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LINGUISTIC CONSIDERATIONS IN THE DESIGN OF THE STANFORD COMPUTER-BASED CURRICULUM IN INITIAL READING.

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DESCRIPTORS- *COMPUTER ASSISTED INSTRUCTION, *LINGUISTICS, *PRIMARY GRADES, *READING INSTRUCTION, *READING MATERIALS, WRITTEN LANGUAGE, READING SKILLS, INDIVIDUAL DIFFERENCES, SPELLING, READING COMPREHENSION, PSYCHOLINGUISTICS, SPEECH SKILLS, STANFORD VOCALIC CENTER GROUPS (VCG),

SOME VIEWS ON THE ROLE OF LINGUISTIC SCIENCE IN THE DESIGN OF READING MATERIALS AND THE TEACHING OF PRIMARY READING ARE CONTRASTED. FOUR AREAS OF LINGUISTIC STUDY RELEVANT TO READING ARE EXAMINED BRIEFLY--(1) THE STRUCTURE OF THE SPEECH SYSTEM, (2) THE STRUCTURE OF THE GRAPHIC SYSTEM, (3) THE RELATIONSHIP OF GRAPHOLOGY TO PHONOLOGY, AND (4) THE COMPARATIVE SYNTAX OF SPOKEN AND WRITTEN ENGLISH. SOME CLASSICAL ARGUMENTS AS TO THE RELATIONSHIP OF LINGUISTIC DESCRIPTION AND PSYCHOLOGICAL FUNCTION ARE REEXAMINED IN TERMS OF PROBLEMS IN DESIGN OF AN INITIAL READING CURRICULUM. THE ADAPTATION OF THE CURRICULUM TO THE INDIVIDUAL LEARNING CHARACTERISTICS OF THE STUDENT PARTICIPANTS WAS VIEWED AS A CENTRAL PROBLEM OF EDUCATION AND OF COMPUTER-ASSISTED INSTRUCTION (CAI) PARTICULARLY. THE STANFORD CURRICULUM IN CAI IN BEGINNING READING IS BASED ON THE FOLLOWING SEVEN PSYCHOLINGUISTIC TENETS--(1) TEACHING SPELLING AND READING INDEPENDENTLY, (2) INITIATING READING WITH A DECODING STAGE, (3) ASSOCIATING SIGHT TO SOUND BETWEEN LETTER PATTERNS AND VOCALIC CENTER GROUPS (VCG), (4) SCALING THE DIFFICULTY OF THE VCG UNITS FOR PRESENTATION, (5) PRESENTING GRAPHIC PATTERNS AS MEMBERS OF A RHYME AND ALLITERATION SET IN A MATIX FORMAT, (6) PRESENTING WORD ITEMS IN VARIOUS CONTEXTS, EMPHASIZING THE MORPHOLOGICAL, SYNTACTIC, AND SEMANTIC FUNCTIONS, AND (7) PRESENTING WORDS IN VARIOUS CONTEXTS IN WHICH PRONUNICATION, GRAMMAR, AND MEANING CONVEY THE WRITER'S INTENT. THESE TENETS ARE DISCUSSED IN TERMS OF CONTEMPORARY PEDAGOGICAL OPINION, RELATED EMPIRICAL RESEARCH, EXPERIMENAL INVESTIGATIONS BY THE STANFORD GROUP, AND PRACTICAL CONSEQUENCES IN CURRICULUM MATERIALS. A BIBLIOGRAPHY AND A TABLE ARE GIVEN. (BK)

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1 D. Davidson, S. Siegel, and P. Suppes. Some experiments and related theory on the measurement of utility and subjective probability. August 15, 1955. (Experimental test of the basic model, Chapter 2 in Decision-making: An Experimental Approach. Stanford Univ. Press, 1957)

2 P. Suppes. Note on computing all optimal solutions of a dual linear programming problem. November 15, 1955.

3 D. Davidson and P. Suppes. Experimental measurement of utility by use of a linear programming model. April 2, 1956. (Experimental test of a linear programming model, Chapter 3 in Decision-making: An Experimental Approach. Stanford Univ. Press, 1957)

4 E. W. Adams and R. Fagot. A model of riskless choice. August 7, 1956. (Behavioral Science, 1959, 4, 1-10)

5 R. C. Atkinson. A comparison of three models for a Humphreys-type conditioning situation. November 20, 1956.

6 D. Scott and P. Suppes. Foundational aspects of theories of measurement. April 1, 1957. (J. Symbolic Logic, 1958, 23, 113-128)

7 M. Gerlach. Interval measurement of subjective magnitudes with subliminal differences. April 17, 1957.

8 R. C. Atkinson and P. Suppes. An analysis of two-person game situations in terms of statistical learning theory. April 25, 1957. (J. exp. Psychol., 1958, 55, 369-378)

9 R. C. Atkinson and P. Suppes. An analysis of a two-person interaction situation in terms of a Markov process. May 29, 1957. (In R. R. Bush and W. K. Estes (Eds.), Studies in Mathematical Learning Theory. Stanford Univ. Press, 1959. Pp. 65-75)

10 J. Popper and R. C. Atkinson. Discrimination learning in a verbal conditioning situation. July 15, 1957. (J. exp. Psychol., 1958, 56, 21-26)

11 P. Suppes and K. Walsh. A non-linear model for the experimental measurement of utility. August 21, 1956. (Behavioral Science, 1959, 4, 204-211)

12 E. Adams and S. Messick. An axiomatization of Thurstone's successive intervals and paired comparisons scaling models. September 9, 1957. (An axiomatic formulation and generalization of successive intervals scaling, Psychometrika, 1958, 23, 355-368)

13 R. Fagot. An ordered metric model of individual choice behavior. September 12, 1957. (A model for ordered metric scaling by comparison of intervals. Psychometrika, 1959, 24, 157-168)

14 H. Royden, P. Suppes, and K. Walsh. A model for the experimental measurement of the utility of gambling. September 25, 1957. (Behavioral Science, 1959, 4, 11-18)

15 P. Suppes. Two formal models for moral principles. November 1, 1957.

16 W. K. Estes and P. Suppes. Foundations of statistical learning theory, I. The linear model for simple learning. November 20, 1957. (Foundations of linear models. In R. R. Bush and W. K. Estes (Eds.), Studies in Mathematical Learning Theory. Stanford Univ. Press, 1959. Pp. 137-179)

17 D. Davidson and J. Marshak. Experimental tests of a stochastic decision theory. July 25, 1958. (In C. W. Churchman and P. Ratoosh (Eds.), Measurement: Definition and Theories. New York: Wiley, 1959. Pp. 233-269)

18 J. Lamperti and P. Suppes. Chains of infinite order and their application to learning theory. October 15, 1958. (Pacific Journal of Mathematics, 1959, 9, 739-754)

19 P. Suppes. A linear learning model for a continuum of responses. October 18, 1958. (In R. R. Bush and W. K. Estes (Eds.), Studies in Mathematical Learning Theory. Stanford Univ. Press, 1959. Pp. 400-414)

20 P. Suppes. Measurement, empirical meaningfulness and three-valued logic. December 29, 1958. (In C. West Churchman and P. Ratoosh (Eds.), Measurement: Definition and Theories. New York: Wiley, 1959. Pp. 129-143)

21 P. Suppes and R. C. Atkinson. Markov learning models for multiperson situations, I. The theory. February 20, 1959. (Chapter 1 in Markov Learning Models for Multiperson Interaction. Stanford Univ. Press, 1960)

22 J. Lamperti and P. Suppes. Some asymptotic properties of Luce's beta learning model. April 24, 1959. (Psychometrika, 1960, 25, 233-241)

23 P. Suppes. Behavioristic foundations of utility. July 27, 1959. (Econometrica, 1961, 29, 186-202)

24 P. Suppes and F. Krasno. Application of stimulus sampling theory to situations involving social pressure. September 10, 1959. (Psychol. Rev., 1961, 68, 46-59)

25 P. Suppes. Stimulus sampling theory for a continuum of responses. September 11, 1959. (In K. Arrow, S. Karlin, and P. Suppes (Eds.), Mathematical Methods in the Social Sciences. Stanford Univ. Press, 1960. Pp. 348-365)

26 W. K. Estes and P. Suppes. Foundations of statistical learning theory, II. The stimulus sampling model. October 22, 1959.

27 P. Suppes and R. C. Atkinson. Markov learning models for multiperson situations, II. Methods of analysis. December 28, 1959. (Chapter 2 in Markov Learning Models for Multiperson Interactions. Stanford Univ. Press, 1960)

28 R. C. Atkinson. The use of models in experimental psychology. May 24, 1960. (Synthese, 1960, 12, 162-171)

29 R. C. Atkinson. A generalization of stimulus sampling theory. June 14, 1960. (Psychometrika, 1961, 26, 281-290)

30 P. Suppes and J. M. Carlsmith. Experimental analysis of a duopoly situation from the standpoint of mathematical learning theory. June 17, 1960. (International Economic Review, 1962, 3, 1-19)

31 G. Bower. Properties of the one-element model as applied to paired-associate learning. June 29, 1960. (Application of a model to paired-associate learning, Psychometrika, 1961, 26, 255-280)

32 J. H. Blau. The combining of classes condition in learning theory. August 23, 1960. (See Transformation of probabilities, Proceedings of the Amer. Math. Soc., 1961, 12, 511-518)

33 P. Suppes. A comparison of the meaning and uses of models in mathematics and the empirical sciences. August 25, 1960. (Synthese, 1960, 12, 287-301)

34 P. Suppes and J. Zinnes. Stochastic learning theories for a response continuum with non-determinate reinforcement. October 25, 1960. (Psychometrika, 1961, 26, 373-390)

35 P. Suppes and R. Ginsberg. Application of a stimulus sampling model to children's concept formation of binary numbers, with and without an overt correction response. December 14, 1960. (Application of a stimulus sampling model to children's concept formation with and without an overt correction response, Journal exp. Psychol., 1962, 63, 330-336)

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Introduction.

