	(86)						
3. GP	22	29	<u>45</u>	24	20	27	<u>68</u>	34	15	30	<u>64</u>	20	21	07	(89)					
4. Voc	26	25	42	<u>48</u>	21	18	44	<u>63</u>	15	16	42	<u>61</u>	25	09	30	(92)				
<u>Wave 5</u>																				
1. PR	<u>23</u>	22	24	26	<u>33</u>	19	28	17	<u>47</u>	30	23	15	<u>66</u>	18	15	27	(68)			
2. Ser	20	<u>25</u>	15	14	12	<u>32</u>	17	05	27	<u>45</u>	15	05	26	<u>28</u>	11	11	26	(59)		
3. GP	16	22	<u>40</u>	19	15	<u>26</u>	<u>48</u>	19	13	19	<u>56</u>	14	10	03	<u>63</u>	24	13	20	(64)	
4. Voc	29	21	43	<u>45</u>	25	20	46	<u>60</u>	13	15	45	<u>56</u>	30	08	41	<u>75</u>	35	02	29	(80)

PR = Perceptual Regulation

Ser = Seriation

GP = Grammatic Prediction

Voc = Vocabulary

Wave 1 = Kindergarten

Waves 2,3,4,5 = Grades 2,3,4 and 5 respectively.

Decimal points have been omitted for convenience of presentation.

Values in parentheses are reliabilities (Cronbach's alpha).

Values underlined constitute the stability value diagonals of each block.

Values in the adjacent column and row of each block exceed the correlations of different traits measured at the same time, i.e., coefficients situated in the adjacent value triangles.

Validity of Predictor Variables. The first criterion of multitrait-multitime analysis is that the stability values (underlined in Table 4.3) be significant and of sufficient magnitude to warrant further examination of validity. Although in some cases there is considerable fluctuation of the stability of the same predictor variable over five years, all 40 coefficients are significant and every variable has at least three coefficients larger than .45. The language variables, Vocabulary and Grammatic Closure, are the most stable with correlations ranging from .40 to .75 and each has an average value of .58. The Piagetian variables, Perceptual Regulation

and Seriation, are less stable with values ranging from .22 to .66 and each with an average value of .38. These lower levels of stability are not surprising, given that this age period is a time of major developmental change, according to Piaget's theory. For all variables, there is reason to proceed further with the investigation.

The second reinterpreted criterion is that the stability value should exceed the correlations between that trait and different traits measured at different times, i.e., in the adjacent column and row of the same block. Vocabulary, Grammatical Closure and Seriation all pass this test upon every comparison (60 for each). Perceptual Regulation meets the criterion on 55 out of 60 comparisons. The exceptions all occur when the year one measure predicts the responses at years three, four and five. Thus, there is complete support for the discriminant validity of Vocabulary, Grammatical Closure and Seriation on this criterion. Support for the discriminant validity of Perceptual Regulation is less strong but is, nevertheless, quite firm.

The third reinterpreted criterion requires that the stability value exceed the correlations of different traits measured at the same time, i.e., coefficients situated in the adjacent value triangles. Vocabulary and Grammatical Closure pass this test on all 60 comparisons, showing very strong divergent validity. Seriation passes this test on all but 3 of the 60 occasions and seems to possess good validity on this criterion. Perceptual Regulation passes the test on 54 of the 60 comparisons which seems to indicate a satisfactory level of validity.

The fourth criterion reinterpreted for multitrait-multitime

analysis, the pattern of the relationships of the values, is relevant to the analysis of the variable groupings and to developmental change so is left for the discussion of those issues.

Table 4.4. Multitrait-Multitime Matrix of the Reading Measures over Four Years.

In summary, the measures of language, Vocabulary and Grammatical Closure, show a high level of stability and of divergent validity. Of the operative measures, Seriation is also stable, although not as stable as the first two and possesses good discriminant validity. For the other operative measure, Perceptual Regulation, the stability, although significant throughout, fluctuates from low at first to high at later values and the discriminant validity is by and large good. Overall, the measures may be seen to possess moderate to strong convergent stability and at least satisfactory divergent validity. Considered together, these two attributes provide firm evidence for the construct validity of each of the four predictor variables. Reasons for the stronger construct validity of the oral language variables will be discussed in the section on developmental change.

Validity of Criterion Variables. To provide additional information on the construct validity of the main criterion variables, Word Recognition (St. Lucia) and Paragraph Understanding, a cloze reading test (GAP) was added to the battery in grades three and four and another reading comprehension test (Progressive Achievement Test) was added in grade four. The multitrait-multitime matrix (Table 4.4) reveals a strong and consistent stability for Word Recognition with six values ranging from .76 to .86 and an average value of .82. Its correlation with Paragraph Understanding and the other reading tests is moderate to strong, with values ranging from .38 to .67, yet it is

clearly distinct from them with its stability value greater than its correlation with any of them at every wave of measurement.

Table 4.4. Multitrait-Multitime Matrix of the Reading Measures over Four Years.

	WAVE 2		WAVE 3		WAVE 4			WAVE 5			
	WR	PU	WR	PU	WR	PU	C1	WR	PU	C1	PA
WAVE 2	WR (94)										
	PU	50 (96)									
WAVE 3	WR	85	52 (95)								
	PU	57	57	62 (95)							
WAVE 4	WR	77	47	84	60 (98)						
	PU	53	40	58	64	55 (90)					
	C1	55	44	62	59	62	66 (88)				
WAVE 5	WR	76	38	83	58	86	51	66 (92)			
	PU	58	42	64	57	58	63	66	67 (82)		
	C1	46	41	51	45	49	50	71	52	63 (84)	
	PR	44	40	57	52	52	60	67	59	66	68 (83)

WR - Word Recognition, St. Lucia Graded Word Reading Test

PU - Paragraph Understanding, Reading Comprehension

C1 - Cloze Reading

PA - Progressive Achievement Test, Reading Comprehension

Paragraph Understanding shows moderate to strong stability which tends to increase over time and which has values ranging from .40 to .64 with an average of .54. Although its convergent stability is not as strong as that of Word Recognition on this first multitrait-multitime criterion, it seems quite sound. Its divergent validity, in contrasts with other reading tests, however, is not strongly supported by the analysis.

In regard to the second criterion, involving discriminant validity, Paragraph Understanding's stability value is greater than its comparison values on 13 of the 21 occasions and, on the third criterion, is

greater on only 4 of the 21 comparisons. Its discriminant validity does increase over time when related to Word Recognition, however overall, it is not very distinct from Word Recognition and is less distinct from other reading measures. It seems that each is measuring a very similar capacity. Perhaps the distinctiveness of Word Recognition is to some degree a methods difference since it is an individually administered oral response test while the other three are group administered written response measures.

It is of interest to note that when comparisons of Paragraph Understanding with Word Recognition are one year removed not only is the convergent stability much stronger but the divergent validity comparisons are much more favourable. For the second criterion, it passes all six tests and for the third, it passes four out of six. When the comparison is two or more years removed on the second criterion, it fails in five of the six comparisons and on the third it fails all six comparisons. There thus seems to be a puzzling change in the rank order of subjects in reading comprehension which does not show itself in word recognition. Perhaps this is a developmental characteristic which is related to reading comprehension in a way it is not related to word recognition. This issue however, requires elucidation on the basis of further evidence.

Thus, in regard to the criterion variables, the analysis shows that Word Recognition possesses strong convergent and divergent validity and Paragraph Understanding possesses good convergent validity but, at best, fair divergent validity. In addition the analysis does support the validity of combining the two main tests even though

it suggests that not a great deal more variance may be controlled by the two than by either one. The validity of the predictor variable grouping will now be examined.

Validity of Variable Groupings. The previous multitrait-multitime analysis has shown that each predictor variable is distinct from all other variables including its theoretically determined partner. It is now necessary to examine whether this theoretical grouping receives empirical support. Do they belong together? The oral language partners, Vocabulary and Grammatic Prediction, will be considered first, then the operative grouping, Perceptual Regulation and Seriation will be discussed. The criteria as adapted from Campbell and Fiske (1959) and discussed earlier in the section, Bringing method and Theory Together Validity of Variable Grouping, will be applied.

The first criterion applied to the language pairing requires their correlation to be significant and involves the 25 coefficients of Vocabulary and Grammatic Prediction shown in Table 4.3. The values range from .14 to .54 with an average value of .35 and, all except one, are significant at the .05 level. Oral language thus passes the first variable grouping test. The second criterion concerns the discriminant validity of the grouping and requires their correlation to be greater than that of either when correlated with other variables measured at the same time. This involves 20 comparisons in the same-time triangles of values adjacent to the diagonal in Table 4.3. Oral language passes on 19 of the 20 comparisons and thus may be deemed to possess very good validity on this score. The third criterion, another discriminant validity test, requires the correlation

across time of a variable with its partner to be greater than its correlation with other variables measured at the same time as its partner. Of the 80 comparisons involved for oral language, it passes this test on 73 occasions demonstrating good discriminant validity. In regard to the fourth criterion, which compares across-time values of the variable partners and their same-time correlation with other variables, there are 80 comparisons. The oral language partners pass this test on 73 occasions, which, considering the stringent nature of this criterion, is an indication of very good divergent validity for that grouping. In sum, the oral language variables, Vocabulary and Grammatic Prediction, in their relationship to one another, are distinct though significantly related and in their relationship to other variables, possess very good divergent validity. Thus, their grouping as measures of oral language on the basis of theoretical considerations receives very good empirical support.

The operative variables, Perceptual Regulation and Seriation, receive some empirical support as a predictor pair but not as strong support for their grouping as do the oral language variables. On the first criterion, which assesses whether they are significantly and substantially related, the range of the values is from .01 to .34 with a mean of .20. Of these 25 values, 21 are significant at the .05 level. The relationship, although generally significant, is not very substantial. However, a closer inspection of the matrix reveals that the 4 non-significant values occur in correlations with Perceptual Regulation measured in the first two waves of testing, i.e., in Kindergarten and Grade 1. If the matrix is considered in two parts, with correlations involving Kindergarten and Grade 1 (waves 1 and 2)

and those involving grades 2 to 4 (waves 3, 4 and 5), there is a striking difference. Correlations with Kindergarten and Grade 1 tests have a mean of .16, while those involving Grades 2 to 4 only, have a mean of .25. This, however, may not be considered a valid comparison as the correlations with the first and second waves include variables tested three and four years later while those with the third and fourth waves are correlated only with variables tested one or two years later. Thus, the same test was applied with time-lag kept equal for both halves of the data, e.g., across no more than a two year span. This meant that the lower four blocks on the left of the matrix were excluded for this analysis. The results change very little with the mean correlation of waves one and two being .17 and of three and four, .25. Thus, although the correlations with the first two waves of testing of the operative variable grouping are not all significant and overall not very substantial, this pattern changes in the last three waves with all values significant and more substantial.

In regard to the second criterion, discriminant validity in relation to other variables measured at the same time (within the value triangles adjacent to the diagonal), the correlations of the two operative tests exceed their correlations with other variables in only 12 of the 20 comparisons. However, when the matrix is considered in two parts again, most of the failures in this criterion occur in correlations with the first two waves (5 out of 8 comparisons) while in the last three waves of testing there is a far smaller proportion (3 out of 12). A similar pattern emerges in application of the third criterion which assesses discriminant validity in relation to across-time correlation comparisons. Overall, of 80 comparisons, the two oper-

ative variables fail to pass the test on 36 occasions. Of these, 34 occur in correlations with wave one or two measures out of 56 comparisons. Of the 24 value comparisons with correlations in waves three and four, only 2 fail this test. Again, holding time-lag constant for both halves, the failure pattern is still greatly disproportionate with 11 out of 24 in the first half and 2 out of 24 comparisons in the second. In regard to discriminant validity as assessed by criteria two and three, the overall result is poor. However, closer analysis of the data reveals that the lack of discriminant validity is found almost entirely in relation to the measures taken in Kindergarten and Grade 1.

The fourth criterion requires across-time correlations of the partners to exceed their same-time correlations with other variables. Values for Perceptual Regulation and Seriation fail this test in 31 of 80 comparisons overall. This breaks down, on considering the two halves of the matrix (columns 1 and 2 in contrast with columns 3 and 4), as 29 out of 56 for waves one and two and 2 out of 24 for waves three and four. Holding time constant as above, this becomes 11 out of 24 for the first half and 2 out of 24 for the second. Again, although the overall data comparisons are not good on this criterion, the lower discriminant validity is found almost entirely in the first two waves of testing. The two operative variables show good discriminant validity in waves three and four.

In sum, the validity of the operative grouping varies across time. In the first two waves, although most of the convergent validity values are significant, they are not very substantial, while

the divergent validity is poor. At later waves, all convergent validity values are significant and more substantial while the divergent validity is good. Bearing in mind the stringent nature of the criteria as discussed earlier, this does not disqualify the operative variables as a grouping, especially since the great majority of the values that throw doubt upon the validity of the grouping occur in predictions spanning three or more years. Nevertheless, it calls for an explanation of the difference between the lower validity with subjects six and seven years old and the higher validity at ages eight and nine. Four possibilities need consideration; variations in reliability, changes in task content, practice effects of repeated measurements, and the influence of developmental change.

A first consideration, that the difference is due to reliability, will bear some explanatory weight but not all. The alpha value for Perceptual Regulation is lowest in wave one (.64) but this is not so for Seriation which has its lowest value in wave five (.59). However, the strongest reliability values are shown in waves three and four which may be part of the reason for stronger validity in relation to those waves. Yet differences in reliability values are not very great and other explanations are needed.

Another possible explanation is that the difference is due to the variations in the Seriation Test content to match changing subject capacity (a 5 x 5 matrix task was added from wave three and single seriation was omitted at wave five). This certainly seems to be the reason why the reliability for this measure is highest in waves three and four where it has the most items. However, the greater part of the

Developmental Change  
lower discriminant validity is in relation to Perceptual Regulation which does not change its form at all over the five waves of testing. Thus, although change in the form of the Seriation Test may be a factor, it does not seem to account, in itself or in combination with the first explanation, for the striking difference between the earlier and later validity values for operativity. The difference is too great.

A further suggestion is that practice effects become evident in regard to operativity after two waves of testing and thus the results become more stable and distinct. However, the failure to find significant differences for operativity between the core subjects and the fresh subjects recruited in wave three, argues against this, as does the absence of this effect in the language variables. Both operativity and oral language tasks seem equally familiar to school pupils. Nor do the measurement procedures admit of any irregularities which could be an explanation of this difference.

All these suggestions, even in combination, do not possess sufficient explanatory strength to bear the full weight of the data. There seems to be another factor (or other factors) operating.

Perhaps the most important explanation is one that is consistent with the developmental theory proposed: In middle childhood, there is such major cognitive developmental change that it will inevitably produce fluctuating values such as these. This possibility will be considered in relation to a broader examination of the data in the next section.

## Developmental Change

There are two principal sources of information on developmental change in longitudinal data - comparison of means and comparison of stability values - which, when considered concurrently, give a far more sensitive index of the nature of change than either on its own. The stability coefficients can provide an assessment of the effects of individual differences in developmental change and perhaps suggest the existence of qualitative change, as discussed earlier. This is very important for the present data in which two different forms of developmental change in the predictor variables, reflecting greater and lesser degrees of continuity and qualitative difference, are expected on theoretical grounds. The forms of change predicted are firstly, those revealing continuous quantitative increments (e.g., oral language), and secondly, those revealing marked qualitative disturbance, either together with continuous quantitative increments, e.g., perceptual regulation or as discrete qualitative change, e.g., seriation. In this study the means and stability values can be compared from one kind of variable to the next to determine whether this theoretically predicted pattern can be detected. This gives further valuable insight into construct validity because it considers whether the variables perform as they are theoretically expected to do. It may thus suggest a broadening of the idea of construct validity as developed on the basis of psychometric assumptions. In this section an additional assessment of the nature of developmental change evidenced in the MTMT analysis will be given by path analysis of the language grouping, the operativity variable grouping and the grouping of the reading measures. The predictor and the criterion

for correlational and related analyses which are independent of the means. To allow easier interpretation of these data and comparability from one variable to another, all means were standardised so that each

variables will be considered separately.

#### 4.1 Development of Predictor Variables

The means and standard deviations for all predictor variables are shown in Table 4.5.

Seriation, the content of which was modified to allow for changes in

Five Waves of Measurement (Kindergarten to Grade 4).

Table 4.5 Means and Standard Deviations for All Measures

	WAVE 1		WAVE 2		WAVE 3		WAVE 4		WAVE 5	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
P R	8.19	3.04	10.40	3.16	11.67	3.05	13.49	3.48	14.92	3.37
Sr I	26.50	9.58	34.20	5.29	37.19	3.32	38.87	2.68	39.60	2.38
Sr II	-	-	-	-	31.05	4.42	32.73	3.70	35.24	3.02
GP	20.16	4.49	24.27	4.16	28.15	3.19	29.63	2.23	30.73	1.73
Voc	59.45	8.06	64.37	7.78	71.32	10.29	76.86	9.92	82.98	6.86
WR	-	-	21.25	8.33	34.07	9.57	44.44	12.34	54.21	12.15
PU	-	-	3.15	3.45	12.84	6.65	20.83	7.73	25.02	5.29
Clo	-	-	-	-	-	-	23.60	6.44	28.33	5.61
PAT	-	-	-	-	-	-	-	-	19.25	6.86
UOP	-	-	17.80	3.60	19.69	2.18	20.87	1.67	-	-

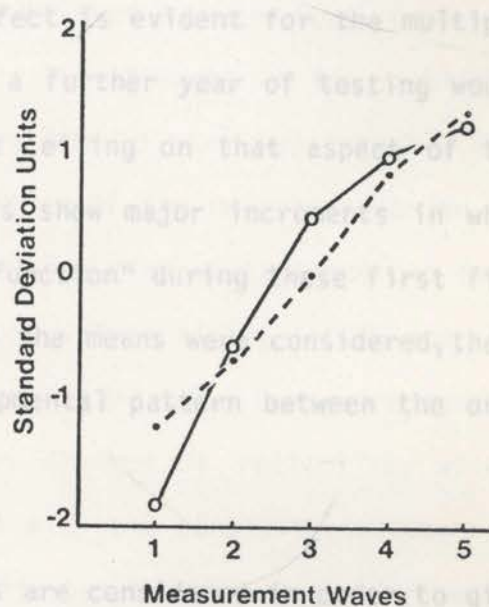
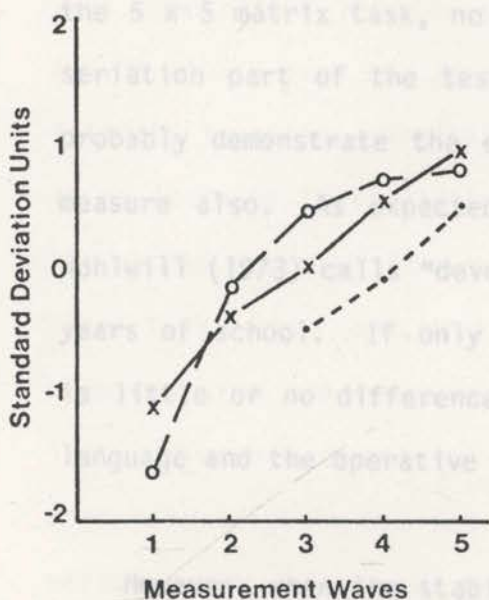
PR	=	Perceptual Regulation
Sr I	=	Seriation: Single & Multiple 3 x 3
Sr II	=	Seriation: Multiple 3 x 3 and 5 x 5
GP	=	Grammatic Prediction
Voc	=	Vocabulary
WR	=	Word Recognition
PU	=	Paragraph Understanding Test
Clo	=	Cloze: Reading
PAT	=	Progressive Achievement Test: Reading
UOP	=	Units of Print

development, is shown in two sections, single and multiple 3 x 3, across all waves and multiple, 3 x 3 and 5 x 5, measured from wave three onwards. The fifth wave value for the first section of Seriation is, in part, an estimate based on the value of single seriation at wave four, since single seriation, having attained a ceiling by wave four, was not assessed in wave five. The two sections are combined for correlational and related analyses which are independent of the means. To allow easier interpretation of these data and comparability from one variable to another, all means were standardised so that each

measure across all years of assessment had a mean of 0 and a standard deviation of 1.0 before being plotted on graphs as shown in Figures 4.1 and 4.4.

**Figure 4.1** Standardized Mean Scores for Predictor Variables over Five Waves of Measurement (Kindergarten to Grade 4).

A. Operativity variables      B. Oral Language Variables



x—x Perceptual Regulation  
 ····· Seriation (Multiple 3x3 & 5x5)  
 o—o Seriation (Single, Multiple 3x3)

o—o Grammatical Prediction  
 ····· Vocabulary

stability values are consistent across the five waves of measurement. An inspection of the oral language stability values (underlined in Table 4.3) shows a uniform and strong pattern across the five years with very little difference between Grammatical Prediction and Vocabulary. In correlations of variables one year removed there are eight values which range from .60 to .75, with a mean of .66. These decline somewhat when variables measured two or more years apart are correlated but remain moderate to strong, ranging from .40 to .68 with a mean of .53. This represents a high stability and indicates little change in the rank order from one year to the

Considering increments in the means first, it is clear that for all four predictor variables, the years of the study have witnessed dramatic quantitative growth (Figure 4.1). Both Perceptual Regulation and Vocabulary follow a near linear function with little sign of any ceiling effect in the measures. Seriation (single and multiple 3 x 3) and Grammatic Prediction tend towards an asymptotic function with ceiling effects of the tests becoming evident at the fourth and fifth waves of measurement. However, when Seriation is expanded by adding the 5 x 5 matrix task, no ceiling effect is evident for the multiple seriation part of the test, although a further year of testing would probably demonstrate the effect of a ceiling on that aspect of the measure also. As expected, all tasks show major increments in what Wohlwill (1973) calls "developmental function" during these first five years of school. If only changes to the means were considered, there is little or no difference in developmental pattern between the oral language and the operative variables. *by changes in reliability which does vary slightly but not in parallel with the stability values.* However, when the stability values are considered in order to give an indication of individual differences from one year to another, there are striking contrasts. An inspection of the oral language stability values (underlined in Table 4.3) shows a uniform and strong pattern across the five years with very little difference between Grammatic Prediction and Vocabulary. In correlations of variables one year removed there are eight values which range from .60 to .75, with a mean of .66. These decline somewhat when variables measured two or more years apart are correlated but remain moderate to strong, ranging from .40 to .68 with a mean of .53. This represents a high stability and indicates little change in the rank order from one year to the

next and not very much more change across two, three, or even four years. Despite major increments in performance for the whole group, the order of students on these language capacities varies little during the years of the study, i.e., individual differences in development are not great.

The stability of the operative variables presents an entirely different picture. Perceptual Regulation, in all its first and second wave comparisons, has low stability coefficients which range from .22 to .35 with a mean of .28 (Table 4.3). The strength of the stability estimate increases marginally from wave one to wave two, probably due to an increase in the internal consistency of the measure recorded at the second testing. However, in comparisons with waves three and four, there is a marked jump, with the stability values rising to .65 and .66 when measures are compared one year apart and .45, two years apart. This difference cannot be explained by changes in reliability which does vary slightly but not in parallel with the stability values. If measures were taken only at waves one and two, the interpretation would be difficult. Is there a degree of developmental instability or is the measure a weak one? The high stability in relation to waves three and four rules out this second interpretation. The considerable switching in rank order across the first three measures reflects individual differences in development, suggesting that the first two years of school witness a period of marked developmental change most likely of a qualitative kind, that settles down in year three. The rank order established then is largely maintained for the next two years.

Seriation possesses moderate stability in all its comparisons

across one year except in the last comparison, with coefficients of .46, .44, .46 and .28. This lower final value seems to be a measurement aberration as the test in wave five is shorter (with the first part, Single Seriation, omitted), captures less variance (especially in the second part, the matrix 3 x 3) and possesses the lowest alpha reliability (.59) for any of the variables over all waves of testing. The stability values across two or more years are low to moderate and range from .25 to .45 with a mean of .36. These values seem to reflect fairly considerable changes in rank order over the five years of testing. Changing the content of the test at year three (adding a 5 x 5 matrix task) to ensure appropriate measurement over the five year period seems to have largely sustained the variance of the test (despite some decline) as well as the level of individual differences across the five years. There seems to be no direct way to register the attainment of high stability on this kind of infralogical task since, when all subjects have mastered the task, the variance is small and correlations decline. Only by indirect assessment can the change from lower to higher stability be shown, for example, in a capacity which possesses some continuity but shows a disturbance in performance by lower stability for a period, as was found by McCall, Eichorn and Hogarty (1977) in the reanalysis of longitudinal IQ data and as has been found here for Perceptual Regulation.

In sum, the variables all reveal marked increases in developmental function (mean increments) over the period studied but varied levels of individual differences in this development as shown by the contrasting patterns of stability. This suggests that different kinds of developmental change may be taking place and, in accordance with the

predictions based on theoretical grounds, two kinds of development may be detected. First, oral language shows quantitative increases and high stability implying minimal interindividual variation in development. Second, the two operative variables also increase quantitatively but, overall, possess far less stability, suggesting marked individual differences as shown by a reshuffling of the rank order. After early instability, Perceptual Regulation settles down at the third wave and remains as stable as the language variables after that. Seriation largely reveals moderate levels of stability throughout because the variance has been maintained by deliberately modifying the instrument over the five years to allow for predicted growth. For both operative variables, this lower stability seems to imply that, unlike language, a qualitative change is occurring which produces these individual differences in development.

language variables.