This paper is a discussion of the linguistic and psycholinguistic propositions underlying the Stanford computer-assisted curriculum in beginning reading. The preparation and presentation of this curriculum has been undertaken as a joint project by staff members of the Institute for Mathematical Studies in the Social Sciences at Stanford, under the direction of Professor Richard C. Atkinson, and by members of the teaching staff at Brentwood Elementary School in East Palo Alto, California, Mr. William Rybensky, Principal.

Although it is impossible to separate completely the linguistic elements of the Stanford program from the total curriculum, we have tried to provide this independent discussion of linguistic issues for those interested in comparing the methodological positions of various linguistically-oriented reading materials. We feel that the precise rationale for many important methodological decisions has been obscure in several reading series claiming a linguistic approach. In this paper we will attempt to state what we consider to be the necessary rationale for some of these decisions, and then detail and defend some specific positions adopted in the Stanford program.

It should be noted that such a rigorously detailed approach as we propose, while perhaps always desirable, is in fact a requirement in a computer-based curriculum.* Such a curriculum demands clearly defined decisions in instructional methodology and detailed specifications of

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*General discussions of the requirements of computer-based curricula are included in Atkinson and Hansen (1965) and Rodgers (1967).

individual items--their wording, sequence, and format. The criteria for evaluating student responses and for determining subsequent instructional sequences must be similarly detailed.

Contributions of Linguistics to Reading Pedagogy.

In discussions of linguistics and the teaching of reading, it has sometimes been assumed on the part of both linguists and teachers that there are essential similarities between the structure of language as described by linguists and the instruction of reading as undertaken by teachers. In actuality, the task of the linguist and the task of the reading teacher are highly dissimilar, and any attempt to equate them can only obscure some rather specific, though limited, areas in which communication can usefully take place. Thus it is that one can find several contemporary reading programs designated as "linguistically" oriented but which differ significantly.* These differences are not primarily due to linguistic disagreements among the consultant linguists, but rather to the pedagogical use of certain basic linguistic information.

As the pedagogical use of linguistic description is varied today, so has, historically, the focus of linguistics within its own sphere been varied. The focus of 18th and 19th century linguistics was primarily philological and, particularly, etymological. During that period the influence of linguistics in the language arts tended to emphasize instruction in word structure, word origins, and word relationships.

*Several series thus designated are presently available. The Linguistic Science Readers (Harper and Row), Basic Reading (Lippincott), Merrill Linguistic Readers (Merrill), Linguistic Block Series (Scott-Foresman), and Programmed Reading (Sullivan) are perhaps the best known.

Twentieth century linguists have been most concerned with analyzing the total structure of a particular language at a particular point in time. Studies of this period have been most detailed and successful in their descriptions of sound structure or descriptions at the phonemic level. This interest has been reflected in current views on reading pedagogy, as seen in the heavy emphasis placed on the sound-symbol relationship--the relationship between phoneme and grapheme. Several contemporary reading series reflect this influence.*

Most recently, studies of sentence syntax have occupied the center stage of linguistic inquiry. Successes in this area have been reflected in recent language arts materials stressing sentence analysis, as in the recent texts of Roberts (1964) and Lefevre (1964). One could conclude then that linguistic studies have provided support at various points in time for reading methods based on teaching word identification, letter-sound correspondence, and sentence analysis.

As Charles Fries indicates, texts based on these methods--the so-called word method, the phonics method, and the sentence method--considerably predate their linguistic rationales (Fries, 1963). Subsequently, when linguistic scholars have turned their attention to these issues, the support for a single approach has been far from unanimous. The following quotations from four scholars who have been most concerned with the development and evaluation of linguistically-oriented reading materials illustrate this point. One can easily note their diverse points

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*All of those previously cited.

of view on the proper linguistic units (sounds, words, sentences) with which initial reading should be correlated, on the use of nonsense syllables, and on the explicit teaching of language patterns or the language code.

> Our first reading material will consist of two-letter and three-letter words in which the letters have the (regular) sound values given... The acquisition of nonsense syllables is an important part of the task of mastering the reading process. The child will learn the patterns of the language more rapidly if you use the nonsense syllables in teaching. (Bloomfield and Barnhart, 1961)

> The teaching of the mechanics of techniques of word recognition is best done with materials which are maximally meaningful to the learner, e.g., words that are labeled for things of interest to the learner or very simple sentences that convey an interesting or useful message. (Carroll, 1963).

> The first task of reading instruction should be to give pupils a conscious knowledge of the language patterns they have mastered in the unconscious operational level... primary reading and writing instruction should begin with developing his consciousness of them in relation to the graphic system. Probably the best method is practice in speaking and oral reading of familiar patterns, with emphasis upon the native intonations. Children who are taught to read with main emphasis on larger patterns than words would be expected to develop their own generalizations of spelling-sound relationships....(Lefevre, 1964)

> The process of learning to read in one's native language is the process of transfer from the auditory signs for language signals, which the child has already learned, to the new visual sign for the same signals. The process of transfer is not [italics mine] the learning of the language code. (Fries, 1963)

Acknowledging this diversification of views, one might well inquire as to the specific areas of interest that linguistics and reading share, and if one can reconcile such "linguistically" supported but apparently contradictory points of view concerning the teaching of reading. If we

accept a single proposition upon which the above scholars agree, namely, that reading is primarily an act of speech reconstruction from a written representation, then certainly one important contribution the linguist can make is in describing the sound sequences (speech) that the reader reconstructs from the written symbols. It must be emphasized again that a description of speech performance is just that.* Such a linguistic description is not, of course, a blueprint for a teaching program.

Secondly, the linguist might contribute structural descriptions of the graphic system. These descriptions could indicate, for instance, what features of shape are shared by various letters or various words. Such graphemic studies have received little linguistic attention to the present.**

In addition, the linguist can detail the correspondence of graphic forms to speech forms. This contribution may be particularly meaningful to those teachers who teach reading to speakers of linguistically analyzed non-standard dialects. For example, all reading teachers are aware of certain classic homonymic problems--that ue and ew may both be pronounced /uw/ (blue - blew); that ee and ea may both be pronounced /iy/ (reed - read); that oe and ow may both be pronounced /ow/ (toe - tow).

Fewer teachers share the explicit realization that speakers of non-standard dialects, such as many Negroes in New York City, have a "regular"

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*Many such descriptions or really partial descriptions of English speech are available. Those of Trager and Smith (1951), Fries (1952), and Pike (1945), have been the most influential in the development of linguistically-oriented reading materials.

**See Bolinger (1946), Gelb (1952), Gibson et al (1962), Gleason (1955), and Edan (1961) for some tentative proposals.

but much more pervasive set of homonyms. For these speakers, the homonymic set including toe and tow may include as well toll, towed and told. For such speakers no distinction in pronunciation will be made between seed and cede as one would expect, but in addition, no distinction will be made between these words and seat, see, and sealed. It is important that a reading program which focuses on the regular correspondences between letter and sound confront facts of dialect if it is prepared for such a population. Studies such as those presently being conducted by Labov (1966) in New York City suggest how dialect differences affect the presentation of sound-symbol relationships in the reading curriculum.

Finally, linguists might offer comparative studies of the syntactic structure of written English and spoken English. Here again there have been few serious efforts and these have been limited in scope. Kenyon (1948) discusses in very general terms distinctions between various registers and styles of written and spoken prose. Humboldt's original attempt (1836) to define lexical, grammatical, and syntactic distinctions existing between prose and poetry has been followed by a number of specific studies, such as those compiled in Sebeok (1960). Frequency studies have shown that passive sentence forms occur in written English with several times the frequency that they do in conversation among the same writers, and that first and second person pronouns dominate spoken English whereas third person pronouns dominate written English. However, these observations hardly provide deep insight into the contrastive features of written and spoken usage, nor do they provide a basis upon which one might structure a reading curriculum.

Some more recent and detailed studies have sought "to compare the redundancy of children's spontaneous language at various ages with that of adults and that of the books" (Carterette and Jones, 1965). The evidence from such studies, though admittedly not directly concerned with syntactic structure as linguists know it, does suggest that for certain syntactic measures such as sentence length, beginning readers as well as more advanced readers prefer reading materials which approximate in length and redundancy their own spontaneous speech patterns.

Strickland's (1962) ambitious attempt to compare the structure of children's speech and children's readers yielded the unsurprising result that the syntax of spontaneous children's speech is much more complex than is the syntax of primary readers. Unfortunately, serious flaws in the sampling techniques and in the linguistic analyses have discouraged any finer-grained interpretation of Strickland's results.

In conclusion, it can be noted that no one of these possible linguistic contributions to the teaching of reading has any direct bearing on the classical questions asked by teachers, i.e., What examples do we present in what quantity over what period of time? What do we say about the examples? How do we organize the examples? How do we test if the topic material being taught is in fact being learned? How do we anticipate and accommodate different speeds and styles of learning among our students? These are legitimate concerns to an educator, but to a linguist only if he qualifies as an educator as well as a linguist.