A further test of the nature of this change is now proposed by subjecting the predictor variable groupings to path analysis in order to study the relationship of the same grouping over the five testing occasions. Will this difference in the pattern of development be evident in the causal relationships of each of these two predictor variable groupings? The analysis, performed with the COSAN program (McDonald, 1980), provides a residual matrix to guide in the addition or subtraction of specific paths and a chi-square test to indicate overall goodness of fit.

B. Full Model

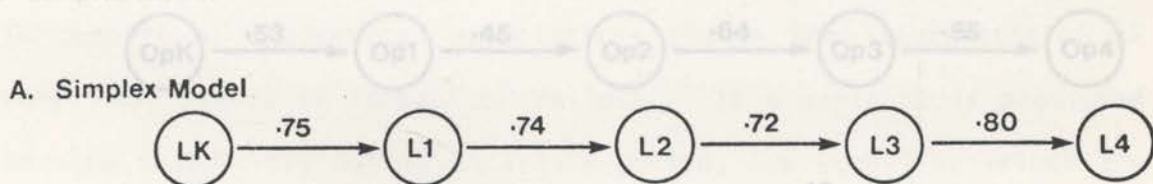
The path analysis of language, shown in Figure 4.2, began with a simplex in which only direct links between successive years of measurement were postulated (Figure 4.2A). This structure did not

reproduce the pattern of correlations ( $\chi^2 = 41.8$ ,  $df = 7$ ,  $p < .0001$ ) so additional paths were inserted until an adequate model (Figure 4.2B) was derived ( $\chi^2 = 1.7$ ,  $df = 4$ ,  $p = .78$ ). This structure, which represents an auto-regressive process of order two (Anderson, 1971), displays a symmetrical pattern of development in which each language result, except the first, depends on two others, the measure immediately prior to it and the one before that. The variance explained at the four waves after the first, ranges from 52% to 64% with an average of 56%. The structure seems to represent a cumulative learning model in which each wave of longitudinal measurement exerts two years of direct influence on future development but its effect is then subsumed by later measures in successive waves. There seems to be a highly stable and regular pattern of change similar to the result indicated by the multitrait-multitime developmental analysis of the language variables.

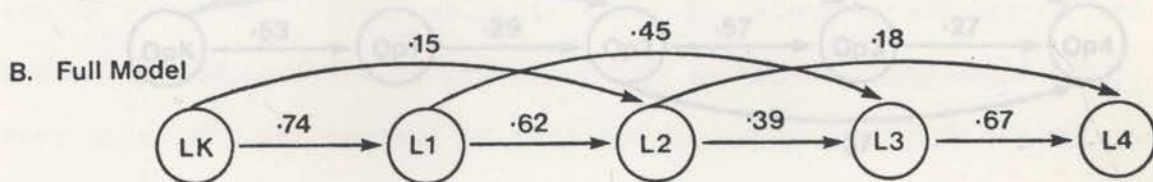
Figure 4.3 Path Analysis of the Relationships between Operativity

Figure 4.2 Path Analysis of the Relationships between Oral Language over Five Waves of Measurement (Kindergarten to Grade 4).

A. Simplex Model



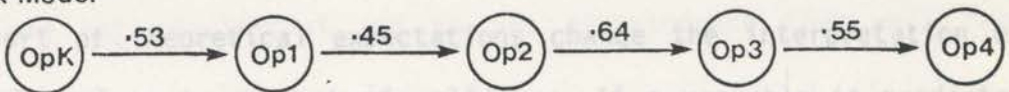
B. Full Model



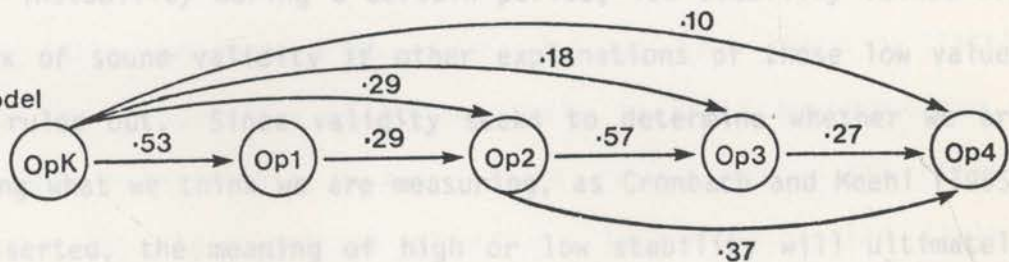
A quite different pattern emerged when operativity was analysed in a similar manner. The simplex (Figure 4.3A), in which only direct paths from one wave to the next were inserted, proved to be an inadequate fit ( $\chi^2 = 41.8$ ,  $df = 7$ ,  $p < .0001$ ) and more paths were added until the most parsimonious structure (Figure 4.3B) was attained ( $\chi^2 = 2.92$ ,  $df = 3$ ,  $p = .40$ ). This displays an asymmetrical developmental pattern in which kindergarten operativity continues to have a direct effect on each subsequent wave of operativity in addition to its indirect effects. Grade 2 operativity (wave three) has an additional direct effect on the Grade 4 capacity but this seems to be a result of the change in test content from wave three onward. The variance controlled at each point after the first is much lower than that controlled by language, having a range from 20% to 41% and an average of 29%.

Figure 4.3 Path Analysis of the Relationships between Operativity over Five Waves of Measurement (Kindergarten to Grade 4).

A. Simplex Model



B. Full Model



Kindergarten operativity seems to exert a unique effect across the whole range of measurement waves that declines as it becomes further removed but continues to be significant to the fifth wave. By contrast with the cumulative learning model of the language variables, there seems to be a basic process laid out in the first year (Kindergarten) which remains directly implicated in the development of operativity at each successive year. Certainly the path analysis presents further evidence that operativity and language follow quite different developmental patterns. The asynchronous pattern of operativity seems to give additional indirect evidence for a qualitative disturbance in development, as noted in the previous analysis and as reported in other studies of this five to nine years age span (White, 1965, 1970).

Development and Construct Validity. We are now in a position to reconsider the question of the construct validity of the operative variables discussed earlier, especially the apparently poor discriminant validity of Perceptual Regulation found by comparisons across the first three waves. The developmental patterns which have emerged in support of theoretical expectations change the interpretation of numerical values in respect of validity. If a variable is predicted to show instability during a certain period, low stability values are an index of sound validity if other explanations of those low values can be ruled out. Since validity seeks to determine whether we are measuring what we think we are measuring, as Cronbach and Meehl (1955) have asserted, the meaning of high or low stability will ultimately depend on theoretical assumptions. The study therefore requires some reconsideration of the construct validity expectations discussed by

Campbell and Fiske. These are based on psychometric assumptions that do not necessarily hold in some kinds of data (Wohlwill, 1980). It may be wondered whether convergent and discriminant validity apply at all to data which reveals developmental disturbance, presumably qualitative change, as is being claimed for some variables in this study. Yet, despite developmental discontinuity, continuity is also evident and the question must become one of whether a variable, even though it shows qualitative disturbance, maintains its identity sufficiently to be recognisable in terms of its original conception. This means that less stringent psychometric demands can be made of it to establish validity during a period of its developmental transformation. Thus, although the construct validity of the operativity variables appears to be considerably less strong than that of the oral language variables, it is, nevertheless, sufficient and a lower validity status does not seem appropriate. Oral language may simply suit the psychometric assumptions of the technique more readily.

On this basis, there may be no need for concern about the validity of the operativity variable grouping when some of their early correlations are not significant and do not discriminate them well from other measures. As the data show, they do demonstrate a considerably greater convergence in correlations at the third and later waves. This is fully consonant with other findings that there is little relationship of operative capacities early in their emergence but a considerable relationship as they become established in the child's repertoire and the cognitive structures become integrated (Arlin, 1981; Flavell, 1971; Tomlinson-Keasey et al, 1979).

By contrast, Paragraph Understanding, although possessing moderate to strong stability with a mean of .54, is consid-

Development within the Criterion Variables. The results in regard to developmental change for the criterion variables are presented in three forms; mean values, stability patterns and path analysis of effects. The means (Table 4.5) which were standardised and represented is little difference in the reliabilities of the two tests in waves

Figure 4.4 Standardized Mean Scores for Reading over Four Waves of Measurement (Grade 1 to Grade 4).

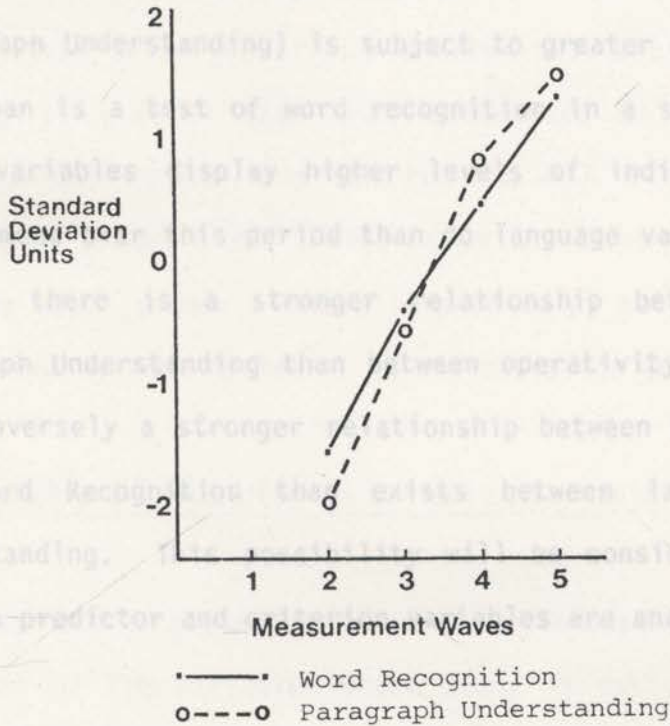
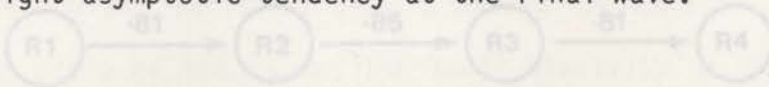


Figure 4.5 Path Analysis of the Relationships between Measures of graphically in Figure 4.4, indicate marked increases in developmental function over the four years of testing, with Word Recognition following an almost perfect linear function and Paragraph Understanding showing a slight asymptotic tendency at the final wave.

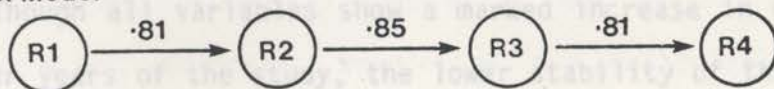


The strong and consistent stability of Word Recognition (mean value .82) over this period shows that, despite dramatic change in developmental function, individual differences from one year to the next are slight. By contrast, Paragraph Understanding, although possessing moderate to strong stability with a mean of .54, is consid-

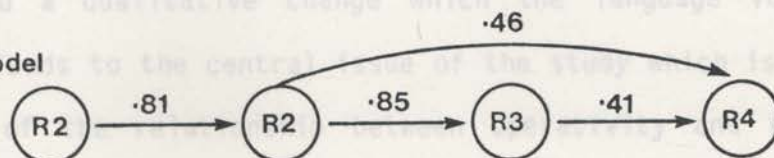
erably less stable during these early years of school. It might be considered that this is caused by the presence of greater measurement error in the tests, however, an inspection of the reliability values (in parentheses, Table 4.4) does not support this explanation. There is little difference in the reliabilities of the two tests in waves two and three and a marginal advantage for Word Recognition in waves four and five. Perhaps by its nature a test of reading comprehension (Paragraph Understanding) is subject to greater developmental disturbance than is a test of word recognition in a similar way that operative variables display higher levels of individual differences in development over this period than do language variables. Furthermore, perhaps there is a stronger relationship between operativity and Paragraph Understanding than between operativity and Word Recognition and conversely a stronger relationship between the language variables and Word Recognition than exists between language and Paragraph Understanding. This possibility will be considered as relationships between predictor and criterion variables are analysed.

Figure 4.5 Path Analysis of the Relationships between Measures of Reading taken over Four Waves (Grade 1 to Grade 4).

**A. Simplex Model**



**B. Full Model**



The path analysis of the reading variable grouping, which is shown in Figure 4.5, was begun with the simplex (Figure 4.5A) which was, however, unable to reproduce the correlations, ( $\chi^2 = 21.7$ ,  $df = 4$ ,  $p < .0002$ ). An additional path was necessary between R2 and R4 (Figure 4.5B) to give an adequate representation ( $\chi^2 = 1.87$ ,  $df = 3$ ,  $p = 0.6$ ). This has the effect of reducing the coefficient of the direct link between R3 on R4 from .81 to .46. Recomposition of the effects at each year after the first indicates that the variance controlled by reading is greater than that controlled by either operativity or language and ranges from 65% to 72%, with a mean of 69%. In sum, reading at Grades 2 and 3 depends on achievement at the previous grade in each case (Grades 1 and 2 respectively) but reading at Grade 4 is influenced by what is learnt at the two prior grades.

#### Relationship of Predictor to Criterion Variables

The results presented so far have demonstrated that the construct validity of the variables under study is satisfactory. In regard to the validity of their grouping, on multitrait-multitime assessment it is generally satisfactory but the operative variables show some fluctuation. This occurs, however, according to developmental expectations and seems to confirm further the validity of the grouping. Though all variables show a marked increase in mean values over the four years of the study, the lower stability of the operative variables suggests that they undergo a period of developmental surge and a qualitative change which the language variables do not. This leads to the central issue of the study which is to examine the nature of the relationship between operativity and reading and thus to test a cognitive developmental theory of learning to read

(Chapter 1). Study one demonstrated a link between the operative variables and reading which is partly distinct from oral language. Study two showed that operativity is causally implicated in the development of an understanding of the units of print - a metalinguistic capacity important for early reading. The present study will now seek to follow this developmental pattern of operativity in its relationship to the child's emerging reading competence during the first five years of school in order to determine whether it has a causal effect upon that capacity. Its influence on reading will be compared with that of language which has been shown to follow a markedly different developmental progression.

Do the different developmental patterns which have been observed for operativity and oral language have distinct and different effects on the development of reading?

The relationship will be studied initially by examination of the simple correlations and of regression analysis. To explicate the pattern of effects for the purpose of causal attributions, path analysis will be used.

Prediction of Dependent Variables. The simple correlations of the operative variables, Perceptual Regulation and Seriation, and the language variables, Grammatic Prediction and Vocabulary, with the reading tasks, Word Recognition and Paragraph Understanding, are presented in Table 4.6.

The values are all positive, mostly significant, and low to moder-

ate in strength. Seriation is generally more strongly correlated with reading than is Perceptual Regulation and Grammatic Prediction is more strongly correlated with reading than is Vocabulary. There is some change in the strength of the relationships over the years but no dramatic shifts. The language variables increase their relationship to reading with time although Vocabulary has the lowest correlations of all predictor variables and Grammatic Prediction possesses the highest. The operative variables seem more strongly related to reading

Table 4.6. Correlation Matrix for the Prediction of Reading by Operativity and Language Variables

		WAVE 1		WAVE 2		WAVE 3		WAVE 4	
		WR	PU	WR	PU	WR	PU	WR	PU
Wave 1.	1.PR	.21	.20	.24	.19	.20	.18	.21	.31
	2.Ser	.31	.28	.33	.28	.34	.38	.27	.34
	3.GP	.28	.24	.27	.31	.27	.25	.27	.29
	4.Voc	.07	.20	.10	.09	.12	.15	.14	.14
Wave 2.	1.PR	.18	.26	.23	.30	.27	.30	.27	.30
	2.Ser	.28	.31	.22	.35	.17	.38	.22	.28
	3.GP	.46	.44	.47	.45	.44	.50	.43	.39
	4.Voc	.07	.25	.14	.18	.09	.24	.10	.18
Wave 3.	1.PR			.18	.21	.11	.25	.20	.30
	2.Ser			.26	.29	.23	.33	.26	.34
	3.GP			.39	.41	.38	.41	.45	.45
	4.Voc			.15	.21	.13	.21	.13	.22
Wave 4.	1.PR					.21	.35	.24	.29
	2.Ser					.22	.22	.20	.28
	3.GP					.47	.35	.48	.43
	4.Voc					.23	.30	.19	.24
Wave 5.	1.PR							.18	.28
	2.Ser							.24	.34
	3.GP							.45	.47
	4.Voc							.22	.25

WR = Word Recognition  
 PU = Paragraph Understanding Test  
 PR = Perceptual Regulation  
 Ser = Seriation  
 GP = Grammatic Prediction  
 Voc = Vocabulary

comprehension than to word reading and, to test this possibility, which has been suggested by the comparison of their stability patterns earlier, the operative variables were regressed onto Word Recognition and Paragraph Understanding in turn (Table 4.7). To test the converse, that language is more strongly related to word reading than to reading comprehension, a similar procedure was followed for the language variables (Table 4.7). This analysis gives further opportunity to compare the predictive patterns of operativity and

Table 4.7. Multiple Regression on the Operative and Oral Language Variables of Word Recognition and Paragraph Understanding

		WAVE 2		WAVE 3		WAVE 4		WAVE 5	
		WR	PU	WR	PU	WR	PU	WR	PU
Wave 1	Oper	.36	.33	.39	.33	.38	.40	.33	.44
	Lang	.28	.26	.27	.32	.27	.25	.27	.29
Wave 2	Oper	.31	.38	.29	.44	.30	.45	.32	.39
	Lang	.50	.44	.49	.46	.47	.50	.45	.39
Wave 3	Oper			.28	.32	.23	.37	.29	.41
	Lang			.39	.42	.38	.42	.45	.46
Wave 4	Oper					.27	.36	.28	.36
	Lang					.48	.41	.48	.44
Wave 5	Oper							.27	.39
	Lang							.46	.49

WR = Word Recognition  
 PU = Paragraph Understanding  
 Oper = Operativity  
 Lang = Oral Language

language to reading and especially to examine the extended predictive relationships over the five annual testing occasions.

The multiple regression values of operativity with the two reading tests show that operativity is more closely related to reading compre-

hension than it is to word reading (Table 4.7). Of the 14 comparisons, the correlation is stronger with Paragraph Understanding on 12 occasions. This cannot be explained as the result of less measurement error in the Paragraph Understanding Test since in all 12 occasions when operativity is more strongly related to Paragraph Understanding its reliability, being equal to or lower than that of Word Recognition, would bias the results in the opposite direction (Table 4.4). The two times when operativity is more strongly related to Word Recognition occur in comparisons with the first and second testing of reading when it is at its most elementary level and reading comprehension is in a relatively unformed state.

Thus, one reason that reading comprehension is less stable than word recognition, as observed earlier, seems to be that it draws to a greater extent on the developmentally surgent operative capacities. The converse, that oral language is more closely related to word reading, does not gain support in the data (Table 4.7), since, of the 14 multiple correlation comparisons, language is more strongly related to Word Recognition on six occasions and to Paragraph Understanding on eight. Its greater stability does not seem to stem from its stronger relationship to the more stable language variables than Paragraph Understanding.

Examination of the patterns of relationship across time for language to either reading measure and for operativity to word recognition, reveals some fluctuation but no major changes (Table 4.7). By contrast, there is generally an increase in the prediction of reading comprehension by operativity as the time interval between them increases. This is most distinct for wave one operativity with values

rising from .33 at waves two and three, to .40 at wave four and .44 at wave five. This cannot be explained by increased reliability since the values do not follow this trend for either operativity (Table 4.3) or Paragraph Understanding (Table 4.4). This result, however, tends to parallel the pattern of increasing stability, at least for the Perceptual Regulation component of operativity and for Paragraph Understanding. As has been discussed, these seem to reflect a qualitative change in development which may also underlie the increasing influence of operativity on reading comprehension over time. Further inspection of the data (Table 4.7) shows that, when concurrent multiple correlations with reading (of variables measured in the same year) are compared with distal correlations (of variables measured one or more years apart), a striking difference between the pattern of operativity and oral language associations is evident. In the prediction of reading comprehension or word recognition by oral language, concurrent correlations are generally stronger (in 15 out of 20 cases) as might be expected. In the prediction of reading by operativity, the opposite pattern exists; distal multiple correlations are generally stronger than concurrent ones (in 17 out of 20 cases). This pattern is most striking for wave one and the effect is much less in waves three, four and five but there can be no doubt about this unusual general trend in the data. Operativity measured a year or more previously in this age range predicts reading more strongly than does a concurrent operativity measure. While there may be some influence of changing reliability on these results, the reliability pattern over the five years does not support this interpretation of the finding. Operativity, especially that measured at Kindergarten, seems to exert a unique influence on reading which will be further explored with path analysis.

In further considering the pattern of relationships, operativity at Kindergarten (wave 1) is, in all 8 comparisons, the stronger predictor of both reading measures. From Grade 1 onward (wave 2), of 20 comparisons, oral language is the stronger predictor in all except one. This seems to suggest a change in the causal relationships over two oral language measures on a composite reading score (a

**Table 4.8.** Multiple Regression of Reading on Operativity and Oral Language with the Effects of Omitting Operativity and Oral Language in turn from the Equation.

		Wave 2 Reading Mult R Sig		Wave 3 Reading Mult R Sig		Wave 4 Reading Mult R Sig		Wave 5 Reading Mult R Sig	
Wave 1	FM	.45	-	.47	-	.49	-	.47	-
	Omit Oper	.30	xx	.33	xx	.30	xx	.30	xx
	Omit Lang	.40	x	.39	xx	.44	x	.41	x
Wave 2	FM	.56	-	.56	-	.58	-	.50	-
	Omit Oper	.53	x	.53	x	.54	x	.45	x
	Omit Lang	.40	xx	.40	xx	.42	xx	.38	xx
Wave 3	FM			.50	-	.50	-	.55	-
	Omit Oper			.45	x	.45	x	.49	xx
	Omit Lang			.34	xx	.34	xx	.38	xx
Wave 4	FM					.55	-	.57	-
	Omit Oper					.50	x	.51	xx
	Omit Lang					.35	xx	.34	xx
Wave 5	FM							.57	-
	Omit Oper							.52	xx
	Omit Lang							.36	xx

Sig = significance of F for the omission of the variable grouping

xx =  $p < .01$ , x =  $p < .05$

FM = Full Model

Oper = Operativity

Lang = Language

time which will be further analysed, first with a backward multiple regression procedure to test the relative strength of operative and other predictor variables, and second, with path analysis.

The multiple regression of the two operativity measures and the two oral language measures on a composite reading score (a standardised unweighted average of Word Recognition and Paragraph Understanding) and the effects of omitting each predictor from the equation are shown in Table 4.8. In all cases, both operativity and language add significantly to the prediction of reading. None of the reductions in the coefficient caused by omitting a variable group fails to attain significance. A closer examination of the values indicates an important pattern in the data which confirms the impression gained from the correlational matrix (Table 4.6). At wave one, operativity is by far the more dominant variable with its omission causing the greater drop in the multiple correlation, e.g., from .45 to .30 for the first comparison while omission of language reduces the value to .40. However, from wave two onward, language becomes the consistently stronger influence. This may have causal implications which will be further elucidated by path analysis.

3. The declining variance of the test (Table 4.5) bears this out. It

see Awareness of the units of print, which has been studied in detail as a criterion measure (chapter 3), is used in this study as a predictor variable of reading. Its relationship to reading when combined with the other predictors in waves two, three and four is shown in Table 4.9.

Multiple regression indicates that operativity and language are partly distinct from each other in their prediction of reading as was found in study one (Chapter 2). In addition, oper-

Table 4.9. Multiple Regression of Reading on Units of Print, Operativity and on Language with the Effects of Omitting Units of Print from the Equation

		Wave 2		Wave 3		Wave 4		Wave 5	
		Reading	Sig	Reading	Sig	Reading	Sig	Reading	Sig
Wave 2	FM	.62	-	.60	-	.62	-	.53	-
	Omit UOP	.56	xx	.56	xx	.58	xx	.50	
Wave 3	FM			.54	-	.54	-	.58	-
	Omit UOP			.50	x	.50	x	.55	x
Wave 4	FM					.56	-	.57	-
	Omit UOP					.55		.57	

Sig = Significance of F ratio for omitting UOP from the equation. xx =  $p < .01$  x =  $p < .05$

FM = Full Model (Operativity, Oral Language, Units of Print)

UOP = Units of Print

Its effects are clearly most powerful in its wave two measurement and less so but still significant in two out of three regressions in its wave three relationships. By wave four, this measure exerts no significant influence. This pattern is not surprising, since, although being able to discriminate a number, a letter, a word and a sentence is a task which is still being mastered in Grade 1, it is largely known in Grade 2 and finds very few who have not mastered it by Grade 3. The declining variance of the test (Table 4.5) bears this out. It seems that other metalinguistic tasks are required to discriminate amongst these older subjects on linguistic awareness.