It is not surprising then that there are conspicuous differences among linguistically-oriented reading materials in their implicit

answers to questions commonly posed by reading teachers. It is necessary, nonetheless, to provide answers to questions about the nature and presentation of teaching exemplars, individualized behaviors, etc. If linguists and linguistics cannot offer clear answers, where will the answers come from?

Psycholinguistics, Applied-Linguistics, and the Teaching of Language Arts.

Workers in the rather new fields known as psycholinguistics and applied linguistics have attempted to suggest answers to questions such as those raised in the preceding discussion. It is the intent of the psycholinguist to seek empirical confirmation or disconfirmation of hypotheses formulated to explain 'the way a speaker's conception, production or assimilation of linguistic material are controlled by features of his history and stimulus situation" (Fodor and Katz, 1964), or more broadly to study "the relations between messages and the characteristics of human individuals who select and interpret them" (Osgood and Sebeok, 1953). It is the intent of the applied linguist to form pedagogical propositions for the teaching of language arts which are compatible with the empirical findings from linguistic description, learning theory, oral and visual perception, and cognition.

Psycholinguistics and applied linguistics are both concerned with two particular issues of considerable linguistic and psychological consequence. These issues seem to underlie much of the discussion in reading theory but rarely receive explicit confrontation. The first of these issues concerns the relationship between linguistic and cognitive units. More precisely, it concerns the psychological viability

of the structural units customarily posited by descriptive linguists, that is, it concerns the specific role played by distinctive features, phonemes, syllables, morphemes, words, phrases, and sentences in the production of language output and in the processing of language input by language users.

The following quotations suggest that various posited linguistic units are felt to have a psychological reality and are not merely constructs invented by the linguist for descriptive convenience.

> A system of distinctive features based on a mutually implicating relation between the terms of each binary opposition is the optimal code and it is unwarranted to assume that the speech participants in their encoding and decoding operations use a more complicated and less economic set of differential criterion. (Jakobson and Halle, 1956)

> The phoneme is probably the one unit that can be demonstrated to exist both linguistically and psychologically. (Saporta, 1953)

> The relational gaps between the sounds of the language are just as necessary to the psychological definition of these sounds as are the articulations and acoustic images which are customarily used to define them. (Sapir, 1925)

> All speech consists of a sequence of syllables and breath groups which are phonetically the basic framework of speech and the most clearly detectable segmentation. (Gleason, 1955)

> The first speech element that we have found which we can say actually "exists" is the word. (Sapir, 1921)

> Th immediate constituent is the unit of speech perception. (Garrett, Bever and Fodor, 1965)

> These data give inductive support to the hypothesis that there are psychological correlates of phrase structure rules. (Johnson, 1965)

> The linguist, aware that the syllable, word, and sentence are functional concepts to the native speaker of the language, has felt obliged to define them rigorously but he has met with little success. (Saporta, 1953)

> Native language learning is generally analytic rather than synthetic in its method...the child's invention of his language begins with large melodic and rhythmic patterns. (Lefevre, 1964)

> Speech implies a selection of certain linguistic entities and their combination into linguistic units of a higher degree of complexity. The speaker selects words and combines them into sentences according to the syntactic system of the language he is using. Sentences are in their turn combined into utterances. (Jakobson, 1956)

> The speaker formulates his utterance first by selecting major sentence types and transformations and then by filling them in with appropriate forms, the listener must apply these procedures in reverse order as it were. (Carroll, 1964)

A second critical issue concerns the internal representation of linguistically acquired information. Vigotsky (1962) sees this question as one which attempts to determine the type of internal response produced to a word. He considers the possibilities to be either optic, auditory, motor or synthetic imagery. Vigotsky's view can be phrased in the form of a question that is more familiar in discussions of reading theory: Is the internal correspondent of a printed word some pattern representing the word as seen, as heard, as spoken, or as the word referent is visualized? These internal response possibilities have been described by others in more dynamic terms, such as tracking through associative nets, tallying of frequency registers, or constructing possible contexts of use. However, the possibilities suggested by Vigotsky appear to be those which have more often influenced speculation on the recognition and recall of "read" words.

As our earlier discussion suggests, there is a notable lack of unanimity concerning Vigotsky's assumption that it is indeed the "word" as such that triggers these internal responses. As a further possibility, Miller et al (1960) have selected the "chunk" as the appropriate unit in which language input is processed and stored. The "chunk" has a rather mercurial psychological and linguistic status, apparently being a codable group of whatever units one is attempting to examine atomistically.

At the moment, the most promising resolution of these contending points of view is the assumption that any one of these "solutions" may be appropriate for a particular individual, for a particular situation, for a particular time. That is to say, (concerning the first issue) some students will be highly receptive to an initial reading approach stressing sound-symbol correspondences at the phoneme-letter level. Other students will find a spelling pattern or word pattern approach most instructive. Still other students will find an experiential approach which initially presents full sentence sequences to be most helpful. The continuing debate as to the role of pictures in primary reading material may reflect differing beliefs on the part of the debaters concerning the second issue discussed above. Here again it seems reasonable to feel that some students will be aided in acquisition of early reading behaviors by an association of text and picture. Other students will find extensive oral practice more facilitating in acquiring the same behaviors. Still others will find visual training using various presentations of orthographic material most helpful during this period. If the teacher and the curriculum recognizes the range of possibilities

discussed above, we may hopefully be in a better position to make a pedagogical choice compatible with the needs of a given individual at a given point in time.

Largely in the hope of developing some successful or at least testable hypotheses concerning the acquisition of different types of language-arts skills, the staff at the Institute for Mathematical Studies in the Social Sciences has carried out a series of experiments to determine and define certain perceptual and cognitive units which might influence the specification of language learning tasks. We have been particularly concerned with the general language competencies which adults bring to the task of learning a second language and with the language competencies which children bring to the task of learning to read. Our discussion in this paper is largely limited to research in the second area; however, we feel for many reasons that investigations in both areas have considerable overlap.

In several ways the child speaker can be considered to have a reasonable approximation to adult linguistic competencies by the time he is customarily introduced to reading. Ervin and Miller (1963), Irwin (1960), Leopold (1949), and others have shown that mastery of the full inventory of phonetic units is reasonably complete by the age at which reading instruction normally begins. Berko (1958) has shown that the child of six has considerable mastery of the important morphological constructions within his language. While the six-year old does not productively utilize the full range of syntactic possibilities, there is little evidence to suggest that he is normatively limited in his ability to comprehend the more complex syntactic productions of his

elders. Menyuk notes in her studies of the speech of three-year old children that these children "have incorporated most of the basic generative rules of grammar that we have thus far been able to describe and are using these rules to understand and produce sentences" (Menyuk, 1963). Due to the child speaker's approximation of adult competencies, we have found that many of our studies of second language learning by adults have directly or indirectly corroborated findings from our studies on beginning reading.

Goals of the Stanford Program.

We have assumed that the ability to transfer strings of written symbols into some form of spoken units is a prerequisite of successful reading. A practical justification for this proposition is that oral reading permits one to evaluate the progress and mastery of the overall reading task.* The major disagreements that have arisen concern what sort of base unit might be the appropriate one through which to encourage reading generalization or transfer. These disagreements have generated the long-standing feud between the proponents of phonics and word recognition. This feud has been recently extended to include champions of larger syntactic and intonational constructions.

*This position has been attacked on several occasions, however. One attack has come from those who object, quite rightly, to any implied claim that successful adult readers invariably mediate their understanding of the written text through some sort of explicit pronunciation, sub-vocalization, or production of motor signals underlying articulation. A second form of attack has come from those who feel that heavy concentration on oral reading may encourage reading for pronunciation rather than reading for meaning (Goodman, 1965). The most extreme attack has come from those who hold that primary reading is best taught without any reference to the sound system at all (Farnham, 1881; Bever and Bower, 1966). Our own position relative to these is hopefully made clear in the body of this paper.

Discussion of these issues has been somewhat confused by several practical considerations. First, no "pure" method has ever been followed in the construction of a particular set of reading materials which might then have been tested in some sort of rigorous experimental situation. Furthermore, it has yet to be demonstrated that any method, sequence, or procedure fails to yield considerable reading success in almost any environment. Our initial efforts at Stanford, then, were not so much an attempt to discover "the" reading method, but rather to describe and examine some aspects of linguistic competency which appear to be relevant to the task of transfer which is implied in beginning reading as viewed from almost any methodological point of view.

In sequencing primary reading materials, educators have traditionally constructed programs built upon basic reading units which are orthographically well-defined. This is generally the reason for advocating letter sounding, word sounding, or sentence sounding as introductory reading techniques, as the letter, word and sentence are well demarcated by the traditional orthographic conventions of spacing and punctuation. All these techniques assume that the reader will not be restricted indefinitely to sounding out each letter or memorizing each new vocabulary word or sentence pattern, but that he will ultimately develop reading generalizations. The precise nature of these generalizations has been rather inadequately formulated, and the result has been confusion as to the relative efficacy of the word recognition or letter sounding techniques. We have therefore attempted to formulate certain hypotheses as to the form and content of reading generalizations. We have tried simultaneously

to examine possible approaches to the acquisition of these generalizations. Finally, we have tried to frame both the generalizations and the acquisition hypotheses in experimentally testable formats.

The Vocalic Center Group and the Transfer Stage of Beginning Reading.

We have chosen what we call the vocalic center group as a base unit for our investigation. The vocalic center group in English is defined as a vowel nucleus with 0-3 preceding and 0-4 following consonants. We deem the ability to recognize, manipulate, and associate printed sequences with vocalic center groups to be one of the generalizations that both letter and word sounding techniques imply. Thus, one could find exponents of either technique who would feel, as we do, that a learned association between the letter sequences map and ten and the pronunciation of these items should facilitate later association of tap and men to the appropriate pronunciations; or that the learned association of tap and rap to pronunciations should facilitate later association of trap to its pronounced form. (An alternative letter-sound assumption might be that tap and rap would facilitate the pronunciation of pat and par. An alternative word recognition assumption might be that the set map, ten, tap, men, is a priori no easier to acquire than the set map, ten, dig, far.)

Our definition of the vocalic center group indicates that it is phonologically rather than semantically defined. Thus we would consider pat, ing, per, sed, and strempts all legitimate vocalic center units. The form that vocalic center groups may assume is fixed by the sound

combination rules of English.* These rules indicate, for example, that slrap, tenps, mealk, or tror could not represent legitimate vocalic center groups in English. Our division of words into sets of vocalic center groups follows some internally consistent though somewhat externally arbitrary rules. These rules are specified in Hansen and Rodgers (1965). The reader will not be seriously misled if he associates the units which result from standard dictionary syllabification with the vocalic center groups.

There are, however, differences between the VCG and the traditional dictionary syllable that we feel are sufficiently crucial to justify adoption of the present terminology. To cite just one example, the latest edition of Webster's New World dictionary notes that the system of syllabification used in the dictionary does not "square with the observable facts of the English language" and that the virtues of the system "are aesthetic not linguistic." Aesthetic taste then suggests different syllabic divisions for the homonymous items caster and castor, as cast-er and cas-tor. The VCG criteria, on the other hand, would have all like-sounding word items divided in like manner according to phonological criteria.

Rather broadly stated, this implies that the specification of morphological segmentation, (cast / er) is less crucial in the initial stages of reading than is the specification of phonological segmentation of linguistic sequences, particularly words. This position is defended

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*Bloomfield (1933), Hill (1958), and O'Connor and Trim (1953) provide easily available synopses of these rules. For more detailed discussion, see Sholes (1964), Wallace (1951), and Yasui (undated).

at some length in Hansen and Rodgers (1965). We might briefly mention one study since completed which further supports this position. This study attempted to evaluate the priorities of word division as viewed by a population of just-beginning readers. In the experimental situation, disyllabic, bi-morphemic words were enunciated in syllables to children who were asked to repeat the words, syllabified in the same manner. Each word item was syllabified according to a "natural" morphemic and a "natural" phonological division, e.g., danc-er, dan-cer; toast-er, toas-ter, etc. The children's errors overwhelmingly tended to favor re-division along phonological rather than morphological boundaries. This result encouraged us to explore further the question of composing the initial reading curriculum from items chosen on the basis of phonological rather than morphological criteria. (The items used in the experiment just reported were purposely chosen so that these criteria would conflict. In the greatest number of cases, diverse criteria suggest identical syllabification, e.g., quick-ly, kind-ness, book-let, fire-man, etc. Thus most VCG and word analysis exercises can be introduced using items which satisfy both morphological and phonological criteria.)

We have formulated various hypotheses about the relative difficulty of learning to associate VCG (syllabic) responses with the appropriate letter sequence stimuli. Development of such associations takes place during what Fries calls the transfer stage or what we have elsewhere called the decoding stage. This is the period during which the student learns to respond "rapidly to the patterns of graphic shapes and the correlating portions of the language signals they represent" (Fries, 1963).

As previously indicated, these hypotheses are based on speech forms, are largely phonological in motivation, and are, thus, largely independent of orthographic considerations such as letter confusability, word shape, or punctuation conventions. It is, of course, a hypothesis requiring empirical confirmation that phonological factors rather than orthographic or morphological factors provide the best predictors of reading difficulty. Most of the experiments which we have reported tend to verify this hypothesis. The series of experiments by Gibson and her associates support our own general conclusion that "pronounciability is inferred to be... the grouping principle for reading or coding to speech units" (Gibson, Pick, and Osser, 1962). Other independent investigations lend further support to this finding. Studies are reported showing high correlation between articulation, audition and reading ability (Russell and Fea, 1963), the dominance of listening ability over I.Q. as a predictor of reading success (Harris, 1956) and the uni-directional influence of auditory perception on visual perception (Postman and Rosenzweig, 1957).

Tenets of the Stanford Program.

We have defined the Stanford approach to initial reading as applied-psycholinguistic. Hypotheses about the nature of the reading process, the nature of learning to read, and the nature of teaching reading have been constructed on the basis of linguistic information about the structure of language, empirical observations of language use, and an analysis of the function of the written code. These hypotheses have then been tested in experimental situations, structured to represent as realistically as possible actual learning and teaching situations. On

the basis of experimental findings, these hypotheses have been modified, retested and ultimately incorporated into the curriculum as principles dictating presentation variables and values. This is, of course, somewhat of an idealization since very little curriculum material can be said to have been the perfect end-product of rigorous empirical evaluation. We would claim, however, that the basic tenets of the Stanford program have been formulated and modified on the basis of considerable empirical evidence. It seems probable that these may be further modified or reformulated on the basis of the considerably greater amount of empirical evidence which will be available as the result of a year's CAI experience with classes of beginning readers.

The tenets of the Stanford reading program, as stated here, are to be taken as propositions intimately related to one another and consequents of the philosophical points of view stated in the preceding pages. A crucial aspect of that philosophy which we will again stress is the requirement for detailed specification which we have imposed upon the preparation and presentation of the instructional materials.

Each student in the program follows an independent course of instruction, making approximately 60 responses in each 20 minute instructional period. The sequencing and data collection programs trace the number and type of instructional items presented to each student and the speed and success with which each student has responded to each item presented. The items in turn are coded as to their linguistic structure, response request type, vocabulary familiarity, etc. We hope that a perspective on the interplay of student learning (or learning avoidance) strategies and our own teaching strategies will emerge from an analysis of the interaction of these factors.

We have attempted to minimize the enormous number of variables which customarily dominate the educational results of teacher and student interaction, and which have driven more than one educational experimentalist to despair. The computer-based environment gives us one sort of control; a sharply defined set of educational objectives and appropriately constrained instructional materials provide a second control. Whether these controls are sufficient to allow us to trace clearly the variable represented by student learning style is a question which remains to be answered. An answer to the really crucial question of how we can generalize from such analyses to better teaching situations is even more remote at the moment.

Some of the more important tenets which have provided the structure for the actual writing of materials are sketched below. In the wording of these tenets we have tried to state clearly our present position on a number of issues which we feel are crucial in the design of a reading curriculum and on which there has been less than universal agreement among reading specialists. A discussion of the tenets follows.

1. Reading and spelling are taught independently.
2. Reading is initiated with a decoding or transfer stage during which the student learns to associate graphic patterns that look alike in a specified way with speech sequences that sound alike in a specified way.
3. The association of sight to sound is initially affected between letter patterns and VCG (or spoken syllabic) units and is meaning-independent.

4. The sequence of presentation of items in this association learning is determined primarily by a scaling of difficulty of the VCG (or syllabic) units. The sequence is determined secondarily by the regularity of the orthographic and phonological correspondences, by the productivity of the items comprising a VCG set, and by the usefulness (e.g., for story-writing) of the items comprising the set.
5. Every graphic pattern is presented as a member of a rhyme set and an alliteration set, the distinguishing characteristics of these sets being displayed in a matrix format.
6. Word items presented in the matrix format, emphasizing the regularity of graphic and phonetic pattern correspondences, are immediately introduced in various sequential contexts which emphasize somewhat independently the morphological, syntactic, and semantic functions of these matrix-learned items.
7. Patterned word items appear in poems, stories, essays, and descriptions in which the features of pronunciation, grammatical function, and meaning of word items are shown to function conjointly to convey the writer's intention to the reader.

Tenet 1.

Reading and spelling are taught independently. There are both practical and theoretical reasons for our decision to separate reading and spelling instruction.

From a practical point of view, our program is an attempt to provide non-readers with some limited analytic skills--phonological, morphological, syntactic and semantic--and some considerable confidence in the use of these skills. It is not our intention to teach the child all of the sound-symbol pattern correspondences, all of the morphological variations, all of the usages of frequent vocabulary items, or all of the sentence patterns of English. It is our intention to give the student enough skill and self confidence to involve him in that confrontation known as beginning reading. We believe it is the ability to make reasonable inferences concerning unfamiliar or unobserved sequences on the printed page that we are ultimately trying to teach in reading. We feel that these heuristic requirements of successful reading are at odds with the deterministic requirements of successful spelling.

Fries takes a somewhat more conservative stand than we do on this issue and yet concludes that the "high speed automatic recognition responses, which readers must acquire, differ quite clearly both in kind and quantity from the productive skills which writers must acquire" (Fries, 1963).

More specifically, we observe that particular reading obstacles are often, if not customarily, unrelated to particular spelling obstacles. Recall of the spelling distinctions between lamb, limb, and thumb, and the rhyme set, ram, rim, and rum, may represent a serious problem for many. However, there is little difficulty in reconstructing the appropriate pronunciations in oral reading for thumb or rum, lamb or ram, limb or rim, since English does not permit final /-mb/ clusters and speakers of English tend to reject pronunciation of final /mb/ in favor of final /m/.

Similarly, the final syllables of carat, garret, merit, carrot, and gamut would all be represented phonemically as /-ăt/. From the speller's point of view these items present a host of problems, not the least of which is the proper spelling representation of the final weak syllable. However, such items present no particular identification problems from the reading transfer point of view. We feel this would be true even if the final syllables were to be "over-pronounced" with full stressed value rather than with the appropriate reduced unstressed value /-ăt/.