Thus, analysis of the prediction of reading using simple correlations and multiple regression indicates that operativity and language are partly distinct from each other in their prediction of reading as was found in study one (Chapter 2). In addition, oper-

activity has a unique and dominant early relationship with reading (at Kindergarten) while oral language has the stronger relationship later (Grades 1, 2, 3 and 4). This is in keeping with the developmental pattern found earlier for each separately; language develops in a synchronous way and operativity in an asynchronous manner, with a basic process laid out by Kindergarten influencing all later levels. This pattern of results suggests that operativity and oral language exert different causal effects on reading. Path analysis will now be used to elucidate this suggestion.

Pattern of Effects. The path analysis, which examines the causal relationships of the data across the five testing periods, has two major analytic phases; the first to establish the pattern of effects of operativity and language on reading and the second to assess the additional influence upon this pattern of an understanding of the units of print. This will allow the longitudinal testing of the hypothesis of the study that operativity has a causal influence on learning to read. The various path analytic models will be introduced in increasing order of complexity.

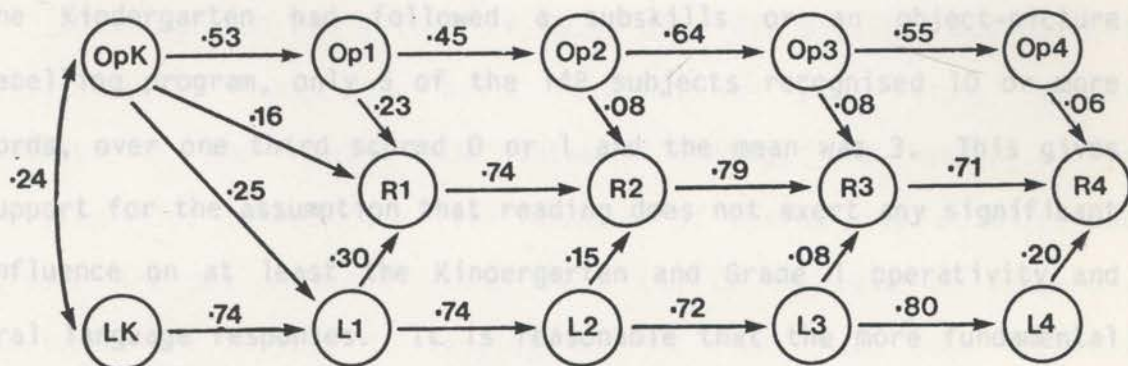
The first phase, linking operativity, language and reading, is addressed by the path diagram shown in Figure 4.6.

This structure is formed by linking the simplex diagrams from the three earlier analyses of language, operativity and reading (Figures 4.2A, 4.3A and 4.5A). The direction of effect is shown by the single headed arrows and the strength of effect by the path coefficients on the shaft of each arrow. A double headed arrow joins the two exogenous

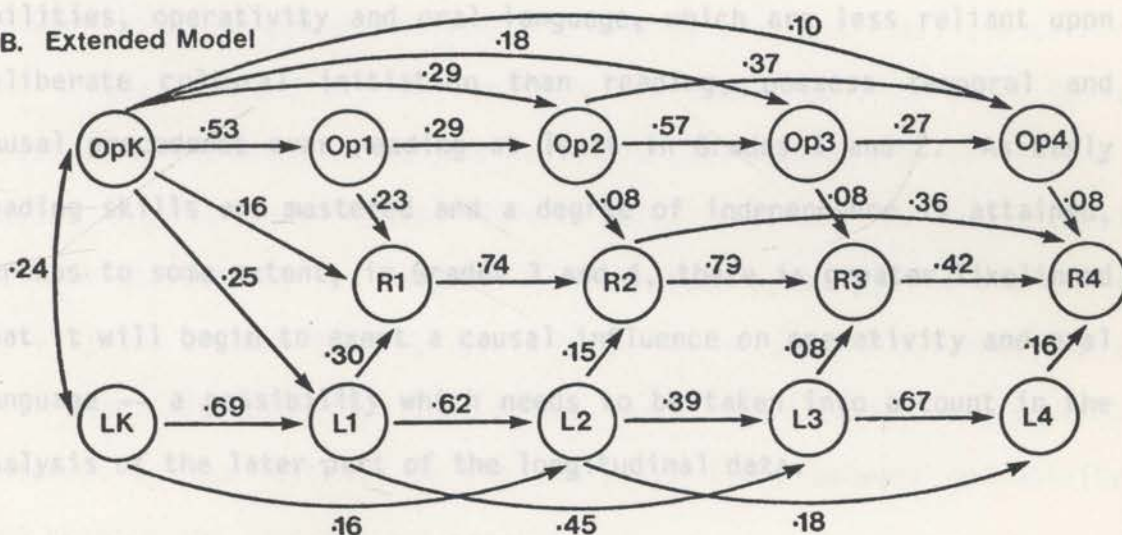
variables, Kindergarten operativity (OpK) and Kindergarten oral language (LK), for which there is no path coefficient, since their causes come from outside the model and are not analysed in this study.

Figure 4.6. Path Analysis of the Relationships between measures of Operativity, Oral Language and Reading taken over five waves (Kindergarten to Grade 4).

A. Combined Simplex Model



B. Extended Model



An assumption of the analysis is that reading at any grade is influenced by operativity and language at the same grade and that Grade 1 reading (R1) is also influenced by Kindergarten operativity (OpK) and oral language (LK). This assumed direction of causal effect

language and either Grade 1 reading or operativity. Thus, the present

seems well justified during the first and second years of formal school instruction when the teaching of reading is only beginning and the children's reading ability is still largely unformed. To ensure that reading was not developed to any significant degree in the sample prior to formal instruction, a word recognition test (St. Lucia, Andrews, 1969) was administered to subjects before they entered Grade 1. Although there were discernable differences depending on whether the Kindergarten had followed a subskills or an object-picture labelling program, only 5 of the 148 subjects recognised 10 or more words, over one third scored 0 or 1 and the mean was 3. This gives support for the assumption that reading does not exert any significant influence on at least the Kindergarten and Grade 1 operativity and oral language responses. It is reasonable that the more fundamental abilities, operativity and oral language, which are less reliant upon deliberate cultural initiation than reading, possess temporal and causal precedence over reading at least in Grades 1 and 2. As early reading skills are mastered and a degree of independence is attained, perhaps to some extent, in Grades 3 and 4, there is greater likelihood that it will begin to exert a causal influence on operativity and oral language -- a possibility which needs to be taken into account in the analysis of the later part of the longitudinal data.

At this stage of the analysis no links are inserted between operativity and language nor between reading at one grade and operativity or language at a subsequent grade. The previous path analysis of a part of the data (Figure 3.2) established that, while there were paths between Kindergarten operativity and both reading and language at Grade 1, no paths were needed between Kindergarten language and either Grade 1 reading or operativity. Thus, the present

structure was adjusted by the insertion of the paths required (e.g.,  $OpK \rightarrow R1$ ,  $OpK \rightarrow L1$ ). This initial structure proved to be too simple to allow a good fit ( $\chi^2 = 192.0$ ,  $df = 70$ ,  $p < .0000$ ) so the additional paths determined earlier in the separate analyses of operativity, reading and language (Figures 4.2B, 4.3B, 4.5B), were inserted (Figure 4.6B).

This improved the fit ( $\chi^2 = 96.3$ ,  $df = 62$ ,  $p < .003$ ) but did not substantially change the basic relationships under study between operativity and reading and between language and reading. The relationships between the five measures of operativity at different grades are not affected since these can be regarded as exogenous variables in respect to reading and no links have been inserted between language and operativity. Similarly the path coefficients for the language aspect of the structure are unaltered from those found previously. Examination of the residuals (See Appendix D for residual table) suggest that further direct paths may need to be inserted between operativity and language (of the form  $L_j \rightarrow Op_{j+1}$  and  $Op_j \rightarrow L_{j+1}$ ) and between reading and language ( $R_j \rightarrow L_{j+1}$ ) but that these will not significantly affect the path coefficients of central interest to the purposes of the analysis, i.e., between operativity and reading and language and reading.

The direct effects of operativity are strongest in the early waves, at Kindergarten and Grade 1 (.16, .23), but decrease quickly at Grade 2 and remain low at subsequent grades (.08, .08, .08). These three paths may well be eliminated without significantly weakening the model and further analysis will test this possibility.

By contrast, the effect of language does not diminish to the same extent. Although initial language (LK) has no significant direct effect on reading at Grade 1 (R1), the effect of language on reading at the same grade, despite some fluctuation, remains reasonably strong (.30, .15, .08, .16) over the four year period.

At each stage after the first, the structure suggests a relationship of the form,

**Table 4.10.** Decomposition of Associations of Kindergarten and Grade 1 Operativity and Oral Language with Grade 1 Reading

VARIABLES	TYPE OF EFFECT	DECOMPOSITION
Kindergarten Operativity & Grade 1 Reading	Total Association	.39
	Total Effect	.35
	Direct Effect	.16
	Indirect Effect	.19
	Through Op1	.07
	Through L1	.12
	Joint Association	.04
Kindergarten Oral Language & Grade 1 Reading	Total Association	.27
	Total Effect	.19
	Direct Effect	--
	Indirect Effect	.19
	Through L1	.19
	Joint Association	.08
Grade 1 Operativity and Grade 1 Reading	Total Association	.40
	Total Effect	.23
	Direct Effect	.23
	Indirect Effect	--
	Spurious Effects	.14
	By OpK	.09
By OpK through L1	.05	
	Joint Association	.03
Grade 1 Language and Grade 1 Reading	Total Association	.40
	Total Effect	.30
	Direct Effect	.30
	Indirect Effect	--
	Spurious Effects	.05
	By OpK	.04
	By OpK through OpK	.01
	Joint Association	.05

the effects of operativity (Kindergarten and Grade 1) in the association of Grade 1 operativity and Grade 1 reading is .37 (.23 + .14), or

Introduction of the links between operativity and reading and between language and reading has the effect of reducing the coefficients between the four observations of reading achievement, as a comparison of Figures 4.5A and 4.6B reveals.

At each stage after the first, the structure suggests a relationship of the form,

$$R_j = B_1 L + B_2 Op + B_3 R_{j-1},$$

with the effect of operativity diminishing after Grade 1, that of language being variable but not diminishing to the same extent, and the influence of reading at prior grades being the most important.

At the first stage (relationships with Grade 1 reading), however, there is a different pattern, with operativity playing a prominent part. In order to show clearly the relationships which exist at this part of the structure, the associations of Kindergarten and Grade 1 operativity and language with Grade 1 reading are decomposed (Table 4.10) using Duncan's fundamental theorem (Wolfle, 1980). This analysis reveals the considerable influence of Kindergarten operativity on Grade 1 reading, as a direct effect, as an indirect effect through Grade 1 operativity and as a spurious effect in regard to both Grade 1 operativity and language. Kindergarten operativity's direct effect on Grade 1 reading is .16 and its indirect effect is .19, giving a total effect of .35 or 90% of the total association. While the direct effect of Grade 1 operativity is .23, the spurious effect of Kindergarten operativity is .14 or 35% of the total association. Thus, the effects of operativity (Kindergarten and Grade 1) in the association of Grade 1 operativity and Grade 1 reading is .37 (.23 + .14), or

93% of the total association. Kindergarten operativity also exerts a significant influence on the association of Grade 1 language and Grade 1 reading as a spurious effect (.05 or 12.5% of the total association). If Kindergarten operativity were left out of the analysis, undue importance would have been attached to spurious effects of Grade 1 operativity and Grade 1 language.

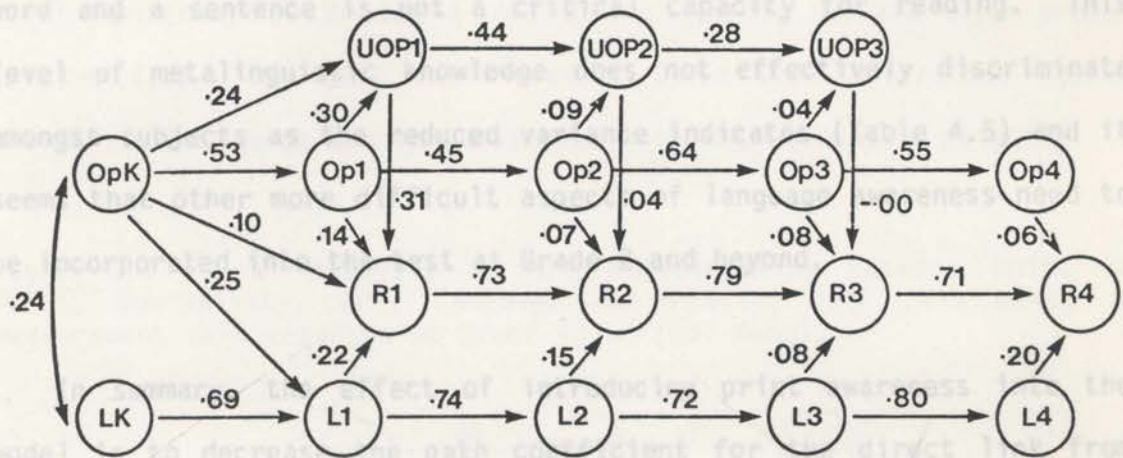
In accord with the hypothesis of the study, this analysis shows that operativity at Kindergarten and Grade 1 exerts a major causal influence on reading which is distinct from that of oral language and, in addition, influences reading through oral language to some degree. Language at Kindergarten has no direct effect on Grade 1 reading but a substantial indirect effect (.19) while language at Grade 1 has a considerable direct effect (.30). Thus, it may be seen that both operativity and language in Kindergarten and Grade 1 independently effect early reading, with operativity in Kindergarten appearing to play a particularly important causal role. This analysis has not yet taken account of the possible effects of the child's awareness of the units of print which seems to play an important part in early reading and to be causally dependent on operativity and language but particularly on operativity (Chapter 3). Does it exert a causal influence in addition to the effects of operativity and language? The next phase of the analysis will address this question.

As in the previous analysis, a simple structure was first studied utilising the relationships found separately for operativity, reading and language and inserting awareness of the units of print into the structure (Figure 4.7). The assumptions of this model, as discussed

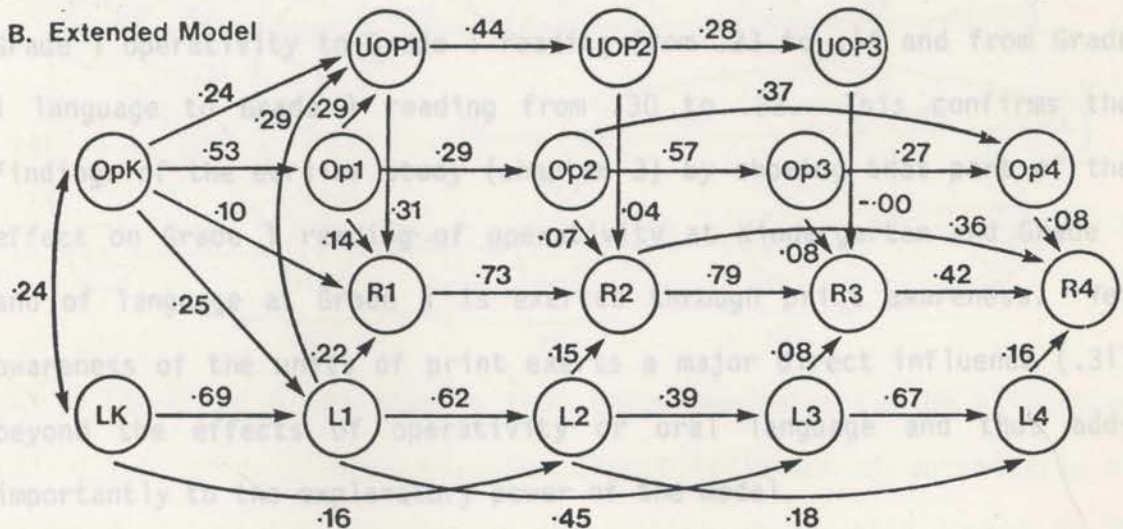
more fully in Chapter 3, are that units of print influences reading when both are assessed at the same time and that operativity and language, assessed in the same wave, influence units of print rather than the converse in each case (Figure 4.7A).

**Figure 4.7.** Path Analysis of the Relationships between Units of Print, Operativity, Oral Language and Reading over five waves of measurement (Kindergarten to Grade 4).

**A. Combined Simplex Model**



**B. Extended Model**



This structure is not adequate ( $\chi^2 = 270$ ,  $df = 106$ ,  $p < .0001$ ), as only the simplex structures have been used for operativity, reading and language (the only direct links used are between one observation and a subsequent one). However, it is sufficient to show that print awareness has a strong direct affect on reading at Grade 1 (.31) but that its subsequent influence is negligible (.04 at grade 2 and -.00 at grade 3). Operativity effects print awareness at Grade 1 (.30) but its influence fades at higher grades (.09, .04). Predictably after Grade 1, a test of the capacity to distinguish a number, a letter, a word and a sentence is not a critical capacity for reading. This level of metalinguistic knowledge does not effectively discriminate amongst subjects as the reduced variance indicates (Table 4.5) and it seems that other more difficult aspects of language awareness need to be incorporated into the test at Grade 2 and beyond.

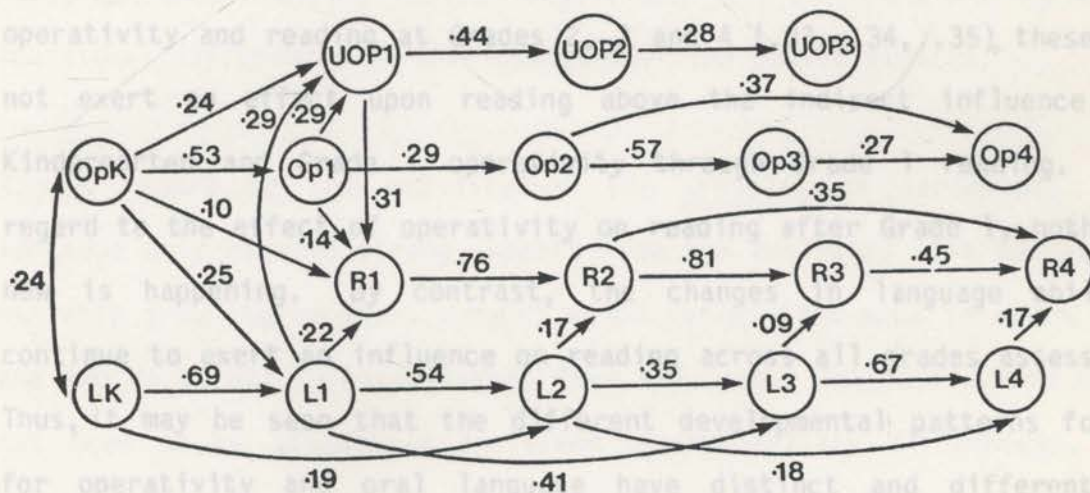
In summary, the effect of introducing print awareness into the model is to decrease the path coefficient for the direct link from Kindergarten operativity to Grade 1 reading from .16 to .10, from Grade 1 operativity to Grade 1 reading from .23 to .14 and from Grade 1 language to Grade 1 reading from .30 to .22. This confirms the findings of the earlier study (chapter 3) by showing that part of the effect on Grade 1 reading of operativity at Kindergarten and Grade 1 and of language at Grade 1 is exerted through print awareness. Yet awareness of the units of print exerts a major direct influence (.31) beyond the effects of operativity or oral language and thus adds importantly to the explanatory power of the model.

Introduction of the additional paths (Figure 4.7B) for each of the

reading, language and operative parts of the structure (from Figures 4.2B, 4.3B and 4.5B) has the effect of making the model more nearly adequate ( $\chi^2 = 167.0$ ,  $df = 97$ ,  $p < .0001$ ) and with a  $\chi^2/df$  ratio of 1.7 this seems to provide a satisfactory solution (Schmitt, 1978). The effect of print awareness on reading is not modified, as a comparison of the relevant parts of Figure 4.7A and 4.7B shows.

In an attempt to find a more parsimonious model, the structure in Figure 4.7B was modified first by eliminating the direct paths between print awareness at Grades 2 and 3 and reading at the same grades (Figure 4.8). The path coefficients, which were determined again, showed little change and the test statistic increased only slightly

Figure 4.8 Path Analysis of the Relationships between Units of Print, Operativity, Oral Language and Reading over five waves of measurement (Kindergarten to Grade 4). Final Model.



( $\chi^2 = 168.6$ ,  $df = 99$ ), showing that these two paths can be eliminated ( $\chi^2 = 1.6$ ,  $df = 2$ ,  $p < .4$ ). The direct influence of operativity at Grades 2, 3 and 4 on reading at those three grades also looked as if it could be eliminated, and this was next assessed. The result of setting these paths to zero made only a slight difference to the test

statistic ( $\chi^2 = 176.1$ ,  $df = 102$ ), indicating that their omission in the more parsimonious model (Figure 4.8) is appropriate ( $\chi^2 = 7.5$ ,  $df = 3$ ,  $p < .05$ ).

In this form of the model the relationships with reading may be summarised as follows.

At Grade 1,

$$R1 = .31 UOP1 + .14 Op1 + .10 OpK + .22 L1.$$

At Grade 2,

$$R2 = .76 R1 + .17 L1.$$

At Grade 3,

$$R3 = .81 R2 + .09 L3.$$

At Grade 4,

$$R4 = .45 R3 + .35 R2 + .17 L4.$$

This means that, after Grade 1, reading is influenced primarily by prior reading and, to a lesser extent, by oral language measured at the same grade. Although there are substantial correlations between operativity and reading at Grades 2, 3 and 4 (.33, .34, .35), these do not exert an effect upon reading above the indirect influence of Kindergarten and Grade 1 operativity through Grade 1 reading. In regard to the effect of operativity on reading after Grade 1, nothing new is happening. By contrast, the changes in language ability continue to exert an influence on reading across all grades assessed. Thus, it may be seen that the different developmental patterns found for operativity and oral language have distinct and differential effects on the development of reading. Operativity develops in a distinctive way at Kindergarten (and to a lesser extent at Grade 1) and exerts a unique effect on reading and on language from this point. Language develops cumulatively across the years monitored and exerts a continuing influence on reading as it does.

## Summary of Results

The main findings, drawn together from this rather lengthy presentation of results, are as follows.

1. The construct validity of all predictor variables, as assessed with multitrait-multitime analysis, is satisfactory. The language variables, Vocabulary and Grammatic Prediction, possess much stronger validity than the operative variables, Seriation and Perceptual Regulation, on this analysis.

2. The reading measures, Word Recognition and Paragraph Understanding, are closely related in multitrait-multitime analysis and their grouping as a composite reading measure is supported. Word Recognition is highly stable both from one year to the next and across several years and is clearly distinct from other reading measures. Paragraph Understanding is less stable and less distinct, showing more individual differences in development over the period studied.

3. In regard to the validity of the grouping of variables, the language pair receive strong support from the analysis. The operative variable grouping receives support which varies from weak in waves one and two to strong in waves three, four and five. This difference does not seem to be adequately explained by reliability differences, by test content variations, by practice effects or by testing irregularities but, most likely, requires an explanation in terms of developmental changes.

4. Developmental change, as indexed by increments in the means and by

stability values, reveals important differences between the language and operative variables. Although all means increase dramatically, the stability of the language variables is very strong, showing little change in rank order across time. The operative variables possess lower stability overall with Seriation showing moderate stability and Perceptual Regulation low over waves one, two and three (in the order of .30), then higher stability over waves three, four and five (in the order of .65). Since variation in reliability values cannot account for the data, this implies that there are far greater individual differences in the development of operativity than of language during this period. Two different forms of developmental change are evident, one which is more stable and continuous (language) and the other which is more surgent and discontinuous. In Perceptual Regulation, the continuity evident in the high stability across waves three, four and five is absent in waves one, two and three, due, it seems, to a period of developmental disturbance. Seriation, being a task mastered by virtually all during this period, shows discrete change with moderate stability consonant again with a considerable degree of developmental disequilibrium.

5. Path analysis of language and operative groupings further indicates that the two are quite distinct in their development. Language shows a symmetrical cumulative pattern over the five waves of assessment while operativity shows an asymmetrical pattern with the basic capacity laid out at the first measurement influencing all later responses.

6. This different developmental pattern has important implications

for the assessment of construct validity in longitudinal data. Less stringent psychometric assumptions apply to variables which are undergoing a period of developmental surgence. Thus, the apparent lower construct validity of operativity on multitrait-multitime analysis and the lack of early convergence of the two aspects of operativity tested, is consistent with theoretical predictions and, in itself, gives support for their construct validity.

7. The two criterion measures, Word Recognition and Paragraph Understanding, possess developmental similarities and differences. While the means of each increase dramatically, Word Recognition is highly stable and Paragraph Understanding is moderate to high in stability. Measurement error as recorded by the alpha reliability cannot account for this difference and Paragraph Understanding seems to be subject to the effects of greater developmental disturbance than Word Recognition.

8. In the multiple regression of operativity on Word Recognition and on Paragraph Understanding as separate reading criteria, operativity is consistently stronger in its relationship with Paragraph Understanding than with Word Recognition. The lower stability (greater level of individual differences) in the development of Paragraph Understanding than in Word Recognition (findings 2 and 6) is consistent with its closer relationship to the developmentally surgent operative capacities.

9. In the prediction of reading by operativity, distal associations are mostly greater than proximal ones, while language follows the

expected pattern by predicting more strongly to reading in its proximal measures.

#### A Developmental Contrast: Operativity and Oral Language

10. The multiple regression analysis shows there is generally an increase over time in the prediction of reading comprehension by operativity. This is especially so in the case of Kindergarten operativity which predicts Grade 4 reading comprehension more strongly than does the concurrent operative measures and exceeds all temporally closer operative predictions of Grade 4 reading comprehension.

11. Both operativity and oral language, in a backward regression procedure, contribute separately to the prediction of composite reading scores in all years of the project. In the first wave (Kindergarten), operativity is the dominant partner, while at subsequent waves, oral language becomes dominant.

12. On the basis of the path analysis, Kindergarten and Grade 1 operativity plays an important causal role in the developmental of reading, directly, and indirectly through units of print and oral language. Language, which is overshadowed by operativity in its wave one effects, becomes the stronger causal influence at later waves.

13. Awareness of the units of print at Grade 1 is an important link in the causal chain between operativity and reading and to a lesser extent between language and reading. It also exerts an additional causal effect of its own above the influence of both operativity and oral language.

DISCUSSIONA Developmental Contrast: Operativity and Oral Language

Several lines of evidence in the results converge to give support for the view that operativity and oral language develop in distinctly different ways, as proposed by the first hypothesis. Of greatest importance is the contrast between the stability patterns over the five waves of testing; language variables are highly stable throughout while the operative variables show considerable change in rank order of subjects. This suggests that operativity is subject to a degree of developmental disturbance in middle childhood which oral language is not. The different intravariability patterns of effect which each shows in path analysis is a second line of evidence for their developmental difference. Operativity's asymmetric path is quite distinct from the highly symmetric path of oral language. Another test of the difference in development between operativity and oral language is provided by their effects on reading over the five waves of testing. At waves one and two, operativity has a marked effect after which its direct influence ceases - a finding consistent with the view that operativity gains a special impetus between five and seven years, during which are laid out basic processes critical for learning to read. Language exerts a direct effect across all four waves at which both it and reading were assessed, suggesting considerable continuity of development. A further line of evidence is found in the apparent stronger construct validity of the language variables on multitrait - multitime analysis and in the stronger validity which a similar analysis gives to the grouping of the language variables by

comparison with the grouping of the operative variables. These lower validity values for the operative variables, which are not adequately explained by differences in reliability or by other task and testing factors, seem best understood as the effects of the greater developmental surge of operativity in middle childhood.

Thus, the different stability patterns of operativity and oral language, their different five year intravariability effects, their differing influences on reading and their different construct and grouping validity values, taken together, provide strong evidence for the conclusion in support of hypothesis one, that operativity and language, as measured in this study, develop in quite distinct ways during early school years. Language seems to show stable, continuous, cumulative change, while operativity seems to show a surge of discontinuous development at ages five, six and seven.

This conclusion is congruent with the findings of Bayley (1970), derived from a much broader data base, that there are multiple mental abilities with some, such as language, which show more continuous and stable development and others, such as reasoning, which show less stability and appear to be more closely bound to a stage progression such as that proposed by Piaget. The conclusion is also consistent with the results of McCall, Appelbaum and Hogarty (1973) who, in the analysis of longitudinal IQ data, found a major developmental inflection at 6 years. The operativity variables seem to be strongly influenced by the same developmental disturbance. A further parallel to this finding is the conclusion of White (1965, 1970), drawn from the analysis of a large variety of studies from differing theoretical per-

spectives, that the years five to seven witness a broad spectrum of behavioural changes which can be summed up as a transition from a relatively associative response capacity to a more cognitive one. The many changes reviewed include a marked growth in inferential capacity, a more systematic perceptual exploration, the onset of resistance to classical conditioning, the increased knowledge of left-right orientation, an increased predictability of IQ, and the spontaneous use of a planning capacity. White proposes that, to the earlier developed associative response layer, a higher level of response capacity is added - a more cognitive function usually ascribed to "symbolic" or "abstract" thought. The operativity capacities seem to be a central expression of this cognitive layer.

#### Stage Progression

The findings provide important insights into the developmental nature of the predictor constructs. What support does the data give for a stage developmental view? While Brainerd's concept of a "measurement sequence" (Brainerd, 1978), with its psychometric assumptions of developmental continuity, may perhaps be applied to the language variables, it does not seem to fit the operativity variables very well. For example, the change in stability values from .30 to .65 for Perceptual Regulation cannot be adequately explained in this way. By contrast, the developmental continuum proposed by Baltes and Nesselrode (1979) seems better able to accommodate the results, with operativity (possessing more stage-like qualities) located towards the strong end of the continuum and oral language towards the weak end. In order to consider the stage development issue more closely, the data

will be applied to the three questions raised in the earlier discussion of the nature of stages. First, is the change abrupt or gradual? Second, is it qualitative as well as quantitative? Third, are the subsystems of the hypothesized structure interrelated and, if so, how?

In regard to the first question, all variables show regular mean increases which suggest gradual development. However, the lower stability values for operativity imply that it is characterized by considerable development upheaval for perhaps two or three years. The presence of this influence is demonstrated most clearly for Perceptual Regulation, where the discontinuity is observed in the change from low stability over waves one, two and three to high stability over waves three, four and five. Whether this effect only begins at about five to six years of age, as assessed in wave one of this study, cannot be determined from the present data. Parallel evidence (White, 1965), however, and the change from a response which is dominated by field effects at five years to one which is able to transcend them at seven or eight years, as in the present data and also in the findings of chapter 2, suggests that this is likely. Thus, language seems to follow a gradual developmental trend throughout the early school years and probably beyond. Operativity also changes gradually at one level but is nevertheless subject, during two or three years, to some less gradual special influence which seems to be part of its essence rather than a peripheral effect. When viewed across a life span, this may even be described as an abrupt change, but in the limited time context and with the data of this project, that description does not seem warranted. Whether this developmental disturbance marks off a quali-

tative change needs consideration and is the subject of the second question.

Unlike language, which seems best described as undergoing quantitative change, operativity possesses characteristics which seem to change qualitatively. The available evidence from this and other studies (e.g. Elkind, 1964b) suggests that early seriation (e.g., the correct ordering of groups of three or four of the ten rods) is attained on the basis of a perceptual strategy while fully developed seriation seems to be attained as a conceptual reasoning process with the child placing the rods in correct order from a mental construction of the parts and not requiring visual checking for correct placement (see Chapter 2). In the case of perceptual regulation, the transition seems to be from figurative perception in which the child's response is dominated by field effects, to an operational response in which field effects are transcended. In the first case, the child at four or five perceives the most salient part of an ambiguous field while in the second case, the child of seven or eight also sees less salient possibilities in the same visual field. It is hard to account for these kinds of changes in cumulative terms alone. The response difference involves essential characteristics which change in their quality. Thus, in considering the first and second questions on the nature of change, operativity, as represented in this study, seems to undergo a gradual but marked qualitative change over two or three years. This begins to look rather like a stage but before this conclusion can be drawn, the third and most difficult question, concerning the interrelatedness of the component parts, must be considered. A number of unrelated qualitative changes would not be described as a

stage since some integration of the different parts to produce a coordinated whole must be evident.

The data are very limited for assessing this third question because only one of Piaget's infralogical tasks, seriation, has been assessed and the only operative comparison can be with a capacity, perceptual regulation, that Piaget has described as "partly isomorphic" with concrete operations. Furthermore, a consideration of the two tests shows that they possess major task dissimilarity. Although both are individually administered, Perceptual Regulation requires an oral response to a visual presentation (line drawing) while Seriation requires the physical manipulation of objects on a board. The task requirements of Perceptual Regulation seem much closer to those of the language measures which call for an oral response to a visual presentation (line drawing). The finding of a significant relationship between Seriation and Perceptual Regulation, which is, at later waves, quite distinct from Vocabulary and Grammatical Prediction, provides notable evidence for some underlying commonality. But the relationship, which varies across time and gains strength at ages seven, eight and nine, is not a simple one. The two aspects of operativity assessed bear little relationship early in their development but are more strongly related as they become better established and presumably as the underlying structures become more closely integrated and stable. Whether this integration is one of several "nodal" points (Wohlwill, 1973) or a part of some "final assembly" (Flavell, 1971) is not clear but there does seem to be a degree of consolidation similar to that reported in other recent studies (Tomlinson - Keasey et al, 1979; Arlin, 1981). This devel-

oping interdependence of quite different but conceptually related skills, which undergo qualitative change, is evidence consistent with a stage conception of development. The stage relationship seems more like the family resemblance model of Feldman and Toulmin (1975) than a Piagetian logico - mathematical structure but the data do not allow a satisfactory test of this suggestion. The results do provide further reason to retain the stage concept as a plausible hypothesis and this analysis makes the difference between the developmental continuity of oral language and the discontinuity of operativity the more striking. The question which must now be addressed is the nature and implications of the relationship between operativity and reading.

#### The Relationship of Operativity and Reading

In accord with their different patterns of development, operativity and language influence reading in different ways, both, in the path analysis, exerting a causal effect. Operativity, which has shown a consistent, moderate correlation with reading in a large range of studies (Waller, 1977) does not seem to be simply an incidental correlate nor only a facilitator of learning to read but a causal influence on reading. However, the attribution of a causal relationship requires close scrutiny. In what sense may operativity be considered as a cause of learning to read?

The use of a longitudinal design in the present investigation enables the time precedence of operativity over reading, an important condition for establishing causality, to be studied. Specific reading instruction was begun subsequent to the kindergarten assessment of the

predictor variables and, although different kinds of informal experience of reading may have had some prior influence, this is slight and seems unable to account for the effects of Kindergarten operativity or language. At the Kindergarten level the more fundamental cognitive and language processes are assumed to have temporal and causal precedence over the more culturally specific skill of reading. Reading instruction in itself is not accepted as a sufficient explanation of learning to read and the wide individual differences amongst children who have had similar experience of reading instruction (same teacher, materials, methods and length of time) bear this out.

Two other possible underlying determinants were examined in this study, oral language and metalinguistic processes. The path analysis (Figure 4.7) shows that the major influence of operativity on reading at Grade 1 is independent of the effects of oral language. This is further clarified by the decomposition of associations (Table 4.10) which shows that the most powerful effect on Grade 1 reading is exerted by Kindergarten operativity. The possibility that linguistic awareness in the form of knowledge of units of print underlies both operativity and reading is addressed in Figure 4.7 and by study 2 (chapter 3). Although print awareness at Grade 1 is importantly involved in reading at that grade, this analysis and the extensive treatment of the issue in chapter 3 shows that it is dependent on operativity at Kindergarten and Grade 1 and could not, therefore, be an alternative explanation to the influence of operativity on reading. A further possibility is that IQ is the common underlying determiner of both. However, the analysis shows that operativity acts independently

of an IQ measure commonly used with young children, the Peabody Picture Vocabulary Test, which was employed in the study as one index of language. Although other IQ measures may have stronger effects, it seems most unlikely that they would eliminate operativity. Furthermore, even if IQ is an important causal influence on reading, its lack of any underlying theoretical basis means that IQ can contribute very little if anything to the explanatory purpose of the present study.

Such competing views as those involving oral language, print awareness, reading instruction and IQ, therefore, in and of themselves, seem unlikely to provide satisfactory alternate causal explanations of learning to read. At the same time, however, it must be recognized that no such elimination procedure for establishing causal effects can ever be complete. The proposed causal relationship between operativity and reading, while receiving strong support from the path analysis, must remain tentative, providing a working hypothesis in need of further scrutiny.

The findings also need some further qualification in accord with the limitations of the middle class sample and the restricted range of operativity and oral language abilities monitored. The use of middle class subjects limits the generality of the findings. The sample of Lunzer, Dolan and Wilkinson (1976), which included a privileged, an under-privileged and an intermediate group, demonstrated social class differences in the relationship of operativity and reading despite a highly significant relationship for the whole sample. The intermediate group showed no significant effects while the other groups did. If the intermediate group is closest to the middle class sample of the

present study, stronger correlations for upper and lower socio-economic groups might be expected. However, the different social class patterns in England and Australia make such comparisons difficult if not misleading and it would seem important to replicate the findings with other Australian socio-economic groups.

A closer examination of the special influence of operativity on reading. The practical demands of extensive individual testing over five occasions meant that a restricted range of operational and oral language capacities was monitored. With a larger number of operational tasks, Lunzer, Dolan and Wilkinson (1976) and Arlin (1981) each obtained a stronger multiple correlation with reading, and, although neither study used both the measures employed here, it is most likely that a wider range of tasks would have produced a stronger prediction than in the present study. In a similar manner, a wider range of oral language tasks is also likely to produce a stronger prediction. The size of correlations in this study is therefore not a very satisfactory guide to the strength of the relationships or to the importance of the results. The qualitative differences between the developmental patterns of operativity and oral language over the five years and the difference in their effects on reading are the most important findings of the study which seem likely to hold up, even if the predictive strength of each was increased. If a high level of operativity cannot be a necessity for the early learning tasks of reading. In sum, at least for a middle class sample, operativity seems to be a necessary though not a sufficient condition for the development of significant reading competence. Oral language capability may also be necessary and some form of social initiation, most commonly school instruction, is apparently required as a precipitating factor. But

what level of operativity is needed for reading? This is the first of two current problems in the literature that will now be considered.

### Some Current Issues

A closer examination of the special influence of operativity on early reading gives insight into two problems in the research and theory of reading. First, the issue of whether there is a critical developmental level necessary for learning to read and second, why there is an increase in the prediction of reading with the passage of time.

Support for this explanation is provided by the unusual finding of the Critical Level. If operativity is necessary for learning to read and it develops gradually over a period of two or three years, is there some critical level of operativity required to support beginning reading instruction? This raises the issue of bridging the gap between "groupments" and behaviour (Tomlinson - Keasey et al, 1979; Arlin, 1981) which has produced considerable controversy (e.g., Gallagher, 1979) and which allows no easy resolution (Waller, 1977). During the same time that operativity is developing, reading typically is also undergoing gradual change and since it is well advanced by the time high levels of operativity are attained, a high level of operativity cannot be a necessity for the early learning tasks of reading. The concurrence of cognitive and language development with learning to read has led to the suggestion that "reading is not inextricably connected to a particular stage of development of cognitive and language skills" (Doehring and Aulls, 1979, p.30) but rather that any such skill deficiencies will be made up as reading pro-

gresses. This may be partly the case but there seems to be important limitations on this process. ing by operativity decreases successively. Language, by contrast, has no such critical level since its proximal

850 The difficulty of learning to read varies considerably. Some aspects, such as responding orally to the visual configuration of some words, seem capable of being learnt at the associative level but other aspects, such as those requiring manipulation of units, seem to need the decision or operative zone of functioning. Some minimal level of operativity may be required in reading soon after beginning, at least as it is usually taught in schools at present. om Grade 1 to Grade 4.

The cross-tabulation of chapter 3 (Tables 3.2) further supports this

cont Support for this explanation is provided by the unusual finding of this study that operativity has distal associations with reading as strong as or stronger than proximal associations with reading. In other words, contrary to the normal pattern of results in correlational studies, earlier measures of operativity are as good or better predictors of reading than concurrent ones. This is no chance single occurrence but is a consistent pattern with few exceptions throughout the data. Variations in reliability as gauged by internal consistency cannot account for this result and, although the variance for one part of operativity, Seriation, is greatest earlier, the other part, Perceptual Regulation, shows very little change in variance but follows a similar trend in its correlations with reading. Better distal prediction indicates that the determinants of variance are not constant and implies that the structure of ability varies across time. This finding is consistent with the view that there is qualitative change in the functioning of the intellect. It seems that there is a critical level of operational development needed for marked

reading progress and each year finds more children past that level so that the prediction of reading by operativity decreases successively. Language, by contrast, has no such critical level since its proximal associations with reading are greater than its distal associations.

multiple correlations of operativity with reading comprehension

This finding is also borne out by the path analysis which shows that there are causal influences of operativity on reading at Kindergarten and Grade 1, then no further effects, despite continuing significant correlations at Grades 2, 3 and 4. By contrast, again, language shows a steady pattern of effect from Grade 1 to Grade 4. The cross-tabulation of chapter 3 (Tables 3.2) further supports this contention. For example, subjects who were low in operativity at Grade 1, were poor in units of print and in reading. The longitudinal data show that they attained at least a moderate level of operativity before, or as they improved in units of print, and before they improved in reading. Perhaps some progress can be made at the associative level but it seems that the reading task soon calls for the cognitive or operational layer of response that shows an important developmental surge at five, six and seven years and that marks off a qualitative change in function.

The first possibility is that less measurement error occurred in

In sum, the data support the view that some minimal critical level of operational development is called upon for the child to make extended progress in early reading. This is not to suggest that elaborate concrete operational structures are prerequisites of reading nor that reading itself does not support further development of operativity. What is maintained is that some basic operational structures precede certain critical aspects of reading such as the one

processing of units required in phonic synthesis and the elaborate seriation of meaning required by sentence and paragraph comprehension.

Kindergarten operativity with reading comprehension rises, the

Prediction over Time. A surprising finding of the study is that multiple correlations of operativity with reading comprehension generally increase as the time interval between measurements becomes longer. This is in contrast to most predictor studies where the correlation declines as intervals between measurement increase. It is most striking for Kindergarten operativity but is also the trend for operativity at Grade 1 and Grade 2 (Table 4.7). Correlations of language to reading comprehension have some tendency to rise but overall, remain fairly steady. This result is most unlikely to be the product of the particular tests chosen since a similar increased prediction over time is reported in three other reading studies which used different predictor and criterion variables (Butler, Marsh, Sheppard and Sheppard, 1981; Clarke, Bruininks and Glaman, 1978; Feshbeck, Adelman and Fuller, 1977). Perhaps there is some important common process underlying reading development in all studies. Four possible explanations of the finding are considered.

Operativity

and oral language are quite different in the pattern of their relationship. The first possibility is that less measurement error occurred in later testing of reading. However, the small changes that do occur in the reliability values of Paragraph Understanding (Table 4.4) follow the opposite direction to the increase in this predictor correlation and could not explain the increase. A second explanation is that the rise in the multiple correlation is due to an increase in the variance of reading comprehension. This is lent some credence by the increase in the standard deviations of Paragraph Understanding across waves one

to three (Table 4.5). However, this pattern does not hold up consistently. From wave four to five, when, for example, the correlation of Kindergarten operativity with reading comprehension rises, the standard deviation of the comprehension test falls. The correlations also fail to follow the pattern of variance in waves three and four and a similar discrepancy from the variance pattern is shown in the predictions of reading comprehension by the oral language measures (Table 4.7). Increases in the variances which may have some influence, do not therefore seem to be a sufficient explanation of the stronger correlations with the passage of time.

ivity may be the reason for the increasing correlations over time in the other studies cited.

A third possibility is that reading performance becomes more predictable over this formative period as its component capacities settle down and become better established in the response repertoire. That the prediction of reading comprehension by neither operativity nor language falls over time supports this and suggests that there is some common effect on both sets of relationships, namely, an increased predictability of the predictor, as is suggested by Butler et al (1981). However, this cannot be the full explanation. Operativity and oral language are quite different in the pattern of their relationship to reading comprehension. There seems to be a special contribution to the phenomenon by operativity. While its correlations with reading comprehension rise, those of oral language are generally stable.

tion) were strongly over time, could well reflect a convergence of the effects of the surgent cognitive abilities in both

The fourth possibility is that operativity exerts a delayed influence or a sleeper effect on reading comprehension. In this view, reading slowly takes on more of the decision oriented character of that

earlier cognitive change. The developmental surge of operativity found at Kindergarten and Grade 1 has a slow cumulative effect on reading which increases to Grade 4. Unlike the externally operating sleeper effect of Kagan and Moss (1962), this effect seems to come from within the structure of ability itself. The rise in the correlations over time thus seems best explained as an interaction of the developmental patterns of operativity and reading comprehension and, if this is so, it provides a strong argument in support of the causal influence of operativity. The pervasive influence of the developmental surge registered by Kindergarten operativity may be the reason for the increasing correlations over time in the other studies cited. Some of the best predictors in the Clarke et al study (1978), e.g., visual sequencing, visual closure, could be descriptions of the operativity measures, Seriation and Perceptual Regulation, used in the present study. Clarke et al (1978) explain that the most powerful predictor, number facility, involves many items requiring complex understandings such as "more", "less", "largest", "next to the last", "most of", all of which seem to be drawing upon the decision-making concrete operational capacities. Furthermore, the highest correlations of these predictors, as in the present study, are with reading comprehension rather than with word recognition or word attack. Similarly, the factors isolated from the Kindergarten screening test by Butler et al (1981), which predict reading (mainly comprehension) more strongly over time, could well reflect a convergence of the effects of the surgent cognitive abilities in both predictor and criterion measures. The first factor, including figure copying and completing, seems to call for considerable perceptual regulation. The second, activities using language, seems to be based

largely on language awareness which has been shown (chapter 3) to be strongly dependent on operativity. If it is objected that operativity is not likely to effect all three factors isolated in the analysis, it must be remembered that, even with the very narrow sampling of operative variables in this study, Kindergarten operativity exerts a highly pervasive effect (Figure 4.7), influencing the Grade 1 measures of language awareness, operativity, oral language and reading.

#### CONCLUSION

The results suggest that the operativity measures of this study are tapping a powerful developmental influence which is partly distinct from oral language in its effects on reading. This influence appears to be part of a broad spectrum of change in mental processing that occurs during middle childhood. This emerging conceptual capacity seems to be a necessary although not a sufficient condition for the development of reading ability. As well as exerting an immediate influence, operativity also produces a pervasive delayed effect in its causal relationship with reading comprehension which, during the early school years, slowly takes on the decision-making, conceptual reasoning character of that operational influence.

Taken together, these two findings suggest the important working

hypothesis that children's surgent cognitive development during the 5  
CHAPTER 5 period exerts a causal effect on aspects of print awareness  
and on learning to read. This hypothesis provides the basis for a  
cognitive

#### THEORETICAL AND PRACTICAL IMPLICATIONS OF THE STUDIES:

##### TOWARDS A COGNITIVE DEVELOPMENTAL THEORY OF READING

There are two principal findings of the research presented in this report. First, two variables involved in learning to read, conceptual reasoning, as represented by Piagetian measures of operativity, and oral language, as represented by measures of vocabulary and grammatic prediction, develop in different ways from each other during the first five years of school. Language undergoes a more stable, continuous pattern of cumulative change while operativity undergoes a surge of development especially between ages 5 and 7. This difference in development is reflected in their qualitatively distinct effects on both print awareness and learning to read: Language exerts a regular and constant influence over the five years studied; operativity exerts a major effect from the first two years after which this effect ceases. This leads to the second main finding, that operativity is a causal factor in the development of an understanding of the units of print and of reading. Although reading, units of print and operativity may well interact as development proceeds, certain minimum critical levels of operativity seem to be necessary for print unit awareness and for the use of a full range of cue sources required by the extended development of reading skill.

lines for investigation.

Taken together, these two findings suggest the important working

hypothesis that children's surgent cognitive development during the 5 to 7 year period exerts a causal effect on aspects of print awareness and on learning to read. This hypothesis provides the basis for a cognitive developmental theory of reading. that children are active agents in their own learning. Although the role of the teacher is recognised Some Foundations for a Theory of Learning to Read children always bring their own unique contributions to the learning

Reading requires a remarkable range of response capacities as diverse as knowing what the spaces between printed words signify, interpreting a user's manual for a new appliance and following the story line of a novel. The tasks of learning to read and its difficulties have tended to be viewed as isolated endeavours unrelated even to one another, let alone drawing on and giving expression to a common underlying and developing mental structure. The results of this research, together with other related findings, suggest a theory of learning to read in which children's success in the diverse tasks that make up reading is critically dependent on mental constructions that are hierarchically related to one another, gain important developmental impetus as part of wider changes in cognitive capacity during middle childhood, and build on and can be claimed by earlier developed associative response abilities. In discussing these three characteristics of a cognitive developmental theory, its similarity to and difference from other current theories of reading will be considered in order to highlight its main features. This will lead to the proposal of a stage related pattern of reading progress, will offer guidance for instructional decisions and will open up further lines for investigation.

A Constructive Process The constructive processes of the learner, the present view seems rather close to the psycholinguistic position of Gopko. The first principle of this view is that reading is a conceptual reasoning, problem solving activity and that children are active agents in their own learning. Although the role of the teacher is recognised as being highly important, it is believed that children always bring their own unique contributions to the learning situation. This principle finds clear support in naturalistic studies of children's early reading which describe the decision-making process used as the child weighs up phonemic and contextual cues to attain the meaning (Clay, 1967; Francis, 1977; Weber, 1970). It is in direct contrast to the behaviourist view which assumes that the learner is acted upon and which allows, as Skinner (1957, p. 459) expressed it, "no originating control inside the skin". The information processing view of Ehri (1979), in which it is proposed that print experience (usually gained by means of instruction) is a sufficient condition for word awareness, seems to take a similar tabula rasa view, giving little place to the unique contribution of the learners, who, it is assumed, will learn whatever they are taught, whenever they are taught it, as long as it is correctly sequenced. By contrast, the present view proposes that there are influences on successful learning which are outside the control of the teacher. Although teachers must seek to take account of all influences on learning, they never have at their command all the factors necessary to produce the learning outcomes. There are, for example, ongoing developmental processes which have their own momentum and which markedly influence learning.