We were interested in the extent to which a "full" rather than a "reduced" vowel pronunciation in a set like that cited above would inhibit word recognition on the part of beginning readers. That is, if a reader were to produce the final syllables of the words cited above with stressed-syllable appropriate vowels or so-called "spelling" pronunciations (i.e., /ǽt/ as in rat, /ét/ as in pet, /ít/ as in bit, /át/ as in rot, /út/ as in put, would this significantly inhibit the reader's ability to associate this "spelling" pronunciation with the normal "conversational" pronunciation of the same vocabulary item?

A series of familiar vocabulary items* were pronounced to beginning readers with the following kinds of distortions. Two syllable words with normal stress on the first syllable were stressed on the second syllable with an accompanying "full" second vowel and "reduced" first vowel, where in normal pronunciation the opposite would be true. Thus carrot, normally pronounced /kérăt/ was now rendered /kărát/. Two syllable words

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*More than 10 observations in the Kolson list (Kolson, 1960).

normally stressed on the second syllable were stressed on the first with similar change of vowel values. Thus, forget, normally /fə̆rgét/ became /fórgə̆t/. Also included in the list of words were several items which had three medial non-contiguous, orthographic vowels, suggesting a three syllable pronunciation, but in which the orthographic medial vowel was not normally pronounced. Such items are general /jénrə̆l/, several /sévrə̆l/, chocolate /čɔ́klə̆t/, evening /íyvnĭŋ /, etc. In the experimental list these items with normally unpronounced medial syllables were pronounced with stressed medial syllables and with accompanying vowel value changes. Thus general became /jə̆nérə̆l/, chocolate /čə̆kólə̆t/, etc. These anomalous pronunciations were presented to pre-reading subjects by tape recorder and without linguistic context. The children were told the items were familiar words pronounced by a foreign speaker of English and were asked to identify the words the foreign voice was trying to say.

There was better than 50 percent one-trial recognition on the two syllable items and better than 40 percent recognition on the three syllable items. Almost all errors were errors of omission. It is not clear with what rigor these data should be interpreted. The results do seem to suggest that in an almost optimal distortion condition children are able to tolerate vowel and stress anomalies such as might arise from severe over-generalization of simple syllable pattern pronunciations.

This observation appears in keeping with the classical observation that "the intelligability of speech depends almost entirely on the presence of consonants" (Carterette and Jones, 1965). Data on spelling errors, on the other hand, indicate that "the majority of spelling errors occur in vowels in mid-syllables of words" (Patten, 1964). Thus

the important cues for correct word recognition are primarily consonants, while the important cues for word spelling are primarily vowels. These data are interpreted as support for the independence of important specific skills in reading versus specific skills in spelling.

From a theoretical point of view we would find ourselves in some disagreement with several studies seeking to show that since reading and spelling skills show high correlation, they should be taught as inter-related subjects. Not all studies, of course, show such correlation (Ibeling, 1961; Plessas and Ladley, 1963). Several supportive studies are incomplete in that they fail to cite correlations between spelling and other school-taught skills (Betts, 1945) or fail to indicate reading and spelling correlations with I.Q., perceptual accuity, attention span and the like (Peake, 1940). The correlations are also somewhat suspect in that most of the correlational studies were undertaken in school systems where integrated teaching of reading and spelling was the common practice.

In studies where one or more of the above objections does not hold true, a serious question appears as to the high "natural" correlation between reading and spelling skills. For instance, Gates and Chase (1926) report a much higher performance in spelling among deaf children than among hearing children matched equally in reading skill. Goodman and Goodman (1963), reporting on the spelling skill of the self-taught reader, show that the child could handle 100 percent of the test words successfully in reading, could recognize correct from incorrect spellings with 91 percent accuracy, but could actually spell the test words with only 58 percent accuracy.

Following the reasoning above one need not constrain reading materials to suppress items which are "regular" and "productive," but which are at variance with conventional spellings. Thus, lam-, lim-, and thum- might appear in pattern exercises whereas lamb, limb, and thumb might not. These last would appear only in sentential context.* From the linguist's point of view these two sets of items are in complementary distribution; that is, roughly stated, lamb, limb and thumb, pronounced /læm/, /lim/, /θəm/, appear only between spaces (as words) whereas lam, lim, thum, likewise pronounced /læm/, /lim/, /θəm/ appear only as word parts.** Some such knowledge on the part of the reader is obviously necessary in order for him to render appropriate pronunciations for Lambert, limber, and lumber as /lǽmbərt/, /límbər/, /lémbər/, rather than /lǽmərt/, /límər/, and /lémər/.

It is our feeling that some benefit in spelling would result from a program such as ours with considerable emphasis on sound-symbol pattern correspondences in reading. It would also appear likely that without specific and independent instruction in spelling, generalizations from appropriate symbol-sound correspondences to inappropriate sound-symbol correspondences might easily take place. It is, perhaps, superfluous

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*In fact, we have tried to establish the appropriate pattern generalization without inclusion of such possibly confusing items as lam, lim, and thum. The advisability of this decision will be examined on the basis of the difficulty experienced by students in handling polysyllabic words where such segments appear.

**This is an obvious over-simplification since the "word" items can appear with prefixes and suffixes as word parts, e.g., unlamblike. The point remains that the mutually exclusive environments in which the two sets occur can be quite rigorously stated.

to state that we feel the benefits of the proposed reading approach will outweigh its liabilities both in reading and spelling.

Tenet 2.

Reading is initiated with a decoding or transfer stage during which the student learns to associate graphic patterns that look alike in a specified way with speech sequences that sound alike in a specified way.

Previous citations of Bloomfield and Fries attempt to justify the initial presentation of items out of sentential context, and in sets such that the visual similarity of the items comprising the graphic set is shown to correspond in some consistent way to the auditory similarity of the items comprising the VCG set. Elaboration of our own position is found throughout the paper and particularly in our discussion on the Vocalic Center Group and the use of matrix displays below.

Tenet 3.

The association of sight to sound is initially affected between letter patterns and VCG (or spoken syllabic) units and is meaning-independent.

We have already spoken at some length about the viability of sight-sound association in matching spelling patterns and appropriate VCG units. In this section and the following we will separately consider the issue of "meaning-independent" pattern association transfer and, secondly, the issue of pattern sequence in the instructional program.

The most controversial point in Tenet 3 is that pattern correspondences are taught as "meaning-independent," or, in other words, that correspondences are taught through the use of nonsense syllables as well as lexical word items. Both Fries and Carroll appear to oppose the use

of nonsense syllables in early transfer training. "The teaching of the mechanics of techniques of word recognition is best done with materials which are maximally meaningful to the learner" (Carroll, 1963). "The 'transfer' stage will have much less confusion for the pupil if the body of language meanings and language signals used is limited strictly to those already within his linguistic experience...contrasts used should always be of items within a whole pattern, never of items less than a word" (Fries, 1963).

Bloomfield takes an opposite point of view. "The acquisition of nonsense syllables is an important part of the task of mastering the reading process" (Bloomfield and Barnhart, 1961). None of these authors cites supporting empirical evidence.

These same authors advocate teaching the relationship of "language signals represented by auditory patterns to the same language symbols represented by patterns of graphic shapes" (Fries, 1963). Such regular "pattern" relationships often hold over word sets we might assume to be of "maximal meaningfulness" for the learner. Such a set might be represented by the items man, can, ran, fan, and tan. But the appropriate pattern generalization holds as well for words of less than "maximal meaningfulness" to the child, e.g., ban, span, van, bran. The generalization also holds over parts of larger words which, as parts, have no meaning at all, e.g., han, gan, san, etc.

We hypothesized that it would facilitate the child's acquisition of the generalization covering all these cases to use items from each of the categories mentioned above as training examples. This initial hypothesis was based on our interpretation of several independently

reported experimental results. In some T-scope* recognition tasks reported by Postman and Rosenzweig (1956), the authors suggest that recognition thresholds for word items -ink, for morphemic non-word items -ing, and for non-morphemic syllables -int are approximately equal, provided the items are of equal frequency in the language; in their words "the failure of English words to yield lower threshold than the nonsense syllables suggests that the subject is no less ready to use syllables as response units than he is English of comparable linguistic frequency" (Postman and Rosenzweig, 1956). Results reported by Brown and McNeill (1966) on the "tip of the tongue" phenomena suggest, again as we interpret their data, that word items may be stored in memory in both a phonetic as well as a semantic net. That is, subjects are often able to retrieve information about the syllabic structure of an item without being able to retrieve the item itself or some semantic equivalent for the item.** We know that adults can render consistent and, in some intonational sense, dramatic readings of Lewis Carroll's "Jabberwocky," although this is composed largely of items without definition, referent, or previous use and thus without "meaning" in any generally accepted use of that term.

In experimental situations with populations more similar to our own we find other corroborative evidence. McNeil and Stone (1965) have

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*Tachistoscope: a device for testing perception, memory, etc. by throwing images of objects on a screen for very brief, measured periods of time.

**Brown and McNeil give the example wherein a dictionary definition for sampan "a small boat used in the harbors and rivers of China and Japan" elicited as responses Saipan, Siam, Cheyenne, sarong, sanching, and sympoon (as well as the expected junk).

found that "children trained with nonsense words made fewer errors during the training period and on the criterion test and did significantly better in identifying sounds found in both nonsense and meaningful words." While we would not concur wholeheartedly with the McNeil and Stone premise that "to learn to read, the child must be able to hear and to distinguish the separate sounds in words," their results do suggest the existence of a phonological processing capability which may (but which usually does not) operate independently of syntactic or semantic processing.