In its emphasis on the constructive processes of the learner, the present view seems rather close to the psycholinguistic position of Goodman (1970) and Smith (1982) in which meaning is gained using sampling, prediction, confirmation and correction strategies based on minimal cues. However, in rejecting the 'data driven' behaviourist position, the present view does not accept the 'conceptually driven', 'inside-out' explanation such as that espoused by Goodman and Smith. Both 'inside-out' and "outside-in" explanations are required by this cognitive developmental view of the reading process. Piaget, for example, despite his interest in the internal constructions of the child, insists that the person and the environment engage in constant dialectic. The nature of reading as a fairly recent cultural invention suggests that social initiation is quite important for its learning. Teachers can train the child's mental strategies ("inside") in order to improve reading performance (Levin, 1973) or they can structure the reading materials ("outside") to simplify the learning task and so improve reading (Rickards and Hatcher, 1978). In practice, however, both usually take place simultaneously and are interactive in their effects. Better strategies are learnt as the materials are structured and simplified appropriately, then progressively made more complex.

This issue finds practical expression in a consideration of the importance of accuracy with words in reading, a matter of considerable theoretical division amongst researchers and of considerable practical importance for teachers. If the child reads, "Look at the fire", instead of "Look at the smoke", is this best regarded as a "miscue" rather than an error and as a sign of progress (because it makes sense

of the context) rather than requiring teacher correction as suggested by Goodman (1969)? Graphic information ("outside-in"), it is argued, is less important than the contextual understanding a reader brings to the passage ("inside-out") (Smith, 1982). The argument seems to be that, if reading is a constructive process, any detailed and prolonged learning of words and their parts is likely to be a distraction, even a hindrance, to that wider task which is the essence of reading - the construction of meaning. In support of this view is the finding (Goodman and Goodman, 1977; Rousch and Cambourne, 1978) that able readers make less use of graphic information than poor readers. However, these results were obtained without holding difficulty level comparable for good and poor readers. This was done (Biemiller, 1979) by studying good and poor readers when both were making about the same proportion of errors. On this contrast, good readers made more use of graphic strategies than did poor readers. In addition, the results of this present longitudinal study indicate that good readers are much stronger in the recognition of context free words than poor readers. Of 21 correlations between word recognition and three different measures of reading comprehension over four years, the mean coefficient is .57 and the range is .44 to .67 (Table 4.4). The strength and consistency of this relationship indicates that ability to recognize individual words out of context cannot be dismissed as of little importance to making sense of extended text. Closer inspection of the results (Table 4.4) shows that word recognition predicted reading comprehension as well as the four different measures of reading comprehension predicted one another.

There may be times when a meaningful error is acceptable, e.g.,

when the child is gaining the idea that print conveys meaning, or if, at a later stage, the child paraphrases on the basis of having grasped the meaning of the words. However, the present view maintains that the child must be able to deal with words, taking full account of phonemic differences and attaining an automatic response level for their recognition. This is held in full allegiance to the constructive, problem-solving explanation of reading. Semantic and syntactic cues of the wider text may support and enhance word reading (Allington and McGill-Franzen, 1980) but competence with words seems to be an important part of fluent reading (Stanovich, 1980). Text, by its nature, is a more precise, more considered means of transmitting ideas than is oral language and must be received by a matching reader precision. As Donaldson and Reid (1982, p.7) put it, "the reader must respect the text". The phases of beginning reading when word precision is critical will be considered more closely in the discussion of reading stages.

#### Changes in Cognitive Processing 5 to 7 Years

Although the cognitive developmental view is similar in its emphasis on the child's constructive processes to the psycholinguistic view of Goodman (1967), the perceptual patterning proposed by Clay (1979), or the developmental language position of Donaldson and Reid (1982), it differs from them all by giving a central place to non-language cognitive processes and particularly to the cognitive changes which take place in the 5 to 7 age period.

If the results of these present studies are accepted, any explan-

ation of beginning reading must take account of the surgent intellectual capacities of middle childhood. No theory of reading is complete which overlooks the conceptual reasoning flexibility which is developing in a special way during the early school years. The findings lend significant empirical support for the call to recognize the inadequacy of linear assumptions of intellectual growth and to develop instruments which are sensitive to qualitative as well as quantitative changes in mental functioning (Elkind, 1981a; Wohlwill, 1980). Likewise in reading, single process views are inadequate and a developmental theory is called for. Clearly, the structure of ability during the first five years of school when reading is learnt is not constant. The age period 5 to 7 witnesses pervasive changes that affect mental processes as widely different as memory, perception, attention and planful behaviour (Flavell, 1977) and bring about marked increases in a wide range of response characteristics such as inhibitory mechanisms, speed of reaction and recognition, and the capacity to shape behaviour in response to a proposition (White, 1970). It would be surprising indeed, if so broad and central a change in intellectual functioning was not critically implicated in reading, an activity described as involving some of the most intricate workings of the human mind (Huey, 1908).

Aspects of concrete operations assessed in this project seem to be involved in early reading tasks

An important contribution of the series of studies reported here is that this emerging intellectual competence is, in part, distinct from the language capacity which is already well developed by this time, since both oral language and operativity affect reading separately. The findings accord well with the view of Anderson (1975) that the executive system may be divided into non-verbal and verbal sub-

systems which cut across one another. The common assumption of language learning explanations of reading that "there is nothing the brain must do to make sense of language that is written, that it does not do to comprehend speech" (Smith 1982, p.1) is challenged by the results. Gallagher's claim (Gallagher, 1979) that the competence base for learning to read is linguistic, cannot account for the findings. Oral language certainly has an important part but non-language cognitive processes make a distinct and a major contribution. The findings lend support to the weak form of the cognition hypothesis for language acquisition (Cromer, 1979). Cognitive processes by themselves are necessary but not sufficient to explain language acquisition. Purely linguistic factors are also necessary. Each has a contribution to make. These cognitive and linguistic factors interact during the acquisition of language and in learning to read. Yet the surge of operational development found between ages 5 and 7, the predominance of operativity, and its pervasive effects, suggest a strong causal role for operativity in reading. It seems that children's response to reading instruction will be determined centrally by the strength of their operational processes.

Some illustration of how various aspects of concrete operations assessed in this project seem to be involved in early reading tasks will help to clarify and explain the relationship. The concept "word" may be taken as an example of a unit of print which children must understand as they begin to read. To gain the "word" unit concept, children must simultaneously classify and seriate. They classify when they recognize that, though all words look rather different, they possess common characteristics, e.g., in print they are

separated by spaces and made up of smaller units - letters. They seriate when they perceive that, though words are different, they bear a complex, ordered relationship to one another thereby partaking of a wider significance in the larger unit of meaning. In addition, the child must match the discreet printed "words" with particular parts of the continuous utterance of speech - a double seriation task in which the spatially ordered marks of print must be related to the temporally ordered sounds of speech. This seems to be a particularly difficult seriation task, since speech possesses no word boundaries and children generally are not aware that speech can be broken into words until they begin to learn to read. A similar but even more difficult operational task is required by letter units which are far harder to isolate in utterance and present an additional problem for the young child. Each letter almost invariably has more than one signification, e.g., "a" takes four different sounds in the three simple words, "cat", "water" and "away". The child must understand that there is no one-for-one correspondence but several spoken subsets of the printed "a". This is even more difficult when phonemes are represented by letter combinations e.g., brown, yellow. The task seems parallel to the item in the Units of Print Test which first and second grade children found most difficult. They were asked to draw a circle around each thing which was a letter: from the parts which form them.

A similar 37 could p made 464 show id a d relationship of perceptual development to the understanding of words in a sentence. The Most children failed to circle the individual letters in "dad" presumably because, having recognized it as part of the set, "word" they were unable to compare a subset "letter" with the set that was

included it. Piaget (1964) and Bruner, Olver and Greenfield (1966) found nested classification a difficult intellectual achievement. the child's serial processing of print, another aspect of reading in which

Perceptual regulation, a task guided by the mental operations, also seems to be required by reading. As children recognize words, they soon need to go beyond the gross features that are sufficient to distinguish "elephant" from "flea" or "television" from "door". Finer discriminations are required to distinguish "goat" from "great" or "hose" from "house". In these, perceptual decentration seems to play an important part. Marchbanks and Levin (1965) tested kindergarten and first grade pupils to discover which parts of words were used as cues for recognition. For both three and five letter words, the first letter was most important, the last letter next in importance and anything in between was given the least consideration. The difficulty some children have decentring their perception will probably mean they are held by the most salient part (e.g., the first letter) and, only as perception develops under the pervasive influence of the developing mental structures, will they increasingly take account of other letter cues. The child's difficulty integrating the parts to form a whole with such items as an animal made of fruit seems parallel to the difficulty children have transforming letters into words, which, in their spoken form, are quite different from the parts which form them. wide array of cues interact and are transformed to produce a message

A similar case could be made to show the relationship of perceptual development to the understanding of words in a sentence. The child whose perception is centred upon the salient words or phrases in a passage, e.g., the first words or best known words, is likely to have difficulty allowing each word to take the weight it was

intended to have by the meaning of the sentence. In this way also, perceptual development will make an important contribution to the child's serial processing of print, another aspect of reading in which operational thought seems to be involved.

As the child processes the sentence or paragraph, we see a seriation task of a different order to that discussed above. E. L. Thorndike (1917) describes it well when he noted that reading is,

a very elaborate procedure involving a weighing of each of many elements in a sentence, their organisation in the proper relations one to another, the selection of certain of their connotations and the rejection of others, and the co-operation of many forces to determine final response. (p. 323)

As readers follow this procedure, they create a very complex seriation of meaning for the passage. The bases for this are the concepts, rules and principles which enable the grapho-phonetic, syntactic and semantic cues to be used. This is rather like the activity which the child performs to solve the multiple seriation puzzle. Pieces are selected according to the overall conception of the problem, then checked and confirmed typically by trial-and-error processes to determine the solution. Reading, then, is usefully characterized as a multi-dimensional seriation of language in which a wide array of cues interact and are transformed to produce a message which is not the sum of the parts but a multiple of their main components.

In multiple seriation, the child who is able to form a strong mental construction of the whole (i.e., is "operational") does not

need to check perceptually where each individual part should go. This seems to explain Kolars' conclusion from an analysis of adult reading errors that "reading is only incidentally visual" (Kolars, 1969). Adults (and competent children) have become "operational" in their performance of the multi-dimensional seriation of reading and seem to use a minimum of perceptual cues. This, however, is not an adequate description of the way less competent readers perform. Lower operational development will mean greater reliance upon perception. If the analogy of multiple seriation is valid, younger and less competent readers will depend far more upon trial-and-error rather than upon mental processes. In this view, children who have difficulties may not only lack knowledge of the specific relationships of reading but may also be deficient in the mental development which underlies the mastery and use of that learning.

One objection to the conceptual reasoning, problem solving view is: These are only some sketchy illustrations of a much more complex reality. The cognitive changes in years 5 to 7 are far more pervasive and subtle than can be monitored by tasks such as those used and their relationship to reading is undoubtedly far more profound. It is clear, however, that learning to read provides greater cognitive difficulty than learning to comprehend speech. Once children attain the basic mental capacity to appreciate the nature of the reading task (especially its units) and to begin to process print, they will bring previously acquired language competence to the new language task of reading. This "figurative learning", as Elkind (1976) terms it, seems to provide some of the raw material for the decision or cognitive processing and claims responses learnt at that decision level and practiced (White, 1965). These seem to become

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on a shorter term latency than decision based responses (White, 1965). Anderson (1975) explains the prominent place given to the effects of the 5 to 7 year developmental surge is the first way in which this cognitive developmental view differs from language explanations. A second difference is that this view accepts the possibility of associative as well as cognitive learning in reading. Recognising that associations are an insufficient explanation of human response capacity (Donaldson and Reid, 1982) does not mean that they should be accorded no place whatever in that explanation as Donaldson and Reid do. The extensive literature which attests the efficacy of associative learning cannot be so easily brushed aside. Its limits in explaining the problem solving nature of reading need to be recognized, yet it possesses a certain explanatory strength that cognitive learning alone does not have. One objection to the conceptual reasoning, problem solving view is that this activity is too slow to account for normal reading which is an instantaneous process. Sheldon White's explanation of the relationship between cognitive and associative zones of response (White, 1965, 1970), which is similar to Anderson's distinction between superordinate and subordinate executive systems (Anderson, 1975), gives a plausible answer to this objection. After being attained at the decision level, responses can be used very rapidly at the associative level. The present cognitive developmental view gives place for the associative response capacities to play a significant part in learning to read. This 'figurative learning', as Elkind (1976) terms it, seems to provide some of the raw material for the decision or cognitive processing and claims responses learnt at that decision level and practiced (White, 1965). These seem to become non-

available as associative responses on a shorter term latency than decision based responses (White, 1965). Anderson (1975) explains the functioning of the two levels as follows: *Plans are formed in the superordinate system and that is where they are executed during the early stages of practice. Later, after some practice, they become automatised, or mechanised and turned over to subordinate systems.* (p. 164)

This distinction, which is similar to that made by Shiffrin and Schneider (1977), helps illuminate the difference between the automatic responses of the mature reader and the slower cognitive process responses of the beginner. The beginner is working at the decision level, gathering clues from graphic and contextual sources and testing hypotheses regarding the meaning. The competent reader has mastered the text at the decision zone and is able to operate with text at the associative or automatic response level until an unusual or difficult construction or word occurs which demands the cognitive zone of functioning. Although the automatic zone of response seems to be the characteristic mode of operation for mature readers, the cognitive layer is necessary for monitoring the automatic responses of competent reading as well as for much of the original learning and is therefore fundamental to reading. The lack of integrative facility amongst the subskills of poor readers by contrast with the presence of that facility in normal readers (Guthrie, 1973) offers evidence for this analysis. The strength of subskills in the disabled group was virtually identical to that of normal readers similar in reading level. Subskill intercorrelations were high and positive for the normal readers but largely non-

significant for the poor readers and Guthrie concludes that inter-facilitation among subskills is necessary for normal reading. It seems that it is possible to possess skills at the associative level but to fail to read effectively because executive control, the decision level, is lacking or poorly developed. The decision level of response makes the fundamental contribution to reading and poor performance at this integrative level, rather than at the associative learning level, may explain the difficulties of poor readers. But both zones of processing seem to be active, each complementing the activity of the other, with the whole under the control of the decision system.

The psychological validity of these two response zones is attested by such common experiences as driving a car to an unfamiliar destination along what is, at first, the route to a well known place. Unless there is a conscious focus of attention when the change of route is necessary, one finishes up at the familiar place. The automatic level of response which has claimed the cognitive learning of that familiar route was not switched off by a conscious use of the decision zone needed to navigate to the new destination. Learning to play a difficult new piece of music seems to be another example of this common response phenomenon. At first, during the slow learning phase, the decision zone predominates then, as mastery occurs, the automatic zone becomes ascendant. Reading seems to be a striking example of this two layer response capability which is shown most clearly during the period of learning to read when the process differences between the zones and the manner in which they interact play a major part in distinguishing the stages of reading.

development (chapter 4).

A difficulty of Stages of Learning to Read is that they are much more susceptible to specific and planned social influence than are, for

The principal concern of this investigation has been to understand how the developing human capacity to organize and make sense of the world deals with the learning task presented by a complex symbolic medium - print. The results have shown that, during the course of cognitive development, there are qualitative changes which have implications for a range of practical tasks, especially reading. As human adaptive capacity moves from the instinctive activities of early infancy to the highly abstract thinking possible in adulthood, the question is asked, at what points along this continuum can the various aspects of reading be efficiently learnt? The finding that qualitative differences in development are implicated in reading means that a single process explanation of learning to read is inadequate. A stage related understanding of reading development is more appropriate. The findings suggest a hierarchical stage progression in which each stage is marked off by the use of a reading process distinct from that of the previous stage but which subsumes the previous process capacity. *stage pattern* is a necessary concomitant of the developmental theory of *read*.

The stage transition, however, must not be understood as an abrupt break. Although the comparison of children well established in one stage with those well established in another will reveal distinct process differences, the transition is best understood as a gradual one. At first, children apply the capacity of the next stage in a tentative, incomplete and arbitrary manner with change showing much regression as well as progression. With further development, they gradually apply the higher stage responses more consistently in a manner similar to the stage progression observed in general cognitive development (chapter 4).

A difficulty of proposing stages of reading is that they are much more susceptible to specific and planned social influence than are, for example, Piaget's stages. This is because reading is a cultural invention requiring social initiation and is not attained as a survival response to the environment as, say, conservation or seriation are. Reading almost always requires deliberate instruction which may take greater or lesser account of the underlying development of the child and impart varying degrees of specific knowledge which is difficult to distinguish from process development and may seem to confound stage predictions. However, as will be shown, there are limitations to the success of various kinds of instruction at some phases of learning which point to the importance of knowing the child's developing process capability and modifying the task requirements on that basis. The stage proposal here will seek to delineate the most desirable sequence to produce an optimal match of reading tasks and developmental capacity. Such an undertaking, it needs to be cautioned, is one requiring more, and more fine-grained, longitudinal research than is currently available. However, a stage pattern is a necessary concomitant of the developmental theory of reading proposed and the present study, together with other data, suggests one which may provide a basis for instructional decisions and for further investigation.

Three stages are proposed which cover the initial learning of reading. Later levels of reading development have been helpfully described by Chall (1979) in her proposal of reading stages. The stages suggested here show some similarity to Chall's three early stages, Prereading, Decoding and Confirmation, but are different from

them in at least two important regards. First, Chall's proposals are avowedly not a theory and have not been developed from an explicit theory of reading, while the present stages are the result of the cognitive developmental theory of reading propounded. Second, the present view does not accept that initial reading is a decoding stage, as Chall does. The four stages suggested by Elkind (1981b), being based on Piagetian theory, show some fundamental similarity to the three proposed here. However, both the number of the stages and the detailed treatment of their content differs significantly.

### Stage 1. Global Impressionism

In the first stage, the child learns to identify meaningful words or phrases which then form the basis of an awareness of the communicative purpose of print. This is achieved on the basis of contextual anticipation and a wholistic impression of the words rather than from a detailed inspection of word parts. This activity can proceed at the associative or figurative level requiring pre-operational thinking only and often begins before school, as in response, for example, to public notices such as, "HOSPITAL", "STOP", "KEEP OFF THE GRASS". It is extended at school when the teacher labels objects in the classroom, writes the childrens' own descriptions of events on class charts and uses commercial programs, e.g., words on cards or in books. The child has to appreciate that speech can be represented on paper, and that there are social conventions governing the relationship of speech and print, e.g., the temporal order of speech is matched with the spatial order (top to bottom and left to right) of print on a page. The child who has not learnt to read usually has no idea that

speech is comprised of words and much less that words are made up of phonemes (Reid, 1966). This is usually learnt as children work with printed words in reading instruction (Francis, 1973). Print, providing a tangible representation of speech, allows it to become an object of study. Means other than print, e.g., counters (Elkonin, 1973), can serve the same purpose of helping the child become conscious of the components of speech. This prepares the way for an understanding of language units. Before this, language has been the means for examining, manipulating and understanding the world but language itself has not been the object of the conscious processes. Now the child begins to gain an awareness of the functions and purposes of language. It is as though children, to this point, have been looking through a window at the world unconscious of the window itself, but now, for the first time, they see the window. In this there seems to be an interaction of associative and proto-operational learning. The associational learning of words and phrases allows the child to begin to use some of the earliest emerging mental operations in order to appreciate the relationship of print and speech. Gaining this awareness is a slow process, requiring, it seems, both maturity of cognitive functioning as well as considerable opportunity to act upon print. Indeed, the language awareness critically needed for reading progress based on the full range of cue sources does not develop until the second stage where much fuller weight is given to the details of the graphic display. When a basic store of words and phrases was well learned, children would seek to make sense of new sentences using

In the present data, five year old children, in stage one, could name the most salient part or parts of a complex perceptual field but found great difficulty in going beyond whatever was salient to less

obvious details. They also found it difficult both to recognise parts and to integrate them to form a whole. Although they were beginning to show single seriation ability, e.g., ordering several rods from smaller to bigger, they were generally unable to order two dimensions simultaneously in the multiple seriation task. For further progress in reading they need more systematic perceptual exploration and a more powerful organising ability which will support their use of the units of print and the more difficult strategic activities required. In other words, the decision zone of functioning (White) or the concrete operations (Piaget), which this research has shown begin to introduce a qualitatively different process capacity at about 5 years of age and which are necessary for extended reading progress, are not functioning in any extensive way at stage 1.

The naturalistic study of five year old (Clay, 1967; Francis, 1977) and six year old (Weber, 1970) children's reading offers support for the general characteristics of this stage as described and provides further insight into the learning activities involved. In these studies the teaching methods used with most subjects promoted whole word and sentence learning. However, one class of 24 children (Francis, 1977) was also given help in using phonic cues. This, nevertheless, made no difference to the strategies employed by the children. It was found that, although novel sentences could not at first be tackled, when a basic store of words and phrases was well learned, children would seek to make sense of new sentences using familiar parts of the new sentences and meaningful expectations. Only a small fraction of the whole text was utilized, with individual words largely ignored. It is as though there is an understanding that print

must make sense but little appreciation of the constraints imposed upon that sense by the graphic display. As an example, Francis found that when children were familiar with, "Meg the hen had no house. Jip had no house to live in" and were presented with, "Meg the hen had a tin pot to live in", typical responses were, "Meg the hen had no house to live in", "Meg the hen went up the hill". That the word unit concept was not well formed is shown by the children's failure to distinguish individual words in known phrases. For example, "fell down" was read correctly in a familiar sentence but children commonly did not know that the printed word "fell" was "fell" or that "down" was "down". Clay (1967) reports a similar failure to use the graphic display in any reliable and stable way during the beginning phase of reading, while Weber (1970) notes that the rigidity of the less able first grade readers' linguistic ability "shapes their reading responses into familiar language structure" (p. 154).

Although children drew upon a basic store of words learnt, it seems, by associational processes, all three studies report that they seek to apply these to new sentences in a problem-solving hypothesis testing manner with the limited cue sources that are available; namely, the scanning of gross textual features and the application of meaningful expectations. It is notable that the subjects in Francis' sample who had received phonic instruction did not use phonic cues to assist in the reading. The common strategies used in all studies, which show some independence of both methods and materials, point to the importance of underlying process variables and suggest the validity of the stage proposed.

The essence of stage two is the integration of graphic detail cues

Further important corroboration of this stage is provided by the developmental study of first graders' use of graphic and contextual information (Biemiller, 1970). In the first stage, contextual information predominated, so that, if a new word was encountered, the response typically fitted the context, not the sound values of the print. The child was untroubled by the lack of correspondence between his response and the graphic display. These five year olds and the less able six year olds required, in Clay's terms, more receptiveness to visual perception cues or, in Weber's terms, greater flexibility in applying their linguistic ability.

Although, as Francis notes (1977), there is a need to consolidate the early (associational) learning to provide a firm basis for the problem solving approach to new words, the limitation of this stage is the inadequacy of pre-operational learning for the problem solving difficulties involved in reading. Even though practice to consolidate the early store of words learnt is important, it can never, in itself, overcome the memory limitations which exist for recognising words on the basis of gross features. More powerful strategies are demanded by the nature of the task. "Television" and "goat" are easily distinguished by their gross features but "hose" and "house" require a much more powerful processing strategy. The emergence of this process capacity and the inefficiency of stage one processing impel the child into the second stage.

### Stage 2. Global and Elemental Integration

The essence of stage two is the integration of graphic detail cues

into the earlier contextually dominated reading strategy. Children learn to moderate their global impressions according to the cues provided by the letters and letter-group elements which compose the print. This requires operational mental processing which enables the child to systematically explore the printed display and to make effective use of the frequently irregular graphophonic cues. The child now attains the capacity to transform individual letter symbols into whole spoken words and to overcome such logical processing difficulties as are presented when the same letter represents different sound values, e.g., in such words as "car", and "care".

In terms of the present study, the development of systematic perceptual capacity enables the more efficient exploration of all parts of the process unit being used, e.g., middle as well as first and last letters of words. Multiple seriation seems to be called on increasingly in the simultaneous processing of different cue sources to attain the final response as in the two dimensional multiple seriation problem. The more powerful processing capacity which distinguishes this stage from the first emerges slowly, enabling two parts of this stage to be distinguished. The first part, in which graphic cues become predominant, is characterised by a period of uncertainty marked by a high degree of non-response to new words. The second part of this stage finds the child capable of fully using contextual and graphic cues, integrating both to determine the meaning.

At the non-response, first part of this stage (Biemiller, 1970), when new words are encountered, instead of saying something which fits the context (as in stage one), children very frequently remain silent.

It seems that they now realise that the response must be constrained by the graphic cues and, not knowing them or not being able to reconcile them with contextual expectations, they say nothing. This may seem to be a regression from the contextually constrained response of stage one but is shown by Biemiller (1970) to be an advance towards greater reading competence, i.e., towards the integration of graphic and contextual cue sources at the second part of this stage and beyond.

Weber's analysis of errors of first grade readers (Weber, 1970) suggests that the simultaneous use of contextual and graphic cues is not possible at this point of development and this conclusion is consistent with Clay and Imlach's finding (Clay and Imlach, 1971) that poorer seven year old readers proceed in a word-by-word or phrase-by-phrase fashion, while better readers pause far less, reading out the processed message in syntactic chunks. Clay and Imlach explain the word-by-word reading as either an acquired habit in which the motor task of saying the words paces the reading, or as a failure to establish contextual anticipation, or both. The 'bad habit' explanation implies that different teaching strategies should have been employed but it seems that, since better and poorer readers had been taught in the same classes with the same materials and similar techniques, the difference is not adequately explained as a bad habit. Why did some acquire it while others did not? Rather, it seems that the poorer readers had not reached or were at the beginning of stage two and needed time and practice to master the word and its components before they could proceed to integrate it with contextual constraints, as the more advanced readers at the second part of stage

two or beyond, were already doing. The suggestion from Weber's work (Weber, 1970) confirmed by Biemiller (1970) that there is a period when first grade beginning readers cannot simultaneously use graphic and contextual cue sources is consistent with the cognitive limitations of early concrete operations. The reading progress of these children from one dimensional processing to simultaneous processing of two cue sources parallels the progression from single seriation in which rods are aligned in one dimension, to multiple seriation in which both bigger to smaller as well as darker to lighter dimensions are aligned (chapter 2). These two aspects of reading development seem to comprise the first and second parts of the second stage which, unlike the first stage, calls for operational thought or the decision zone of response. While the cognitive or decision processing of this stage is its strength, enabling the child to make remarkable progress, it also becomes its limitation, since continuous decision processing is too slow and laborious for efficient reading. This leads the child into the next stage.

### Stage 3. Automatic Processing

The central achievement of the third stage is to make automatic the slower decision processes attained at the previous stage. With practice, the associative response layer claims responses attained by decision (or cognitive) processes and makes them available on relatively short term latency (White, 1965, 1970). The child begins this stage with the capacity to use a wide range of cue sources, contextual and graphic, and becomes proficient in their instantaneous application during the stage, developing fluency and confidence in

reading. Together with this new speed and efficiency of processing, there develops a flexibility of strategy usage which enables a switching from automatic to decision zones of response as is required by the task. While new graphophonemic and contextual skills may be learnt, these are not the major focus of the stage.

Evidence for this stage is provided by the increasing predictiveness of reading after grade one in this report (chapter 4) and in several other studies (Butler, Marsh, Shepherd and Shepherd, 1981; Clarke, Bruininks and Glamon, 1978; Feshbeck, Adelman and Fuller, 1977). Understandings, skills and knowledge gained earlier become settled and stable in the response repertoire and so are applied consistently and efficiently.

Some support for this stage is also provided by the delayed effect of conceptual reasoning capacities on later reading shown in study 3 (chapter 4). Operational thinking at Kindergarten, upon which stage two is built, exerts a delayed or sleeper effect on reading comprehension in grades three and four, with reading increasingly putting to use the decision oriented capacities of the earlier cognitive change. The principle learning process utilized at this third stage, like the first, is associative, but it now has been greatly amplified by the effects of the developing cognitive capacities so important in stage two. More complex associations can now be formed on the basis of the more powerful cognitive process capacity developed.

The common teacher observation of a burst of reading confidence and progress as the child discovers the enjoyment possible from

reading a well written story without being unduly held by the words, attests the validity of this stage. This introduces a degree of independence which enables reading to progress in large measure under its own momentum. The hierarchical pattern of the second and third stages is suggested by the nature of the tasks involved; a complex series of skills must be acquired before they can be applied with high proficiency.

As the third stage progresses, reading becomes more and more like the "inside-out" or "top-down" activity of mature readers (Cambourne, 1976-77; Smith, 1982) and possesses considerable similarity to stage one reading activity. At neither stage is very close attention paid to the script; reading is "only incidentally visual" (Kolers, 1969). Stage two seems to be a developmental regression from the seeming maturity of context based responses in stage one to a slower painstaking learning of graphophonics and its integration with context cues, before the mature speed and ease of stage three appears. Yet the second stage is an advance over the first, since the earlier a child entered it, the better his reading performance at the end of first grade (Biemiller, 1970). Despite similarities, there is a profound difference between the first and third stages. Readers in stage one have no option but to supply their own words, since they are not able to analyse and reconstruct the print to ascertain the author's words. Readers who have mastered stage three give much less attention to the script by choice because they are very efficient at gaining the author's meaning, by automatic processing, by sampling minimum cues (Goodman, 1967), and by operating with larger print units.

more than one thing at a time, for example, to talk while driving, to sing while playing the guitar, or to think while shaving.

(Anderson, 1975, p.169)

This change in the nature of the units of print being used is an important characteristic which distinguishes the third stage from the second. The study of pauses and stress in the oral reading of 103 first grade children (average age 7 years 7 months) by Clay and Imlach (1971), although not longitudinal, gives useful insight into this change. The best readers (the top quarter) made fewer pauses and used stress far less than all others. The best readers paused, on average, after 7 words, while the poor readers paused every 1.3 words. The best readers used stress every 4.7 words, while poorer readers used stress every 1.1 words. These competent readers, who meet the description of stage 3, are making use of phrase and sentence units while less able readers, in stage two, mainly use word and part-word units. Automatic response at the letter and word level allows the "chunking" of smaller units into the larger, more cognitively efficient process units required for extended reading development. As this takes place, the child needs to make fewer and fewer decisions to determine the writer's meaning and has available more and more attention for interpreting, evaluating and storing that meaning. However, readers in the third stage possess the flexibility of strategy to give more detailed attention to phrase, word and letter probabilities if necessary (Clay and Imlach, 1971).

Anderson's description of the effects of responses being made automatic seems to fit reading very well. Automatization frees CP/STM [central processing/short term memory] both to attend to additional tasks and to attend to strategic matters within a task. Automatization is what enables us to do more than one thing at a time, for example, to talk while driving, to sing while playing the guitar, or to think while shaving.

(Anderson, 1975, p.169)

As a further example, it might well be added, to argue with the author while reading. Indeed, it is possible for someone to read orally so that the listeners understand but for the reader to be thinking of something else and not know what he or she has read! *Reasoning required by standard orthography.*

It seems that, as this stage progresses, oral language is able to exert a greater effect on reading than it could at stage two. This may be why the data shows little influence of oral language at the end of Kingergarten but a marked increase at the end of Grade 1 and a continuing effect thereafter for the next three years (Figure 4.8). The child's oral language strength comes into its own as the decision task becomes automatic and the reading content requires more sophisticated language knowledge. *ing the process demands made by the*

*teacher. For example, attempts to teach five year olds to do phonemic segmentation has* Implications for Instruction *(Ehri, 1979).* These children seem to be stage one processors and unable to comfortably

#### Readiness and the Match *ask.*

The central task of the teacher, promoting a productive match of the child and the curriculum, is directly illuminated by the cognitive stage theory proposed. Since reading is not attained by one learning process but by a hierarchical series of processes begun informally in most cases, it is not very helpful to ask the general question, 'Is the child ready to read?'. Nor is it very useful to ask, 'Is the child ready to begin to read?', because the answer will depend on the kind of teaching approach proposed and the needs of the child. The child who is ready to begin learning whole words and phrases may not be ready to begin phonemic analysis and synthesis; the child who may be ready to learn phonics with i.t.a. (initial teaching alphabet)

as Downing suggests (1964) may not be ready to learn with standard orthography. The reason for this latter possibility seems to be that the increased number of letters used (44) in i.t.a. instruction removes much of the difficult operational reasoning required by standard orthography.

Readiness for learning to read can thus answer the 'when' of teaching only in relation to the process task required by the approach chosen and will involve different considerations at different stages. As teachers understand children's reading developmental states, they can present suitable material in such a way that learners will be enticed to take the next step towards competence. The stages proposed can play a vital part in guiding the process demands made by the teacher. For example, attempts to teach five year olds to do phonemic segmentation has met very limited success (Ehri, 1979). These children seem to be stage one processors and unable to comfortably manage that stage two task.

In the diagnostic assessment of reading progress and instructional needs, existing norm referenced tests possess limited value, since they focus on specific reading knowledge. An equally important source of information is found in the assessment of the kinds of processes they are able to use and the degree of competence they show in using them; in other words, in pupils' reading stage level. Determining stage progression seems best achieved by informed teacher observation of children's oral reading and can be another aspect of such commonly used procedures as the Informal Reading Inventory. Process level assessment will add a useful dimension to other test information, since

it will guide the teacher's choice in regard to the process demands of the instructional material and approach.

### Meaning Emphasis Versus Code Emphasis

Variations in the stage needs of children point to a resolution of the old debate over whether a meaning emphasis or a code emphasis method of teaching reading is better. The protagonists in this debate, which has raged for decades and continues to arouse passions, constrain their conceptions of reading to fit their own views of how it should be taught. Chall (1979), for example, who advocates a code emphasis, believes reading begins as graphophonic decoding is learnt (Stage 2 in terms of this report). Informal learning of words and phrases on the basis of gross graphic features and the attaining of initial print awareness (stage one in this report) are 'pre-reading' in her view. Goodman (1970), who advocates a meaning emphasis, defines reading with such weight on the attaining of meaning that instruction in sound-symbol relationships is considered not to be reading at all and even detrimental to its learning. The cognitive developmental view proposed here asserts that this controversy may be resolved in terms of the developmental learning needs of the child. Both methods have a place which is determined by the stage and the process needs of the learner. In stage one, emphasis on the graphophonic code has little place, while in stage two, it has a very important place. Yet, even in stage two, there will be major differences in individual needs for help to master the relationships between spoken and printed units of language. Some children, who are strong conceptualizers, require little if any instruction in the code. Others, who have not the same conceptual strength, will need

much specific graphophonic instruction. Most need considerable help and guided practice during the second stage, where a great deal of the smaller unit code learning must take place. However, in the first and third stages, larger language units predominate and the teaching requirements are different accordingly. At Stage 1, labelling of familiar objects and writing and reading the child's descriptions of experiences are appropriate to help the child make a bridge from oral to written language and to master some initial sight words. At stage three, the child needs much practice in reading extended discourse with familiar subjects, language constructions and vocabulary, so that automatic responses can be practised and perfected.

#### Developmental Lag

Individual differences noted in development and in rate of progression through the stages imply that developmental lag will be a basis for difficulties experienced by some children in learning to read. The finding that the mildly retarded function in the same manner as normal children but are about two years later in attaining that same development (Ingalls, 1978; Wyne and O'Connor, 1979) is consonant with the theory proposed here and finds support in the data. Although these children do not progress as far as normal children (their development is later and more closely circumscribed), they typically develop far enough cognitively to be capable of mastering the basic cultural skills. They will learn to read later, it seems, if instruction is matched to the appropriate reading stage and to their older interests and if they have not built up insurmountable negative attitudes towards reading due to earlier difficulties. Reading instruction which provides much process directed

experience may promote more effective learning in these cases. It is often a major problem, however, to overcome the flat, unmotivated effect commonly found in the developmentally delayed, it seems, to regular failure. The importance of preventing this by understanding the nature of the development of such children and presenting tasks they are able to handle comfortably cannot be overestimated. Teachers need to be made aware of the possibility of developmental delay and helped to diagnose its presence and to devise suitable teaching. The seriation and perceptual regulation tasks used in this project could usefully be extended for developmental diagnosis of those not learning as well as their peers, to provide an index of general cognitive and perceptual lag. They may also suggest cognitive and perceptual activities that teachers can use to stimulate the development of process abilities important for the mastering of the basic skills.

#### A Developmental Perspective

Taking a developmental view of the reading task gives the teacher a longer term perspective from which to view problems, a sceptical attitude to many short-term solutions and a greater resilience to discouragement. If cognitive development with its "sturdy, relentless, inexorable quality" (Flavell, 1977, p.232) is important for learning to read, a child's difficulties may often arise because of a later emergence of critical capacities such as perceptual decentration and decision processes involving single and multiple seriation. It has been found, for example, that reversals are often the result of

perceptual centration (Cohn and Striker, 1976). This does not mean, however, that the teacher should sit about waiting for development to take place! Even the most developmentally delayed are ready for reading experience in some 'intellectually honest form' and Bruner's famous readiness dictum is pertinent here (Bruner, 1960). The child needs experience using the capacities he or she currently has; in the case of reversals, for example, exercise in recognising the distinctive features of the letters reversed.

#### Issues for Further Investigation

Often, however, in the learning of a specific task, the missing ingredient is time. Piaget (1967) felt that Bruner had drawn some hasty conclusions regarding the development of conservation and cautioned him against hurried interpretations; "adults - even great psychologists - just like children, need time to reach the right ideas!" (p.533). The nurse at a teachers' college in East Africa, where the author was once a member of staff, had a fascinating Swahili proverb displayed on her door, "Mtabibu atibu, mungu aponya": "The doctor treats, God cures". When teachers have done their best, they may rest easy. Even though all children have not attained the teachers' expectations in reading when they move to the next grade, there may be no need for self-reproachful criticism. Not all the factors to produce this are at the teacher's command. Although there is no room for presumption about the adequacy of teaching, specific instruction cannot succeed if the appropriate underlying development has not taken place. *consistent pattern of relationships across various socio-economic groups? The middle class sample of the present work may* This is not an unfounded pessimism or a primitive fatalism in regard to children's learning capacity. It is a realism which is borne

out by the daily experience of teachers. It is a naive optimism which believes there are no limits to human learning - only to human teaching, and one which is likely to produce disillusionment. The genius of the teacher is surely to size up the strengths and limitations of the student and then to determine goals and present learning experiences in such a way that there is a productive match of the child and the task.

of operative tasks as predictive and diagnostic instruments.

### Issues for Further Investigation

3. How does linguistic awareness in its later developed forms relate to reading? This investigation has sought to place reading firmly within the framework of cognitive developmental psychology by demonstrating the importance of the child's intrinsic developmental momentum for beginning reading. Such a framework opens up vast possibilities for further research and development. Four particular issues meriting further investigation come to mind. mental pattern and how do they relate to general cognitive development and to later levels of reading?

The first research need is to replicate and extend the findings by further longitudinal study, starting with pre-school children and tracing the relationship of reading competence and cognitive development through to the emergence of formal operational thought. In doing this, there are five important questions, among others, arising from the present work that deserve attention. school child and the further study of it is likely to add significantly to our knowledge of both cogl. Is there a consistent pattern of relationships across various socio-economic groups? The middle class sample of the present work may be a limitation and some class differences in the size of the relationship found by Lunzer, Dolan and Wilkinson (1976) may indicate

different emphases in the mode of functioning across social groups.

2. Are the relationships general, i.e., between operational ability and reading, as has been largely assumed in this project or are they more specific, e.g., a particular operative task relates to a specific aspect of reading? There is much scope for this finer grained investigation which would provide a firmer basis for the use of operative tasks as predictive and diagnostic instruments.

3. How does linguistic awareness in its later developed forms relate to reading and to general cognitive development? Brown (1980) reviews a wide range of metalinguistic and metacognitive tasks developmentally beyond those studied in this project, such as whether instructions make sense, or whether a passage is difficult to comprehend or not, and suggests they are important to advanced reading progress. What is their developmental pattern and how do they relate to general cognitive development and to later levels of reading?

4. Is the ability to adapt reading for varying purposes as discussed by Chall (1979) a further stage to those proposed here? Certainly the child's growing ability to interact with his own cognitive processes plays an increasingly important part in the intellectual life of the late primary school child and the further study of it is likely to add significantly to our knowledge of both cognitive development and reading.

5. Will changes in the error pattern of children's reading bear significant relationship to changes in their cognitive development as

predicted in the reading stages proposed? fluidity or flexibility in learning - which Inhelder ascribed to her subjects? Perhaps effective teaching

A second major research need suggested by this work is for training studies to guide teacher intervention as required by the varying learning needs of pupils. Although experimental research has serious limitations in regard to the study of developmental change (Wohlwill, 1973), it is nevertheless important for helping the teacher bridge the gap between what is and what might be. Will practice in concrete operational tasks strengthen reading? Will teaching which emphasises concrete operational aspects of reading, e.g., perceptual exploration of unknown words or sentence seriation with anagram tasks, be especially beneficial for poor readers? Will there be an interaction of pupil operational capacity and teaching emphasis? For example, will poor seriators learn reading best given exercises that provide serial order practice with words? Perhaps the techniques of the instructional approach to developmental cognitive research (Belmont and Butterfield, 1977) could be gainfully applied to the area of reading. Direct measurement of task-related activity, e.g., lip movements, eye fixations, relevant verbalisations, could become the basis for creating instructions to produce gains in reading performance, as it has done in other cognitive performance tasks, especially in school learning situations. There seem to be large individual differences

A third area which could become the focus of special research concern is developmental delay. Inhelder (1968) found that the mildly mentally retarded child follows the same stage path as normal children with slower progression, longer transition periods between stages, more frequent reversion to lower stages and fixation at concrete operations. Do mildly retarded readers follow a similar pattern? Do

they exhibit the "viscosity" - the lack of fluidity or flexibility in learning - which Inhelder ascribed to her subjects? Perhaps effective techniques for teaching the first three stages of reading can be devised for use at a later time with those who are developmentally delayed. Modest success of training studies with such subjects (Ingalls, 1978) gives hope that, with a better informed approach and correct timing, reading intervention could be made more effective.

Finally, research must take seriously the complex cognitive character of learning to read if continuing progress is to be made in understanding the nature of the task and in improving the quality of instructional technique. It is not sufficient to view reading only as a language learning task or as an associative skill or as any single process activity. Research must further explore the multiple processes that seem to be involved and must give a much more detailed specification of how those processes draw on the associative and decision zones or layers of response which provide so useful an explanation of the difference between the learner and the competent reader. Although it has been claimed that the associative and decision zones each operate by different laws of learning (Anderson, 1975; Elkind, 1976), these differences are not well established and need testing especially in school learning situations. There seem to be large individual differences in the strength of associative learning capacity and in decision process capacity and there may be an important relationship between the functioning of the two. Yet, some children are perhaps strong in associative learning and poor in cognitive learning or vice versa and would benefit by a teaching approach which allowed them to make greatest use of their strength. Alternatively it may be more

desirable in the long run to strengthen weaknesses by appropriate training. The interrelationship of the two zones, however, is very little understood and seems to offer great promise for research investigation, since much of the flexibility of response so important for reading and for most human activities depends on the inhibition of aspects of the associative zone and the deliberate use of the decision

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## APPENDIX A

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## APPENDIX A

MULTIPLE SERIATION TEST

Matrix A and matrix B are used with children approximately 4-7 years old. Matrix C is added to the test for 7 to 10 year olds. With children approximately 9 years and older matrix A may be omitted.

Instructions for Administration

Score throughout as shown on the response record.

Matrix A 3 x 3

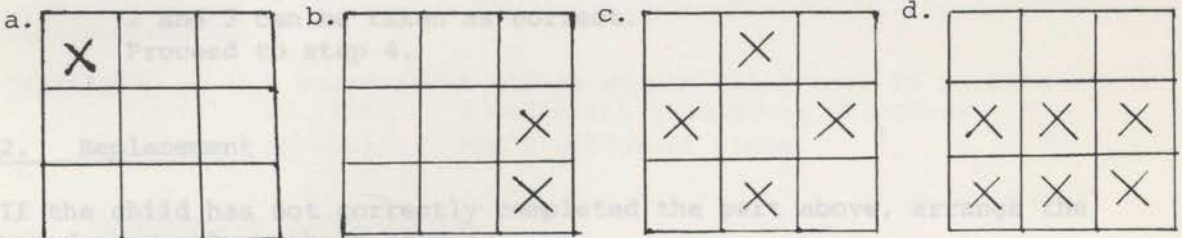
Materials: 1 board 300 mm square ruled in 9 equal squares.  
9 pieces 3 different colours; red, blue, yellow  
3 different shapes; triangle, circle, square.  
The size of each piece such that it fits into the squares on the board.

1. Replacement

Place the board on the table before the child with the 9 pieces in position on the matrix.

Say: I have a puzzle for you to do. I am going to take some pieces off this board and I want you to put them back where they should go, where they belong.

Remove the pieces as indicated <sup>(x)</sup> in a, b, c, d in turn, allowing the child to replace them each time. If the child makes mistakes, correct them without comment before going on.



If the child fails on b, c, and d. discontinue.

Record the scores as shown on the response record.

2. Reproduction

Tip all pieces on the table and mix them.

Say: I want you to put them all back where they should go, where they belong.

Matrix B 3 x 3

Materials: 1 board about 300 mm square ruled into 9 squares.  
9 circle pieces 3 different gradations of blue  
3 different sizes to fit into the squares on the board.

## 1. Spontaneous Construction

Place the board on the table before the child and place the nine pieces, well mixed, on the table between the child and the board.

Say: I want you to look carefully at these pieces and to place them on the board where they belong. Put them where they should go.

Watch very carefully how the child does the task. If the multiple seriation is correct and there are no redundant comparisons upon the board, it is an operational response.

Prompt: If there is no multiple seriation a prompt is given. This may be repeated once if necessary.

Say: Yes, that's a good try. Can you improve it? Can you do any better?

If the child begins to reorganize it without improving, discontinue. If, after prompting, the child improves, he scores the higher mark less one.

Check: If the child constructs a multiple seriation a check is necessary. Switch the two columns with lighter shaded pieces.

Say: Does this make any difference? Is it not quite as good or better or just as good? Why?

If the child says it is no different he scores as for single seriation and matching. If he identifies the two dimensions it is multiple seriation.

If the child achieves "Multiple Seriation Operational" steps 2 and 3 can be taken as correct.

Proceed to step 4.

## 2. Replacement

If the child has not correctly completed the part above, arrange the board correctly without comment.

Say: Now I am going to take off some pieces and I want you to put them back where they should go.

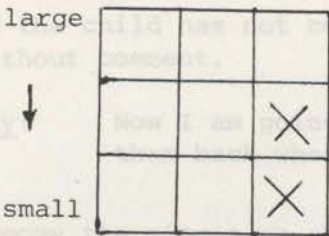
Remove the pieces as shown. If there are mistakes, correct them without comment before going on. If the child's arrangement is in opposite directions from the following you remove the same pieces as indicated, but, from the opposite side of the board, of course, i.e. for "a" you will always remove the two smaller light pieces.

Prompt: If there is no multiple seriation give a prompt. Repeat it once if necessary.

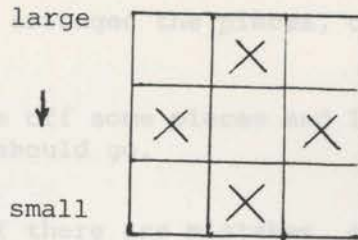
Say: Yes, that's a good try. Can you improve it? Can you do any better?

If there is no improvement, discontinue. If there is improvement, the higher score, less 1, is counted.

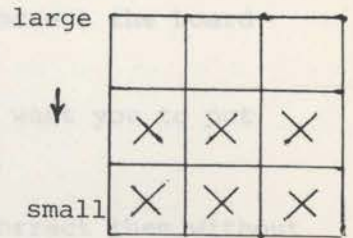
a. dark → light



dark → light



dark → light



### 3. Reproduction

Tip all pieces on to the table and mix them.

Say: I want you to put them all back where they should go.

Check: If the child constructs a multiple seriation, check by switching columns and ask, is that better, not so good, or just as good as it was. Only if two dimensions are identified is multiple seriation counted. Otherwise score as for single seriation.

Watch carefully for operational or trial-and-error responses.

### 4. Two Dimensions 1 Choice

Pointing to the middle piece

Say: Point to the piece which is bigger and darker than this.  
Point to the piece which is smaller and lighter than this.

### Matrix C 5 x 5

Materials: 1 board about 450 mm square ruled into 25 squares  
25 fish 5 different gradations of colour  
(green) and 5 different sizes.

#### 1. Spontaneous Construction

Place the board on the table before the child. Place the 25 pieces, mixed and spread so each is visible, on the table between the board and the child.

Say: Now I have some fish for you to put on this board. Look at them carefully and put them where they belong - where they should go.

Watch very carefully how the child does the task. If correct with no redundant comparisons it is "operational"; otherwise it is "trial and error."

Prompt: If there is no multiple seriation give a prompt. Repeat it once if necessary.

Say: Yes, that's a good try. Can you improve it? Can you do any better?  
If there is no improvement, discontinue. If there is improvement, the higher score, less 1, is counted.

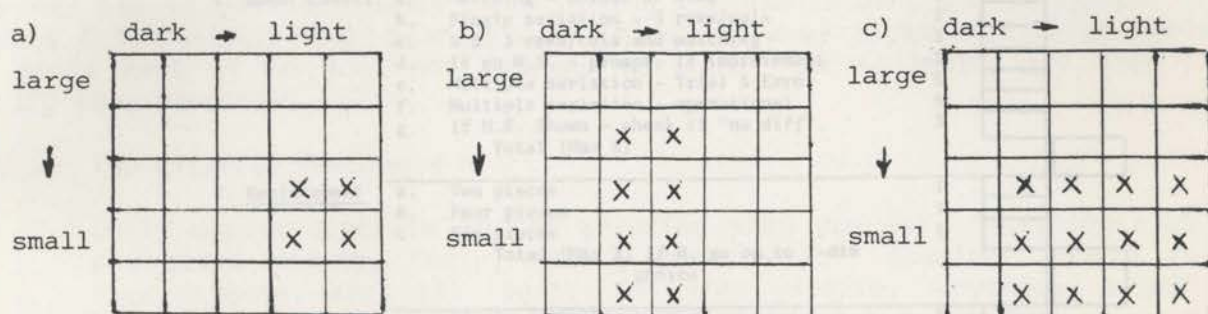
## 2. Replacement

If the child has not correctly arranged the pieces, correct the board without comment.