It is not surprising that the willingness to consider the sound system of language and the meaning system of language independently is more prevalent among linguists than among psychologists, philosophers, or educators. In a passage from the classic work in American linguistic studies, Leonard Bloomfield states the most generally held view of historical sound change.

> Theoretically we can understand the regular change of phonemes if we suppose that language consists of two layers of habit. One layer is phonemic. The speakers have certain habits of voicing, tongue movement, etc. These habits make up the phonetic system of the language. The other layer consists of formal semantic habits. The speakers habitually utter certain combinations of phonemes in response to certain types of stimuli and respond appropriately when they hear the same combinations. These habits make up the grammar and lexicon of the language.
>
> One may conceivably acquire the phonetic habits of the language without using any of its significant forms. This may be the case of a singer who has been taught to render a French song with correct pronunciation or of a mimic who, knowing no French, can yet imitate a Frenchman's English. On the other hand, if the phonemes of a foreign language are not completely incommensurable with ours, we may utter significant forms of this language without acquiring its phonetic habits. This is the case of some speakers of French and English who converse freely in each other's languages but, as we say, with an abominable pronunciation. (Bloomfield, 1933).

This theoretical position is closely related to the practical or pedagogical position that the transfer from the graphic system to the sound system of language can be effected independently of transfer from the graphic system to the meaning system. Fries' defense of the use of meaningful materials in the transfer stage is not a linguistic defense but a pedagogical and, in particular, a motivational one. The motivational justification may well be warranted; this we must consider. The point to be stressed here, however, is that Fries' decision to effect transfer at the "sound" level, using "meaningful" materials, is not a "linguistic" decision, and thus needs to be supported by evidence other than linguistic evidence.

It was this phonological processing capability which we felt could be tapped in the transfer or decoding stage of initial reading--that stage during which the child learns to respond quickly to graphic sequences in the same manner as he does to corresponding vocal sequences.

We examined this question in some detail in our own experiments. In one experimental situation (Atkinson and Hansen, 1966) 12 five-year old children were taught to associate the appropriate sound patterns to a series of letter patterns. The training was conducted daily for 15 30-minute sessions. The training items were 77 CVC items composed by taking all orthographic combinations of initial m, n, p, t, c, b, d, f, h, s and r; final m, n, p, t, b, d, g; and the medial vowel a. The set contained 31 word items which appeared more than five times in the observations reported in John Kolson, The Vocabulary of Kindergarten Children (1960). These are items which can perhaps be considered of "maximal meaningfulness" to the children in Carroll's sense. We were

interested in observing the relative difficulty that children displayed in acquiring "nonsense" as opposed to "meaningful" responses to these orthographically presented items.

The mean proportion of correct responses (pronunciation per graphic exposure) to all 77 word items for all children over all trials was .898. The mean for the 31 items defined as meaningful was .908 and for the 46 non-meaningful items .891. However, for several individual patterns this order was reversed. Thus, of the 11 items comprising the consonant + an rhyme pattern, there were six "meaningful" items (man, pan, tan, can, fan, ran) and five "non-meaningful" items (nan, ban, dan, han, san). The mean proportion of correct responses was .893 for the meaningful items and .909 for the non-meaningful items. Similarly, for the 14 items comprising the sa + consonant and ca + consonant alliteration patterns, the mean proportion correct for the seven meaningful items (can, cap, cat, cab, sap, sat, sad) was .908 and for the seven non-meaningful items (cam, cad, cag, sam, san, sab, sag) was .933. Our interpretation of this data is that 1) children can learn to associate regular pronunciations of nonsense items to spelling patterns fairly easily, and 2) for some pattern sets nonsense associations appear easier to learn than meaningful associations.

We do not know how many examples are needed to establish a given reader's ability to generalize over a sound-symbol relationship such as those we have been discussing. A tentative model for such a determination is outlined in Hansen and Rodgers (1965). It is obvious that certain sound-symbol relationships which are fully as regular as the sets we have cited have an inventory of few items of maximal meaningfulness.

For example, the two high frequency items cup and pup would seem an insufficient number for acquisition of the generalization which holds between letter sequences of the form consonant + up and the set of rhymed pronunciations of which /kəp/ and /pəp/ are members. One has the choice then of not presenting such items as cup and pup, or of treating them as exceptional non-patterned items, or of including cup and pup in a practice series which also includes other regular items of lesser familiarity or which represent word partials, e.g., gup, hup, rup, sup, yup, etc. The principal objection to this last course has been that the learner has no meaningful "image" for such items as /gəp/, /həp/, /rəp/, /səp/, and /yəp/, and hence finds these letter pattern-sound pattern associations hard to learn.

The data reported above seem to indicate that this is not necessarily the case. There are in addition several pedagogical possibilities for minimizing the objection as stated. First, the items can be made more "meaningful" either by showing their use in a fuller context, e.g., gup in guppy and sup in supper, or by assigning fantasy meanings to these items after the fashion of Dr. Seuss. Another possibility is to use the items in brief games where the emphasis is on learning the sound correspondences and not on establishing a tie between a printed form and some meaningful mental image. Success in learning to pronounce and recognize nonsense items seems to represent a "real" accomplishment for the child in the same sense that winning marbles is a "real" accomplishment. Neither of these accomplishments has an immediate or meaningful reward other than in terms of the game itself. Our curriculum has attempted to employ all of these techniques--maximal use of highly meaningful and

easily picturable word items as pattern exemplars, and as well, assignment of fantasy meanings and use of game techniques for practicing on other word pattern instances.*

Tenet 4.

The sequence of presentation of items for association learning is determined primarily by a scaling of difficulty of the VCG (or syllabic) units. The sequence is determined secondarily by the regularity of the orthographic and phonological correspondences, by the productivity of the items comprising a VCG set, and by the usefulness (e.g., for story-writing) of the items comprising the set.

There are several diverse sorts of evidence which tend to support our assumption 1) that sets of pronunciation units (vocalic center groups in our interpretation) can be hierarchically ordered in terms of speaker preference, 2) that this preference hierarchy tends to be quite pervasive for speakers of the same language, and 3) that this preference scaling presents a useful schema for ordering spelling patterns in teaching primary reading. The demonstration of this claim is presented in Hansen and Rodgers (1965).

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*We might inject a brief aside here as to the range of "other patterned word instances." In the pattern we have been discussing, pup represents an occurring meaningful and well-formed pattern example; gup represents an occurring (in guppy) well-formed but non-meaningful pattern exemplar; vup represents a non-occurring, non-meaningful but well-formed pattern exemplar; xup represents a non-occurring, non-meaningful and non-well-formed pattern exemplar. In our materials we have restricted ourselves to use of the first two pattern example types. Use of these two provides, we feel, a sufficient number of patterned items for practicing and learning the relevant sound-symbol generalizations, useful in their own right as observable instances of that generalization.

The literature contains supportive studies which we will mention only briefly. Evidence from studies of language universals provides "objective evidence of the difficulty of [consonant] clusters" (Greenberg, 1965). Greenberg demonstrates that the longer the consonant sequence is, the less favored is that sequence in language use. He also demonstrates that certain consonant combinations of a given length are universally less favored than certain other combinations of the same length. From this evidence we would infer, for instance, that the final two consonant sequence in apt makes the syllable in which it occurs less favored and more difficult than the syllable ant in which a different final two consonant sequence occurs. Studies of language change (Meillet, 1926), language pathology (Jakobson, 1942), language ontogeny (Švačkin, 1948), speech perception (Pickett, 1958), speech articulation (Trubetskoy, 1939), speech synthesis (Liberman et al, 1959) and second language learning (Rodgers, 1967) similarly suggest the existence of such a hierarchy of preferred VCG types, and are in substantial agreement as to the basic features determining the hierarchical scaling.

In our experimentation we have attempted to measure the extent to which young speakers are influenced by VCG preferences similar to those demonstrated for adult speakers (Greenberg and Jenkins, 1963), and further, to see to what extent such preferences might be reflected in early reading behaviors. In one experiment children were taught to render appropriate pronunciation responses to orthographic nonsense sequences. Each sequence was five letters long and each corresponding pronunciation was five phonemes in length. Examples of alternate consonant vowel sequences (CVCVC) fegom, of initially clustered sequences

(CCCVC) strem, of initially and finally clustered sequences (CCVCC) brind, and of finally clustered sequences (CVCCC) borst were presented. Our prediction was that the difficulty of acquisition would be easy to hard in the order presented above. The results significantly confirmed this prediction. In other studies we examined performance on highly familiar words of the same syllabic shape (CVC). The preference ranking predicted on the basis of Jakobson and Halle's interpretation of the sonority theory (Jakobson and Halle, 1956) was generally confirmed.

The results of these studies led to sequencing principles for the initial vocabulary presentation. This sequence is presented schematically in Table 1. Typical of these principles are the following:

1. VCG sets containing single consonant elements are introduced before those containing consonant clusters (tap and rap before trap).
2. VCG sets containing initial consonant clusters are introduced before those containing final consonant clusters (stop before post).
3. VCG sets containing check (short) vowels are introduced before those containing letter name (long) vowels (met and mat before meat or mate).
4. Single VCG sequences are introduced before multiple VCG sequences (mat before matter, stut before stutter).

More detailed decisions were required to determine the order of introduction of specific vowels and consonants within a VCG pattern and the introduction of specific VCG patterns in polysyllabic words. These decisions frequently represented a compromise, hopefully clearly defined,

between linguistic factors, pattern productivity, item frequency, and textual "usefulness" in that order of significance. (See Hansen and Rodgers et al, 1966, for a fuller discussion of these issues.)