Say: Now I am going to take off some pieces and I want you to put them back where they should go.

Remove the pieces as shown(x). If there are mistakes, correct them without comment before going on. If the child's arrangement is in the opposite direction to the following, you remove the same pieces as indicated, but, from the opposite side of the board.

Watch carefully for operational or trial and error procedures.



## 3. Reproduction

Tip all the pieces onto the table, mix them and ensure all pieces are visible.

Say: I want you to put them back where they should go.

Watch for operational or trial and error response.

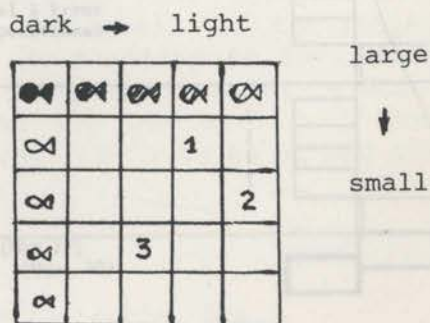
## 4. Two-Dimensional Choice

Set up the board with 9 pieces on the left and upper edges as shown. Give the child piece number 1.

Say: I want you to put this on the board where it should go - where it belongs.

Watch for either trial and error or operational response.

Repeat the procedure for pieces 2 and 3 as shown in the diagram



APPENDIX B. PERCEPTUAL REGULATIONS TEST - ELKIND

B1. DIRECTIONS FOR PERCEPTUAL INTEGRATIONS TEST (ELKIND) (PIT)

The child is tested individually and the cards are shown one at a time. They are held upright about a foot from the subject. The child is then told, "I am going to show you some pictures one at a time. Look at the pictures and tell me what they are like to you."

Name: \_\_\_\_\_

Multiple Seriation - Response Record

Matrix A, 3 x 3			
1. Replacement	a. 1 piece	0	<input type="checkbox"/>
	b. 2 pieces	1	<input type="checkbox"/>
	c. 4 pieces	1	<input type="checkbox"/>
	d. 6 pieces (Max. 3 Discontinue if 0)	1	<input type="checkbox"/>
2. Reproduction	a. Matching shape or colour with prompt	1	<input type="checkbox"/>
	b. Matching shape or colour no prompt	2	<input type="checkbox"/>
	c. Cross classif. with prompt	3	<input type="checkbox"/>
	d. Cross classif. no prompt	4	<input type="checkbox"/>
Total (Max 4)			<input type="checkbox"/>
Matrix B, 3 x 3			
1. Spont. Constr.	a. Matching - colour or size	1	<input type="checkbox"/>
	b. Single seriation - 3 rows/cols	2	<input type="checkbox"/>
	c. S.S. 3 rows/cols and matching	3	<input type="checkbox"/>
	d. If no M.S. - prompt. If improvement	-1	<input type="checkbox"/>
	e. Multiple seriation - Trial & Error	5	<input type="checkbox"/>
	f. Multiple seriation - operational	6	<input type="checkbox"/>
	g. If M.S. Shown - check if "no diff".	3	<input type="checkbox"/>
Total (Max 6)			<input type="checkbox"/>
2. Replacement	a. Two pieces	1	<input type="checkbox"/>
	b. Four pieces	1	<input type="checkbox"/>
	c. Six pieces	1	<input type="checkbox"/>
Total (Max 3) If 0, go on to 2-dim choice			<input type="checkbox"/>
3. Reproduction	a. Single seriation	1	<input type="checkbox"/>
	b. Single seriation and matching	2	<input type="checkbox"/>
	c. Multiple seriation T & E	3	<input type="checkbox"/>
	d. Multiple Seriation Operation	4	<input type="checkbox"/>
	e. If M.S. - check. If "no diff".	2	<input type="checkbox"/>
Total (Max 4)			<input type="checkbox"/>
4. Two dimen. Choice	a. Bigger/darker	1	<input type="checkbox"/>
	b. Smaller, lighter	1	<input type="checkbox"/>
Total (Max 2)			<input type="checkbox"/>
Total Matrixes A and B (Max. 22)			<input type="checkbox"/>
Matrix C, 5 x 5			
1. Spontaneous Construction	a. Single seriation - 1 or 2 rows/columns	1	<input type="checkbox"/>
	b. Single seriation - 3-5 rows/columns	2	<input type="checkbox"/>
	c. Single seriation and matching (colour) 5 rows	+1	<input type="checkbox"/>
	d. Prompt?	-1	<input type="checkbox"/>
	e. Multiple seriation - Trial & Error	5	<input type="checkbox"/>
	f. Multiple seriation - operational	6	<input type="checkbox"/>
Total (Max. 6)			<input type="checkbox"/>
2. Replacement	a. 4 pieces	1	<input type="checkbox"/>
	b. 8 pieces	1	<input type="checkbox"/>
	c. 12 pieces	1	<input type="checkbox"/>
	d. Operational	1	<input type="checkbox"/>
Total (Max. 4)			<input type="checkbox"/>
3. Reproduction	a. Single seriation 5 rows/columns	1	<input type="checkbox"/>
	b. Single seriation and matching		<input type="checkbox"/>
	c. Multiple seriation Trial & Error		<input type="checkbox"/>
	d. Multiple seriation - Operational		<input type="checkbox"/>
Total (Max. 4)			<input type="checkbox"/>
4. Two Dimensional Choice	a. Item 1	1	<input type="checkbox"/>
	b. Item 2	1	<input type="checkbox"/>
	c. Item 3	1	<input type="checkbox"/>
	d. Operational	1	<input type="checkbox"/>
Total (Max. 4)			<input type="checkbox"/>
Total Matrix C (Max. 18)			<input type="checkbox"/>
GRAND TOTAL Matrixes A, B, C (Max. 40)			<input type="checkbox"/>

Accept mislabels of fruit, e.g. orange for apple, etc.

CARD 6 Face APPENDIX B. PERCEPTUAL REGULATIONS TEST - ELKIND

B1. DIRECTIONS FOR PERCEPTUAL INTEGRATIONS TEST (ELKIND)  
(PIT)

The child is tested individually and the cards are shown one at a time. They are held upright about a foot from the subject. The child is then told, "I am going to show you some pictures, one at a time. Look at the pictures and tell me what you see or what they look like to you."

After the subject's first response, if he doesn't see both parts and wholes, he is asked, "Anything else?" Thereafter, only responses that need clarification are questioned and only spontaneous responses are recorded. If a child mislabels one of the picture, it is to be scored as long as the concept is there, e.g., calling a giraffe a zebra.

Sometimes children see the wholes, but do not always describe them fully. They may say in Card 3, "Candy canes making the handle bars and lollypops" or in Card 4 "An orange head, pear, etc." Child is to be given credit for whole and parts even if he does not respond further. The following are ways to clarify some responses.

CARD 1 Two giraffes forming a heart.

Child may perseverate on the giraffes when you ask, "Anything else" and start saying, "hair, spots, dots, etc." Examiner should say "yes, those are all parts of the giraffe, anything else?" Discontinue if child continues to name parts of the giraffe.

CARD 2 Vegetables forming a fish (plane).

This card is presented on its side. Responses such as fish, plane, shark, etc., are acceptable. If child comments on lines in the body of the potato (fish) after asking him, "Anything else?" say "Yes, that is part of the potato (fish, etc.), anything else?" Discontinue if the child continues to name parts of the potato. (fish, etc.)

CARD 3 Candy forming a scooter

This card is held on its side, the candy canes forming handle bars, should be in the upper left hand corner. Child who sees parts may only mention candy canes or lollipops. Scooter, trike, or bike are acceptable responses for the whole of this card.

CARD 4 Fruit and vegetables forming a rabbit

This card is held on its side. Some children do not have the label for the radish or beet, the part that forms the tail of the animal. If the child has provided the names of the other fruits and vegetables, the examiner may provide the label. If the subject has made no part responses and seems to be fixating on this part, the examiner may encourage the child by asking him to point to what he is looking at and then asking if he knows the name of it. If not, ask him what he would do with it. Encourage child to go on and tell you if he sees anything else.

CARD 5 Man made of fruit

Accept mislabels of fruit, e.g. orange for apple, etc.

5 and 6 year olds - parts and some wholes - 16 points  
7 and 8 year olds - parts and some wholes - 16 points  
9 and 10 year olds - 16-21 points

## CARD 6 Face made of "electrical" equipment

Children sometimes have trouble labeling the seitch, as above, if they have named the other parts, provide them with the label. If not, ask them what they would do with it.

## CARD 7 Face made of toys

Children sometimes call the tops, diamonds or cannot give you the label. Provide the label if they have given the other parts, if not, ask them to tell you or demonstrate what they would do with the item.

## INSTRUCTIONS AND SCORING OF THE PICTURE INTERGRATION TEST (PIT)

1. See numbers and arrows on back of each card for presentation order and position.
2. Tell me what you see on this card. Anything else?
3. Write down everything child says - score after completion of test.
4. Scoring-Points      Parts = one point      Wholes = two points

- |    |    |   |   |                                      |
|----|----|---|---|--------------------------------------|
| 1. | a. | giraffes  | 1 |                                      |
|    | b. | heart   | 2 |                                      |
|    | c. | giraffe, forming a heart                            | 3 | (top score on this card is 3 points) |
| 2. | a. | vegetables  | 1 |                                      |
|    | b. | fish  | 2 |                                      |
|    | c. | vegetables making a fish                            | 3 | (top score on this card is 3pts)     |
| 3. | a. | candy   | 1 |                                      |
|    | b. | scooter (bike)                                      | 2 |                                      |
|    | c. | candy making a scooter<br>(bicycle bike)            | 3 | (top score is 3 points)              |
| 4. | a. | fruit or vegetable                                  | 1 |                                      |
|    | b. | rabbit (dog, animal)                                | 2 |                                      |
|    | c. | animal (rabbit, dog)<br>made of fruit               | 3 | (top score is 3 points)              |
| 5. | a. | fruit   | 1 |                                      |
|    | b. | man (figure)  | 2 |                                      |
|    | c. | man made of fruit                                   | 3 | (top score is 3 points)              |
| 6. | a. | electrical equipment<br>(or individual parts named) | 1 |                                      |
|    | b. | face  | 2 |                                      |
|    | c. | face made of elec. equip.<br>naming of parts        | 3 |                                      |
| 7. | a. | toys  | 1 |                                      |
|    | b. | face  | 2 |                                      |
|    | c. | face made of toys                                   | 3 |                                      |

SCORING

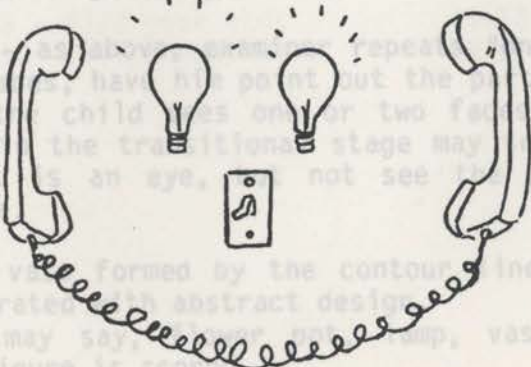
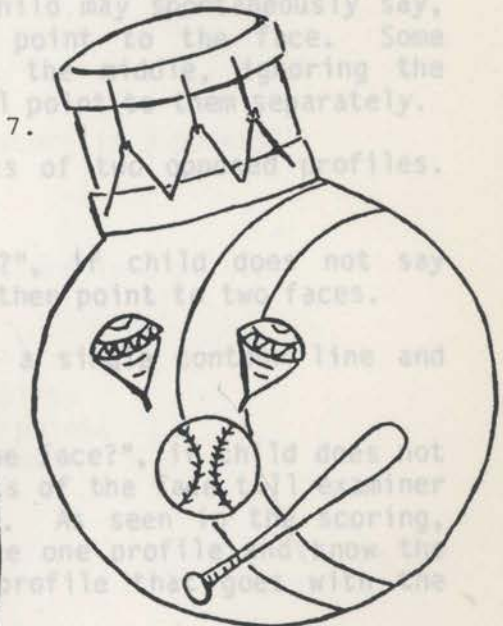
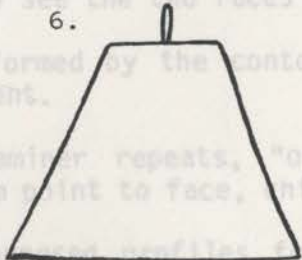
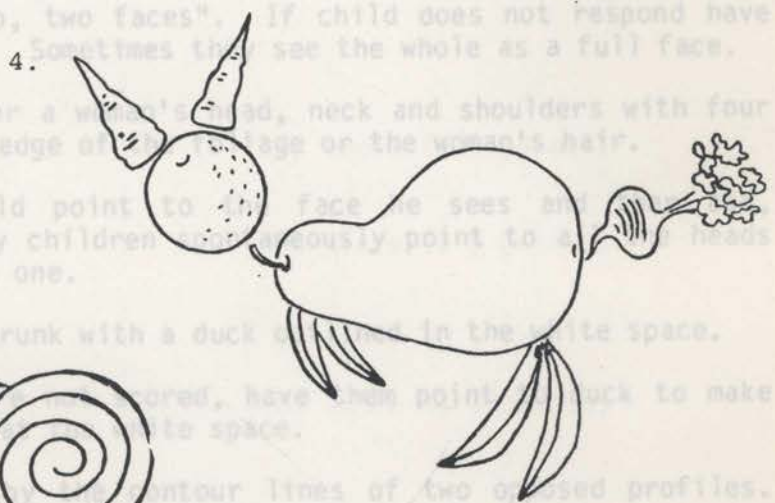
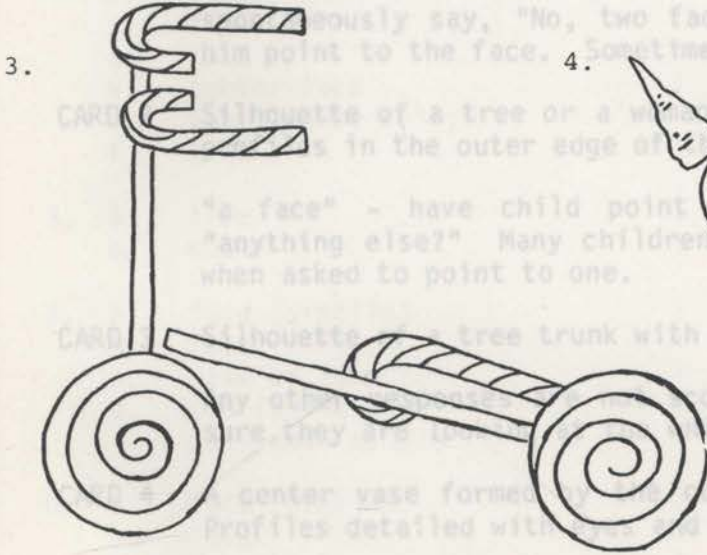
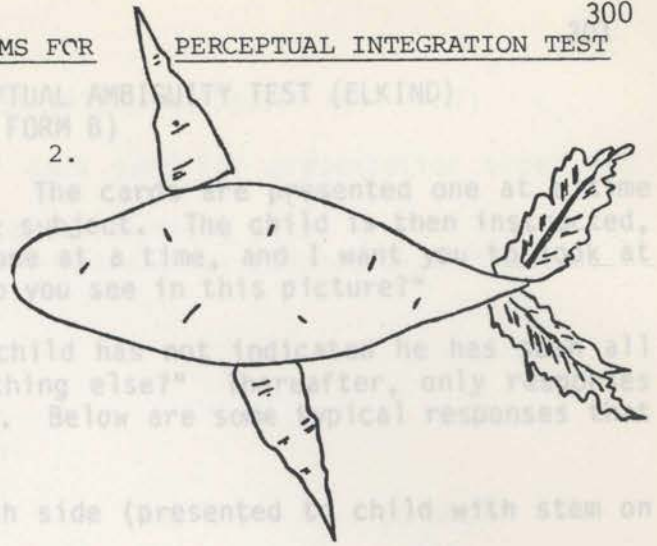
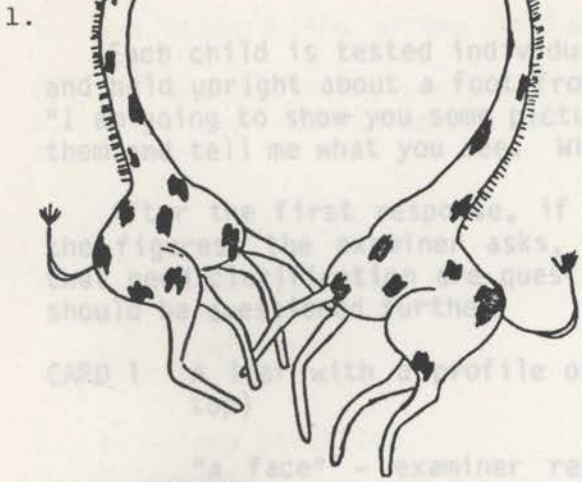
1. Perception of parts and wholes increase with age.
2. Parts perceived more readily than wholes.
3. By 9 years of age, the majority of children make part-whole intergrations.

5 and 6 year olds - just parts - 7 points

7 and 8 year olds - parts and some wholes - 7-16 points

9 and 10 year olds - 16-21 points

B2. ITEMS FOR PERCEPTUAL INTEGRATION TEST



B3. DIRECTIONS FOR PERCEPTUAL AMBIGUITY TEST (ELKIND)  
(PAT FORM B)

Each child is tested individually. The cards are presented one at a time and held upright about a foot from the subject. The child is then instructed, "I am going to show you some pictures one at a time, and I want you to look at them and tell me what you see. What do you see in this picture?"

After the first response, if the child has not indicated he has seen all the figures, the examiner asks, "Anything else?" Thereafter, only responses that need clarification are questioned. Below are some typical responses that should be questioned further.

- CARD 1 A leaf with a profile on each side (presented to child with stem on top)
- "a face" - examiner repeats to the child "one face?". child may spontaneously say, "No, two faces". If child does not respond have him point to the face. Sometimes they see the whole as a full face.
- CARD 2 Silhouette of a tree or a woman's head, neck and shoulders with four profiles in the outer edge of the foliage or the woman's hair.
- "a face" - have child point to the face he sees and then ask, "anything else?" Many children spontaneously point to all the heads when asked to point to one.
- CARD 3 Silhouette of a tree trunk with a duck outlined in the white space.
- Any other responses are not scored, have them point to duck to make sure they are looking at the white space.
- CARD 4 A center vase formed by the contour lines of two opposed profiles. Profiles detailed with eyes and mouths.
- "a face" - examiner says, "one face?", child may spontaneously say, "No, two faces", if not, ask them to point to the face. Some children see one face with a pole down the middle, ignoring the profiles or they see the two faces and will point to them separately.
- CARD 5 A center vase formed by the contour lines of two opposed profiles. No details present.
- "a face" - examiner repeats, "one face?", if child does not say "two", have them point to face, child may then point to two faces.
- CARD 6 Two staggered opposed profiles formed by a single contour line and detailed with eyes only.
- "a face" - as above, examiner repeats "one face?", if child does not say two faces, have him point out the parts of the face till examiner is sure the child sees one or two faces. As seen in the scoring, children in the transitional stage may see one profile and know the other dot is an eye, but not see the profile that goes with the second eye.
- CARD 7 A center vase formed by the contour lines of two opposed profiles. Vase decorated with abstract design. Children may say, flower pot, lamp, vase, anything that indicates central figure is scored.

INSTRUCTIONS AND SCORING OF PERCEPTUAL AMBIGUITY TEST (PAT)

1. See numbers and arrows on back of each card for presentation order and position.
2. Tell me everything you see on this card. Anything else?
3. Write down everything the child says - score after completion of the test.
4. Scoring

- |    |     |                |   |                         |
|----|-----|----------------|---|-------------------------|
| 1. | a.  | face (profile) | 1 |                         |
|    | b.  | face (profile) | 1 |                         |
|    | c.  | leaf (tree)    | 1 |                         |
|    | *d. | center face    | 1 | (top score is 4 points) |

- |    |    |                                  |   |                         |
|----|----|----------------------------------|---|-------------------------|
| 2. | a. | face (profile)                   | 1 |                         |
|    | b. | face "                           | 1 |                         |
|    | c. | face "                           | 1 |                         |
|    | d. | face "                           | 1 |                         |
|    | e. | center face<br>(outline is hair) | 1 |                         |
|    | f. | tree                             | 1 | (top score is 6 points) |

- |    |    |      |   |                         |
|----|----|------|---|-------------------------|
| 3. | a. | tree | 1 |                         |
|    | b. | duck | 1 | (top score is 2 points) |

- |    |    |                                   |   |                         |
|----|----|-----------------------------------|---|-------------------------|
| 4. | a. | face (profile)                    | 1 |                         |
|    | b. | face "                            | 1 |                         |
|    | c. | vase or lamp                      | 1 |                         |
|    | d. | one face with<br>pole down middle | 1 | (top score is 4 points) |

- |    |    |                       |   |                         |
|----|----|-----------------------|---|-------------------------|
| 5. | a. | face (profile)        | 1 |                         |
|    | b. | face "                | 1 |                         |
|    | c. | face "<br>and one eye | 1 | (top score is 2 points) |

- |    |    |                |   |                         |
|----|----|----------------|---|-------------------------|
| 6. | a. | face (profile) | 1 |                         |
|    | b. | face "         | 1 |                         |
|    | c. | vase or lamp   | 1 | (top score is 3 points) |

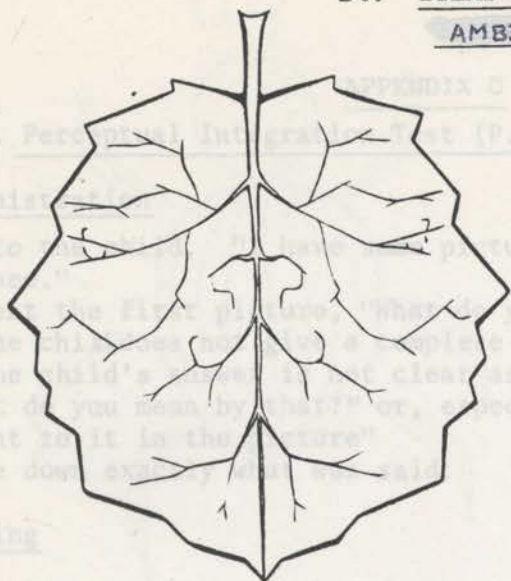
- |    |    |                |   |                         |
|----|----|----------------|---|-------------------------|
| 7. | a. | face (profile) | 1 |                         |
|    | b. | face "         | 1 |                         |
|    | c. | vase or lamp   | 1 | (top score is 3 points) |

\*not usual responses

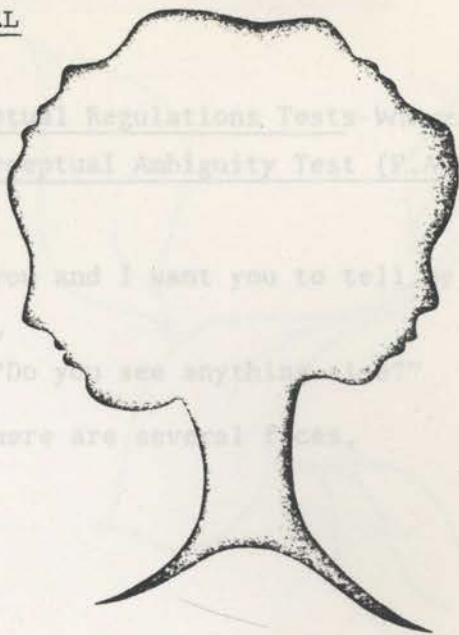
Average scores for 6 1/2 - 7 1/2 year olds  
 Average scores for 8 - 9 1/2 year olds  
 Average scores for 10 - 11 1/2 year olds

7-8 points  
 11-14 points  
 14 points

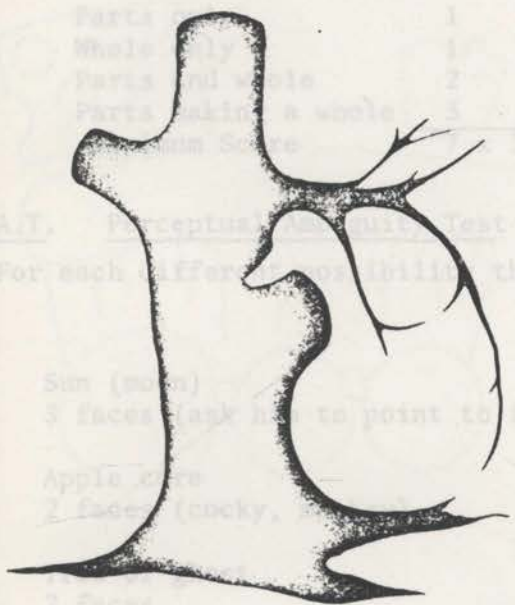
1.



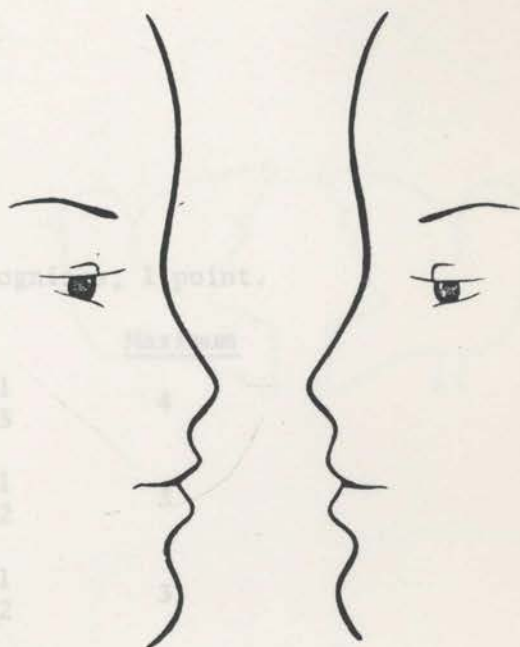
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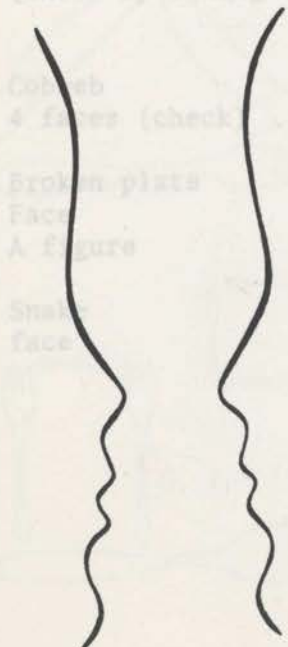
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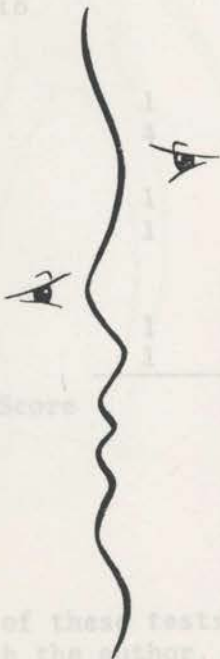
4.



5.



6.



7.



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C1. Perceptual Integration Test (P.I.T.) and Perceptual Ambiguity Test (P.A.T.)Administration

Say to the child. "I have some pictures to show you and I want you to tell me what you see."

Present the first picture, "What do you see here?"

If the child does not give a complete answer say, "Do you see anything else?"

If the child's answer is not clear ask,

"What do you mean by that?" or, especially when there are several faces,

"Point to it in the picture"

Write down exactly what was said.

ScoringP.I.T. Perceptual Integration Test

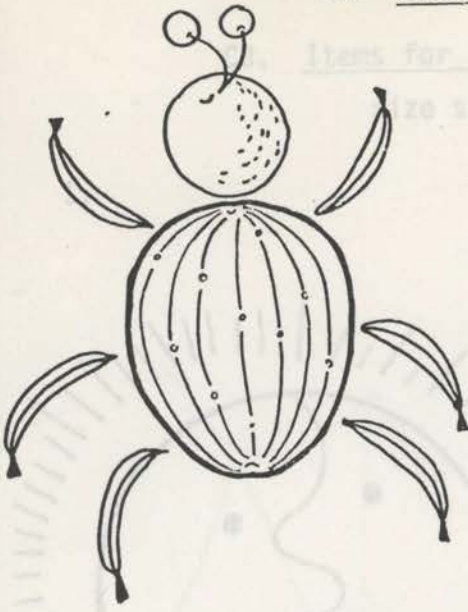
Parts only	1
Whole only	1
Parts and whole	2
Parts making a whole	3
Maximum Score	$7 \times 3 = 21$

P.A.T. Perceptual Ambiguity Test

For each different possibility the child recognises, 1 point.

		<u>Maximum</u>
1. Sun (moon)	1	4
3 faces (ask him to point to faces)	3	
2. Apple core	1	3
2 faces (cocky, monkey)	2	
3. Tree or ghost	1	3
2 faces	2	
4. 3 faces (1 front on, 2 profiles) (check by asking child to point to faces)	3	3
5. Cobweb	1	5
4 faces (check)	4	
6. Broken plate	1	2
Face A figure	1	
7. Snake face	1	2
	1	
Maximum Score		<u>22</u>

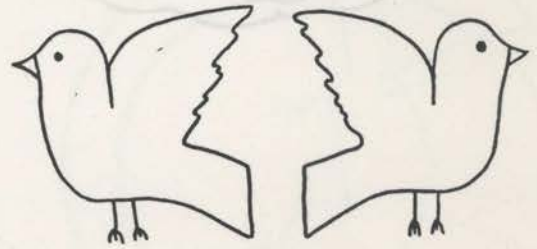
1.



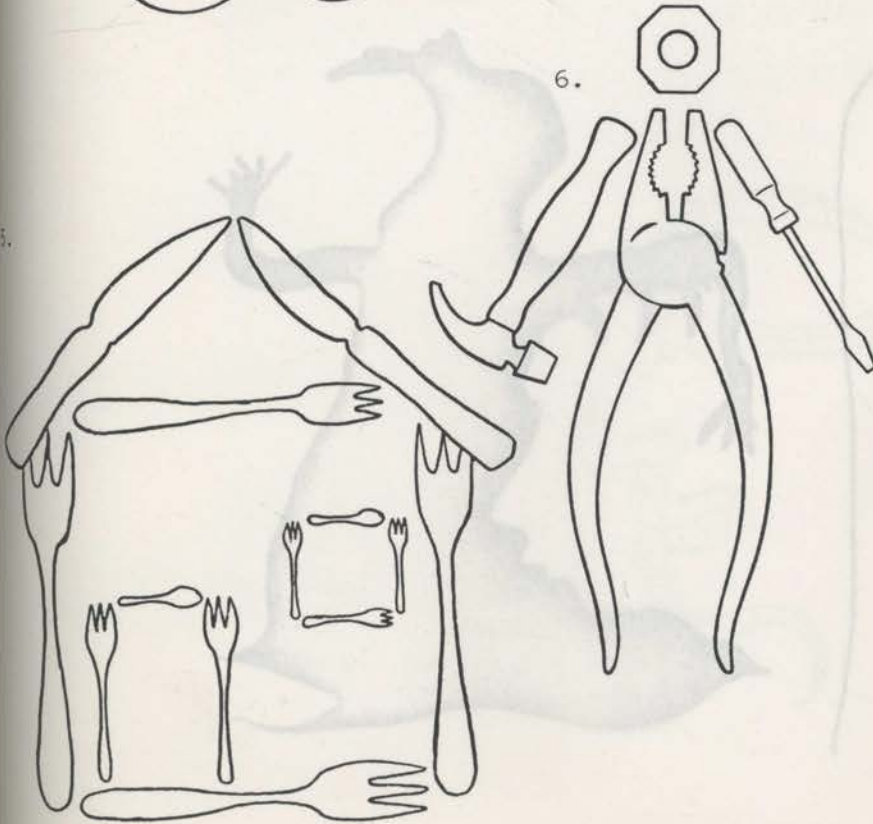
2.



4.



6.

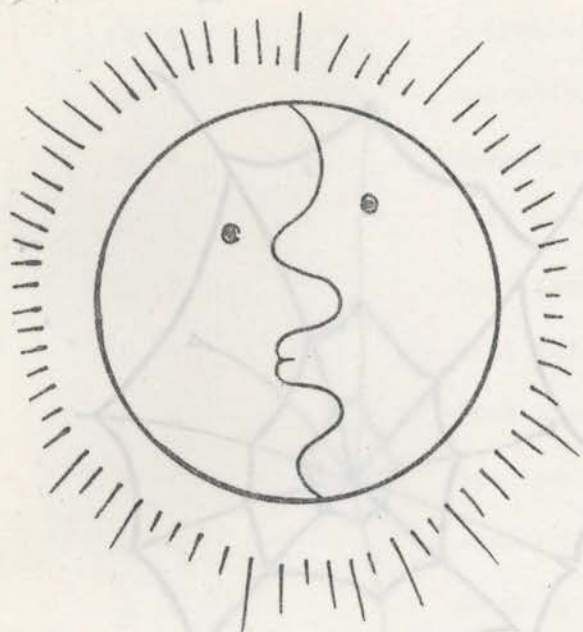


7.



C3. Items for the Perceptual Ambiguity Test  
size shown is 1/3 the original

1.



2.



3.



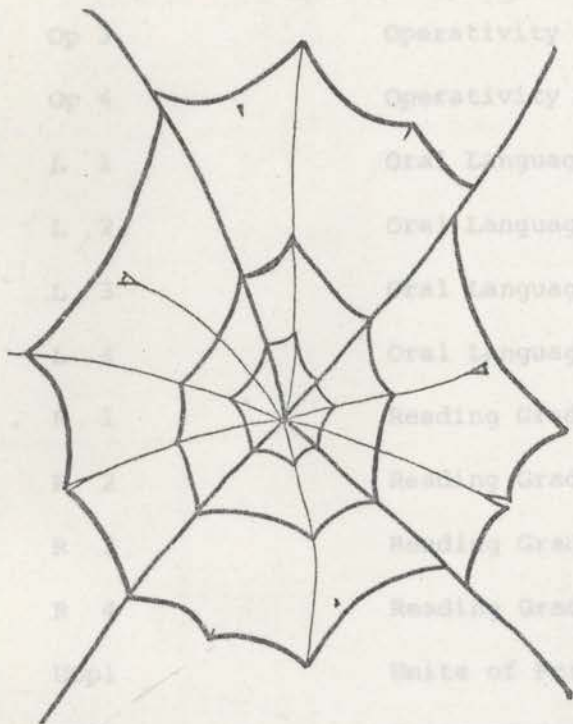
4.



Residual Matrix for the Path Analysis of Study 3

Key to Variables, Figure 4.5B

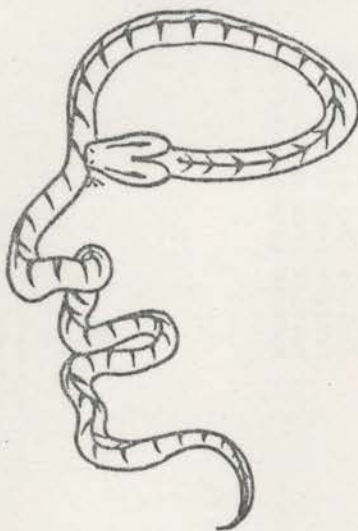
1	Op 1	Operativity Grade 1
2	Op 2	Operativity Grade 2
3	Op 3	Operativity Grade 3
4	Op 4	Operativity Grade 4
5	L 1	Oral Language Grade 1
6	L 2	Oral Language Grade 2
7	L 3	Oral Language Grade 3
8	L 4	Oral Language Grade 4
9	R 1	Reading Grade 1
10	R 2	Reading Grade 2
11	R 3	Reading Grade 3
12	R 4	Reading Grade 4
13	U 1	Units of Print Grade 1
14	U 2	Units of Print Grade 2
15	U 3	Units of Print Grade 3
16	Op K	Operativity Kindergarten
17	L K	Oral Language and Kindergarten



5.



6.



7.

Residual Matrix for the Path Analysis of Study 3

Key to Variables Figure 4.6B

1	Op 1	Operativity Grade 1
2	Op 2	Operativity Grade 2
3	Op 3	Operativity Grade 3
4	Op 4	Operativity Grade 4
5	L 1	Oral Language Grade 1
6	L 2	Oral Language Grade 2
7	L 3	Oral Language Grade 3
8	L 4	Oral Language Grade 4
9	R 1	Reading Grade 1
10	R 2	Reading Grade 2
11	R 3	Reading Grade 3
12	R 4	Reading Grade 4
13	UOp1	Units of Print Grade 1
14	UOp2	Units of Print Grade 2
15	UOp3	Units of Print Grade 3
16	Op K	Operativity Kindergarten
17	L K	Oral Language and Kingergarten

APPENDIX E

Correlation Matrix for the Path Analyses of

Study 3

Key to Variables

RESIDUAL MATRIX

	1	2	3	4	5	6	7	8	9	10	11	12	13
1 OP1	.0000												
2 OP2	.0000	.0000											
3 OP3	.0128	.0000	.0000										
4 OP4	.0924	.0000	.0000	.0000									
5 R1	.0899	.0830	.0230	.0823	.0000								
6 R2	.1707	.1022	.1255	.1159	.0000	.0000							
7 R3	.1953	.1657	.1124	.1384	.0000	.0000	.0000						
8 R4	.2224	.1132	.0972	.1740	.0050	.0000	.0000	.0000					
9 OPK	.0238	.0699	.1520	.0548	.0204	.0126	.0981	.0785	.0108				
10 LK	.0789	.0673	.1035	.0735	.0324	.0170	.1552	.1109	.0151	.0186			
11 OP4	.1291	.0649	.0901	.1305	.0194	.0398	.1306	.0711	.0536	.0347	.0443		
12 OPK	.1043	.1104	.1048	.1094	.0836	.0338	.0867	.0829	.0674	.0444	.0522	.0592	
13 OPK	.0000	.0000	.0000	.0000	.0000	.1099	.1261	.1160	.0000	.0392	.0744	.0653	.0000
14 LK	.0749	.0640	.1287	.2057	.0000	.0000	.0071	.0426	.0170	.0544	.0128	.0386	.0000

READ

LANK

OPK

RESIDUAL MATRIX

14

.0000

DISTRIBUTION OF MAGNITUDES OF RESIDUALS

RANGE	COUNT
GREATER THAN OR EQUAL TO .200	2
GREATER THAN OR EQUAL TO .100 BUT LESS THAN .200	25
GREATER THAN OR EQUAL TO .050 BUT LESS THAN .100	27
GREATER THAN OR EQUAL TO .010 BUT LESS THAN .050	21
GREATER THAN OR EQUAL TO .005 BUT LESS THAN .010	1
GREATER THAN OR EQUAL TO .001 BUT LESS THAN .005	1
LESS THAN .001	26

SOE > .01

MEAN = .05926407    LARGEST = .22241980    SMALLEST = .1735-017

KEY. OP1 - OP4 = Operativity, Grades 1-4.    L1 - L4 = Language, Grades 1-4.  
 R1 - R4 = Reading, Grades 1-4.    OPK = Operativity Kindergarten.    LK = Language Kindergarten.

Correlation Matrix for the Path Analyses of

Study 3

Key to Variables

1	Op 1	Operativity Grade 1
2	Op 2	Operativity Grade 2
3	Op 3	Operativity Grade 3
4	Op 4	Operativity Grade 4
5	L 1	Oral Language Grade 1
6	L 2	Oral Language Grade 2
7	L 3	Oral Language Grade 3
8	L 4	Oral Language Grade 4
9	R 1	Reading Grade 1
10	R 2	Reading Grade 2
11	R 3	Reading Grade 3
12	R 4	Reading Grade 4
13	UOp1	Units of Print Grade 1
14	UOp2	Units of Print Grade 2
15	UOp3	Units of Print Grade 3
16	Op K	Operativity Kindergarten
17	L K	Oral Language and Kingergarten

SAMPLE COVARIANCE OR CORRELATION MATRIX

1	2	3	4	5	6	7	8	9	10	11	12
1.0000											
.4453	1.0000										
.3591	.6440	1.0000									
.4039	.5875	.5507	1.0000								
.3102	.2658	.1996	.2390	1.0000							
.3270	.2319	.2508	.2271	.7357	1.0000						
.3554	.2985	.2408	.2523	.7369	.7205	1.0000					
.3580	.2307	.2059	.2704	.6220	.6641	.8002	1.0000				
.3956	.2910	.3466	.2284	.4040	.2892	.3786	.3165	1.0000			
.4110	.3252	.3146	.2627	.3773	.3838	.4825	.3967	.8058	1.0000		
1	2	3	4	5	6	7	8	9	10	11	12
.4292	.3272	.3425	.3302	.4122	.3937	.4753	.3661	.7120	.8478	1.0000	
.3944	.3756	.3455	.3518	.3390	.4271	.4637	.4745	.6778	.7968	.8057	1.0000
.4404	.3345	.3348	.3416	.3373	.3362	.3633	.2854	.4847	.4598	.4542	.3965
.2871	.2351	.2560	.1815	.2227	.2331	.2546	.1517	.3398	.3397	.3447	.3475
.1842	.2849	.1069	.0868	.1058	.2257	.2384	.2584	.2527	.2601	.2289	.2131
.5331	.4423	.4274	.3792	.4133	.4031	.4265	.3703	.3924	.4072	.4198	.4112
.2017	.1692	.2304	.2959	.7449	.6169	.5828	.5401	.2663	.2320	.2648	.2660
13	14	15	16	17							
1.0000											
.4723	1.0000										
.3287	.2855	1.0000									
.4130	.4413	.1057	1.0000								
.1605	.1149	.0379	.2379	1.0000							

## APPENDIX F. UNITS OF PRINT TEST

## F1. DIRECTIONS FOR UNITS OF PRINT TEST

Instructions for Administration

Two examiners are needed for the administration of this group measure, each should have a rubber to help children with corrections.

Ensure children cannot see each other's work and that each has a sharp pencil. Distribute the test booklets. Say:

I have some puzzles for you to do and some questions to ask about print. At the top of the booklet write your name and school. (Pause)

We will now start. Listen very carefully so that you will know what to do. We will do some trail exercises first.

Trial a

Look at the long box which has a clock at one end of it. Put your fingers on the clock. (Check all children)  
Now look at the things in that box.

Find the thing you can eat.

Draw a circle around the thing you can eat. (Pause)

Who has drawn a circle around the apple? Good.

(Check that all are correct. Help any who are not).

Trial b

Now look at the next long box which has a fish at one end of it. Put your finger on the fish.

In that box draw a circle around each thing which has legs - each thing with legs. (Pause)

Who has drawn a circle around the table and the cat? Yes, two things have legs - a table and a cat. Good work. (Check that all are correct. Help if necessary.)

Trial c

Now find the box with a balloon at one end. Draw a circle around the first animal in the box. Circle the first animal.

Pause.

Notice there are two animals - a pig and a tortoise. Which one is the first? Yes, the pig. Who had drawn a circle around the pig? Good. That is the first animal in the box.

(Check that all are correct. Help if necessary).

We have now had our practice. Turn over the page.

- Put your finger on the chair. (Check that all children have the correct place). Look at the other things in that box. Draw a circle around each thing you think is a number. Circle each number.

2. Put your finger on the seal. Look at the other things in the box. Draw a circle around each thing you think is a number. Circle each number.
3. Put your finger on the waggon. Circle each thing in that box which is a number. Circle each number.
4. Put your finger on the girl. Circle each thing that is a number. Circle each thing that is a number.
5. Put your finger on the house. Circle each thing that is a letter. Circle each letter.
6. Put your finger on the block. Circle each thing that is a letter. Circle each letter.
7. Put your finger on the bed. Circle each letter in the box. Circle each letter.
8. Put your finger on the bucket. Circle each letter. Circle each letter.  
Now turn the page.
9. Put your finger on the chimney. (Check that everyone has turned to the right page).  
In that box draw a circle around each thing that is a capital letter. Circle each capital letter.
10. Put your finger on the pig. Draw a circle around each capital letter. Circle each capital letter.
11. Put your finger on the comb. In that box draw a circle around the first letter in each word. Circle the first letter in each word.
12. Put your finger on the leaf. Circle the first letter in each word - the first letter in each word.
13. Put your finger on the cocky. Draw a circle around each word. Circle each word.
14. Put your finger on the shoe. Circle each word. Circle each word.
15. Put your finger on the space man. In that box circle the very first word - the very first word.
16. Put your finger on the horse. Circle the very first word - the very first word. Turn over the page.
17. Put your finger on the birthday cake. Who has found the birthday cake? (Check) There are some sentences in this box. Circle the first sentence in the box - the first sentence.
18. Put your finger on the circle. In this box are some sentences. Draw a circle around the first sentence. The first sentence.
19. Put your finger on the candle. In that box are some sentences. Draw a circle around the first sentence - the first sentence.

20. Put your finger on the apple. In that box are some sentences. Draw a circle around the first sentence. Circle the first sentence.

21. Put your finger on the rabbit. In that box are some sentences. Circle the first sentence - the first sentence.

22. Put your finger on the triangle. In that box are some sentences. Circle the first sentence - the first sentence.

23. Put your finger on the sock. In the box are some sentences. Circle the first sentence - the first sentence.

24. Put your finger on the turtle. In the box are some sentences. Circle the first sentence - the first sentence.

Scoring

For each correct item score 1

Any mistake in an item score 0

Maximum score 24



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BIRMINGHAM, N.S.W.

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THE ASSISTANCE OF JEN BOSS-BASIS AND  
MIRELLA LANE IN PREPARATION OF THE TEST  
IS GRATEFULLY ACKNOWLEDGED.

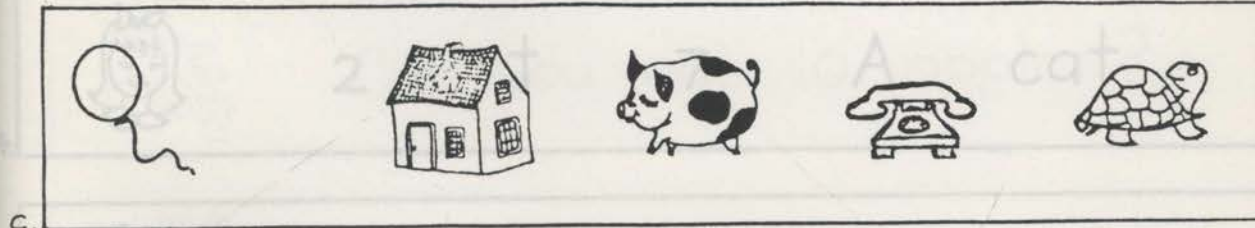
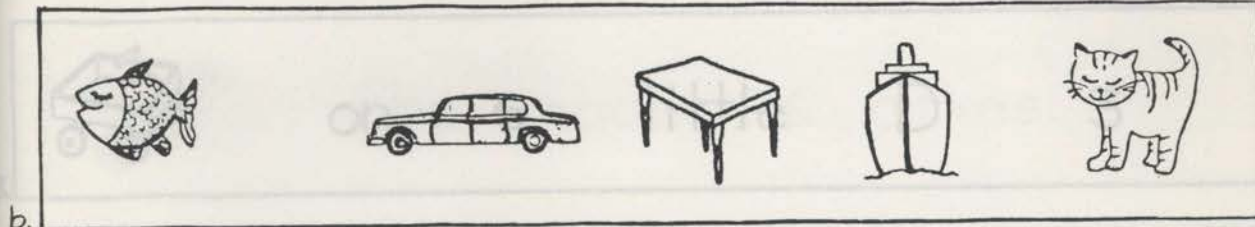
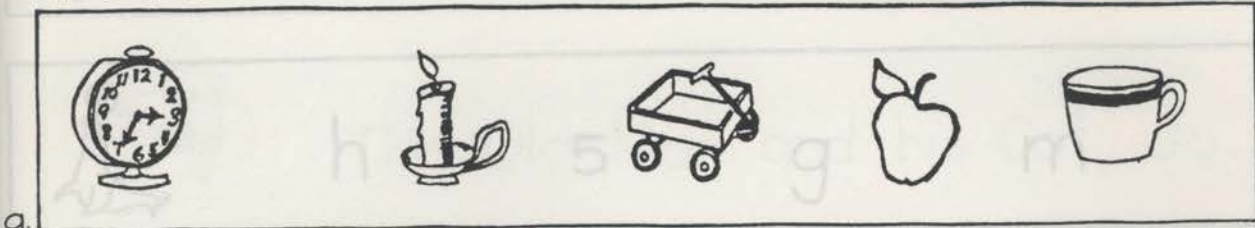
Name: \_\_\_\_\_

School: \_\_\_\_\_

F2 ITEMS FOR UNITS FO PRINT TEST.

# UNITS OF PRINT TEST

Trial Exercises:



A. WATSON

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MITCHELL LANE IN PREPARATION OF THE TEST  
IS GRATEFULLY ACKNOWLEDGED.



△ cartoon is 4 Bog



h The Old Man g his m, Jo.



on the 6 little Dkes. 3



2 Can t 7 10 A app cat?



t 4 idog 6 p d sit



b G 89 5 teleT sion 7 of



75 n mum days z w 8 sw P.



K 37 like p fish 464 dad



9. Sartolow is in Bognor.



10. The Old Man and his Cat, Jo.



11. She made 36 cakes.



12. Can you eat 10 apples?



13. M d is dog It p s sit



14. h 289 television of



15. On hot days we swim.



16. A cat likes fish.

## REFERENCES LIST



17. He came home. We all played games.



18. The rain is coming soon. Run quickly.  
You might get wet.



19. A man cut a tree and it fell  
over. Some branches hit our house.



20. Children play many games at the  
park down the road. They run and jump.



21. On a very hot day, we have a swim.  
The water is cool. It is fun.



22. When school is over, Tom plays football.  
The boys like to run and kick the ball.



23. Jump in. The water is not cold.  
It is your go now.



24. Wait. I will come soon.  
I must put on my shoes.

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