Tenet 5.

Every graphic pattern is presented as a member of a rhyme set and an alliteration set, the distinguishing characteristics of these sets being displayed in a matrix format.

In considering the optimality of various presentation formats for word items, one is concerned with several different kinds of measures. Let us consider three possible presentation formats and several of the more important measures we might use to test the effectiveness of the presentation formats.

Presentation Format 1 is the matrix format.

	ad	at	it
b	bad	bat	bit
d	dad	dat	dit
f	fad	fat	fit

Learning exercises consist of having the student build words from column and row intersections, identify a row (alliteration) or column (rhyme) set and pronounce and identify individual word items. The matrix test consists of having students point to a particular word or appropriate word location in the matrix.

Presentation Format 2 is the list format. Here the same nine items of the matrix might be listed in random or controlled order. Learning is essentially rote. The first word in the list is indicated, the child does or does not pronounce it, he is shown a picture referent and/or given the pronunciation of the word, and continues in a similar manner through the items of the list. In the list test the student is asked to point to a particular word in a list of four to eight words.

In the sentence format (Format 3) the same word items might be presented in sentential context (Dad had a tan cat. Dan can bat the bad cat., etc.). Sentence construction usually requires foreknowledge on the part of the student of some "sight" function word items (the, is, a in the experimental situation). The student is read a sentence which he also sees, and is directed to identify a word in the sentence, e.g., "The cat is bad. Touch 'bad'." In the sentence test the student is asked to read the entire sentence.

The measures in which one might be interested are 1) trials to criterion, i.e., learning time required to identify and pronounce all word items, 2) short term and delayed recall of word items, 3) identification and pronunciation of format learned words in a new format, e.g., list and sentence format for matrix learned items, and 4) transfer of training to new word items.

Tests such as those we propose have not, to our knowledge, yet been made. The CAI program permits the presentation of alternate formats in particular lessons and thus will yield data such as that we propose might be gathered. There is, however, some relevant empirical research

which led us to consider the matrix format as at least a reasonable if not demonstrably optimal means for displaying the regularities which define spelling pattern sets.

In the discussion of the presentation of sets of word items, one encounters two lines of evidence which suggest contradictory conclusions. We specify our task, or part of it, as an attempt to establish habits of response to letter and sound patterns. To define and demonstrate the set of items comprising a pattern, one may present a number of pattern instances in an instructional block. The items in the block look alike and sound alike in some particular way. Contrast between items is minimal. Thus, a typical Bloomfield pattern block is dam, ham, jam, pam, ram, sam, am. We expect training on such a list to facilitate learning of subsequently presented items, such as bam, cam, mam, tam, etc.

On the other hand, we know that among adults, lists which have large perceptual differences among the items comprising the list are learned more rapidly than lists with small or minimal perceptual differences among items (Rothkopf, 1958). We might expect, then, that a list of items of minimal contrast would be difficult to discriminate, hard to learn, but conducive to pattern generalization, whereas as a list containing items of maximal contrast would be easy to discriminate, easy to learn, but not conducive to pattern generalization. Levin and Watson (1961a) examined a related issue in a list learning experiment with children and found that maximally contrastive or "variable" lists of nonsense items were learned faster than were minimally contrastive or "constant" lists. No significant transfer (generalization) was observed in either case.

The Levin-Watson results are less relevant to our own investigations than might initially appear. We would, for example, have different views as to what constitutes a list of a sufficient number of items (W and L use only four), as to what represents a "pattern" (W and L "constant" list items are similar only in medial vowel), and as to what represents a legitimate test of transfer (W and L used transfer items having no letters or sounds in common with the learned lists).

Moreover, in a subsequent study Levin and Watson (1961b) found that learning of a constant or patterned list was significantly faster than learning of a non-patterned or variable list. In a similar study Levin, Baum and Bostwick (1963) concluded that when only regular (or constant, or one letter to one sound) correspondences had to be learned, a constant list facilitated such transfer learning better than did a variable list. This was felt to be a special case for Spanish children, in that Spanish displays a relationship of the orthography to the phonology which is regular or constant in the above sense. Theoretically, this result would also apply to English children as long as they encountered only constant items, i.e., items which display a consistent one to one correspondence between orthography and phonology. This, of course, returns to the crucial question which we have raised previously; that is, if we teach initial reading as if the relationship of orthographic to phonologic patterns in English is one to one, does this later prove facilitating or inhibiting to the student in actual reading performance on materials containing a normal number of irregular pattern correspondences?

Colleagues of Levin and Watson report studies which show that young readers intuitively "perceive some regularities of correspondence between

the printed and written terms and transfer these to the reading of unfamiliar items. This generalizing process undoubtedly promotes reading efficiency and could be facilitated by presenting material in such a way as to enhance the regularities and speed up their incorporation" (Gibson, Osser and Pick, 1963). In an earlier T-scope recognition experiment, Gibson, Pick and Osser (1962) concluded that the appropriate unit over which such reading generalization takes place is "neither the single letter or the whole word but a higher order invariant derived from grapheme-phoneme correspondences." The matrix presentation is a format which we believe displays such "higher order invariant" patterns in a manner that most "enhances the regularities."

The practical question of what form of presentation does most to "enhance these regularities" was considered by Silberman (1964) in some learning studies somewhat more comparable to our own. Silberman was concerned with the design of a program teaching spelling patterns that optimized learning of the items and, more particularly, optimized transfer to similar but novel items. After a number of program comparisons, Silberman concluded that "children do not necessarily induce letter-sound relationships upon being exposed to whole words and that a synthetic approach (building whole words out of parts) produced results superior to those obtained with the general program which was restricted to whole words." Successful performance with a subsequent analytic approach program suggested that the part to whole or whole to part sequence is less important than "that both whole words and their parts be explicitly

included within the program." Specifically, program comparisons contrasted the effectiveness of various presentations of the pattern items comprising the matrix below.*

	an	it	at	in
f	fan	fit	fat	fin
r	ran	rit	rat	rin
s	san	sit	sat	sin
m	man	mit	mat	min

The diagonal items fan, rit, sat, and min were not taught and were used as transfer test items. The program yielding maximum transfer was composed of 757 learning items presented over a period of 11 days. This program instructed students in "amalgamation" of initial continuent consonants with final rhyme patterns (C + VC → R + AN → RAN). A comparative program teaching amalgamation of CV + C (RA + N → RAN) proved considerably less effective.

The program of amalgamating or blending initial continuent consonants with final rhymes was achieved with some difficulty. Silberman notes "some children would consequently pronounce RUHAN rather than RAN when asked to put the sounds together and say them both quickly." This problem becomes considerably more severe when non-continuents appear as initial consonants, e.g., p + an, c + an, b + an, t + an,

*Silberman uses matrices in the discussion of experimental patterns but not as instructional devices.

d + an, g + an. This is one of the principal reasons why, while agreeing with Silberman's general conclusions, we encourage children to see the explicit components of the matrix learned items on the axes, r [an ran], but to say only the whole word or syllable in the cell. Silberman found no problem in transfer from pattern reading to reading for meaning and notes that "in every case if the child could pronounce the word he was also able to match the word with its picture." Our own results confirm this finding.

Our discussion of the matrix as a means for presenting and teaching alliterative and rhyming patterns should note, at least in passing, certain CAI system desiderata. The most important of these concerns our intent to make on-line, real-time decisions as to the optimal program sequences for each individual student. A straightforward approach for arriving at such decisions is to look at the gross response scores for each student after the completion of a certain block of material and to decide on the basis of these scores whether he should proceed, repeat, or review. A more sophisticated approach to this decision making is to attempt to determine those aspects of the learning materials which are particularly trouble-some or trouble-free for the individual, and to provide materials concentrating on, or in the second case, minimizing instruction in the critical areas. The issues here are essentially parallel to those classically discussed as achievement as opposed to diagnostic testing.

It is our conviction that the evaluation of student progress should be diagnostic in nature and that the diagnoses should be as thorough as

we can feasibly make them. Since the mass of CAI evaluated responses made by the student are multiple choice responses in one form or another, it follows from the previous discussion that the structure of the alternate choices must be diagnostically analyzable if the program is to isolate individual reading problems and prescribe appropriate diagnostic blocks. This is a principal reason why features of phonological, morphological, syntactic, and semantic structures are analyzed, taught, and tested in separate instructional blocks as well as in blocks stressing their coordinate functions.

Likewise, in that instructional block stressing graphic and phonetic correspondence patterns (the matrix materials), we wish to evaluate those features which cause individual difficulties in word recognition. The matrix format permits a fairly straightforward analysis of several different types of errors in word recognition. This classification of word recognition choices allows a comparison of a student's performance across lesson sections and suggests the selection of particular remedial materials focusing on individually relevant word recognition criteria. In the following matrix, for example, the student might be asked to identify (touch and say) "bat."

	ad	at	it
b	bad	bat	bit
d	dad	dat	dit
f	fad	fat	fit

Correct selection would be registered as such. An incorrect selection of bad would be classified as a final consonant error, selection of bit as a medial vowel error, selection of dat as an initial consonant error, selection of fad as a random or "other" error. A consistent pattern of error types suggests an appropriate instructional focus. An inconsistent pattern of errors suggests, perhaps, the desirability of a more basic "phonics" type presentation. It might also suggest inattention or lack of motivation on the part of the student. Identification of these problems is obviously the first step to their remediation.

Tenet 6.

Word items presented in the matrix format, emphasizing the regularity of graphic and phonetic pattern correspondences, are immediately introduced in various sequential contexts which emphasize somewhat independently the morphological, syntactic, and semantic functions of these matrix-learned items.

This position raises several controversial issues; the following are possibly the most crucial: 1) the status of linguistic units as reading units, 2) the status of linguistically defined markers as reading cues, and 3) the separability of phonological, morphological, syntactic and semantic task skills in the instructional program.

Some discussion of the status of linguistic units as reading units can be found in our previous treatment of linguistic and psychological units. Although there have been several attempts in reading research to find some correlation between reading units (determined, say, by studies of visual blocks defined by eye movement), and linguistic units such as phrases or clauses (determined by descriptive grammars), these studies have not

proved particularly revealing. (See Dechant (1964), and Anderson and Dearborn (1952), for discussion.) One experimental technique for examining the relationship between linguistic and "natural" reading sequences is discussed below.

Hopefully, studies now underway will provide some information concerning the second issue, that of the status of linguistically defined markers as reading cues. It has generally been agreed that the sentence represents a "natural" (well-marked) sequence common to both speech and text.* We were interested in the relationship of various other types of linguistic constituencies to specific reading tasks. The particular issue in which we were interested concerned the effect of linguistic context on the identification of unfamiliar word items. A pilot study was designed which would hopefully suggest some approaches in investigating this issue. The following represent the constituencies in which an "unfamiliar" word item was presented:

1) Streg (no constituency)

2) White streg (pre-modifier)

3) The white streg (noun phrase)

4) Ate the white streg (sentence predicate)

5) The old horse ate the white streg (sentence)

Several different sets of similar items were presented individually to second graders in two school communities as a "read and explain" task. Our "disadvantaged" school test group showed a slight but consistent

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*The larger units by which texts are usually structured, e.g., paragraphs, chapters, and books, are linguistically undefined.

preference for the pre-modifier constituency, that is, they showed a decreasing tendency to define or to hazard a pronunciation for the unknown item streg as the context enlarged or as streg was presented in isolation. The middle class school test group showed an equivalently slight but consistent tendency to favor the sentence constituency. Although each child did receive examples of each sentence type, the number and composition of sentences were inadequate to justify strong claims on the basis of the data. Similar results obtained in a more thorough study would suggest re-examination of some fairly deeply ingrained practices in the presentation of words "in context."

Additional informal evidence concerning the relationship between linguistic markers and reading cues has been noted by Fries and Lefevre. Both Fries and Lefevre advocate rather explicit teaching of the morphological and syntactic cueing system in reading instruction, but offer no suggestions as to the optimal means for teaching this system or evidence as to how graphically cued linguistic markers are used by competent readers.

The third issue concerns the separability of "phonological," "morphological," "syntactic" and "semantic" attack skills in the instructional program. There is, unfortunately, little empirical evidence on this issue, but we would interpret the consensus of pedagogical opinion to favor an integrated presentation of attack skills rather than the somewhat analytic one we have chosen. One justification for this analytic course can be seen in our attempt to "factor out" those elements of reading instruction and reading interpretation that seem to cause particular students to experience difficulty with particular materials.

Certainly one way to evaluate the relative influence of these factors is by attempting to teach various interpretative skills independently, measuring the impact of training *per se*, as well as the impact of the training on general reading skill.

"Phonological" skills are taught through the device of the matrix and various rhyming and alliteration games which are discussed elsewhere.

"Morphological" skill exercises can be considered as having essentially two forms. In one type of exercise, words of controlled phonological shape (previously learned matrix items) but of different form class (e.g., nouns versus verbs) are multiple choice answers in the context of a sentence read by the students:

The	sad sit rat	snapped the trap.

Word selections thus cued by inter-word combination are likewise cued for grammatical form class by appropriate intra-word combinations. These combinations involve affixation (snap, snaps, snapping, snappy, snappily, unsnap, unsnapping) and compounding (snapshot, gingersnap).

In an experiment concerned with intra-word cues and morphological distinctions, Labov (1966) presents interesting experimental data showing that morphological distinctions which are not distinguished in speech are also often not observed in reading. Thus, in test sentences such as "When I passed by, I read the poster," the subject is cued to the proper pronunciation of read by the -ed marker of the verb in the subordinate clause. Labov's results showed "that -ed is interpreted correctly less than half the time" by the experimental group of New

York Negro children. This suggests that when the past tense is unmarked in speech due to a shortening of final consonant clusters (passed /pæst/ → /pæs/), it is likewise ignored in reading where the distinction is well-marked by the letter sequence -ed. Labov argues that it is important in reading instruction to stress the linguistic cueing function of the graphic sequence -ed, but that this is quite a different matter from getting the student to render a correct pronunciation of final -ed, either in reading or in normal speech.

A form of syntactic reading skill exercise consists of the presentation of a set of brief sentences which we refer to as "expansion frames." These provide patterned sentences in which students can practice recognition and pronunciation in context of newly acquired items. These are "frames" in the sense that they represent a clearly delimited number of sentence pattern types (8) that are introduced early in the reading program and continue without permutation of the "major" elements. They are "expansion frames" in that after a determined number of exposures (approximately 20), the frames are augmented by syntactic adjuncts,* usually in the form of modifiers which the students may or may not have met previously in the lesson materials. The development of the frame type noun-verb-noun might be as follows: 1) They (verb). 2) They can (verb). 3) They can (verb) it. 4) They can (verb) it now. 5) There they can (verb) it now, and so forth, where new matrix-learned verbs are presented in the (verb) position.

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*See Harris (1962) for discussion of adjuncts.

The purpose of these expansion frames involves several independently evaluated issues: the frames reinforce inter-word form class cueing; they provide a natural and familiar context for recognition practice of new items in sentential setting; they encourage sentence pronunciation with natural intonation; and they promote high speed recognition of items in context as well as high speed recognition of the context itself. These exercises look a bit like pattern practice drills in second language learning and have many of the same faults and virtues. It should be stressed that these exercises are performed at high speed. A total lesson block of 25 expansion-frame sentences is presented for reader pronunciation and instructor reinforcement in less than two minutes. A typical pattern is the following: a student is asked to read the sentence aloud when it appears and to finish before the instructor voice pronounces the sentence (2 seconds after appearance). They can flap it. They can trap it. They can snap it.... What's a snap? What's a trap? What's a flap? .... They're too flat. They're too fat....

The similarity between the basic expansion frames and the kernel sentence types in English as described theoretically by Harris (1962) and pedagogically by Roberts (1962), is not accidental. It is our hope that an analysis of response speed and accuracy over certain syntactic sentence types will suggest if "sentence type," in the sense here discussed, is correlated with any significant measure of reading behavior.

The sections of the instructional materials stressing "semantic" interpretation of matrix-presented word items represents a fairly traditional approach. One section assures that the student is familiar with the meaning of items as they are used in the lessons. These

"usage" sections stress semantic function rather than paraphrase or synonomy. A typical presentation item asks the students to identify and pronounce a word "that means something you might use to hit a baseball."

Semantic function in context is the focus of another lesson section-- the wh question section. Here controlled question patterns initiated with the so-called wh words--who, what, where, when, why, how-- are presented to the student after the initial presentation of an information sentence or text. (Who hit the ball? What did he hit it with? Where did he hit it?) Variables of interest here are 1) the type of wh question, 2) the type and length of information text, and 3) form class and position of the appropriate response word(s) within a particular information text.

An objection, with which we would have to agree, was raised at the last Claremont conference by William Iverson: "As an outside observer it seems to me that the computer-assisted program above the sentence level is less well defined than that below the sentence level" (Iverson, 1967). We would further concur, at least in part, with Iverson's explanation for this failing. "Adequate hypotheses about comprehension in the larger pieces of discourse are only partially formulated" (Iverson, 1967). As was suggested earlier, the area under discussion is one in which there is a dearth of relevant empirical data. It is our belief that our program results will provide some data relevant to certain propositions of general interest. These propositions, in sum, are as follows: 1) that word discovery and textual interpretation are tied to the reader's ability to make optimal use of phonological, morphological, syntactic and semantic cues in the text; 2) that such

cues are linguistically definable; 3) that these four types of cues can be taught somewhat independently; 5) that the effect of this teaching on certain specific and general reading skills can be measured; and 6) that these measures will yield valuable information as to the usefulness of particular cues in particular texts for particular readers.

Tenet 7.

Patterned word items appear in poems, stories, essays, and descriptions in which the features of pronunciation, grammatical function, and meaning of word items are shown to function conjointly to convey the writer's intention to the reader.

Presently it is difficult to discuss this tenet in specific detail, as there is little evidence to suggest by what internal process the skills taught in the first stage of reading become automatic and are differentially applied to different types of reading materials.

Again, it is important to stress that this paper has been devoted almost exclusively to one stage of reading--that which we consider to be initial and highly crucial. This is the stage which Fries calls the transfer stage, which Carroll calls the translation stage, and which we have referred to elsewhere as the decoding stage. As to those stages of reading which Fries calls the "productive" stage and, later, the stage of "vivid imagination realization," we have offered some speculation but little specification. In our discussion we have tried to suggest how coordinated exercises stressing grammatical meaning, function, and intonation of sentential sequences will lead beginning readers to reading interpretations of the types stressed in these subsequent stages.

We can, at present, make less useful generalizations about the processes by which an individual ultimately develops or fails to develop an adult mastery in reading.

We feel that transfer or decoding skills can and indeed should be taught as general skills which are subject-independent. However, when these skills have been developed and demonstrated in high speed recognition and response tasks, the subsequent stages of reading instruction can best be considered in the specific context of the subject field of the texts to be read. This assumes, for example, that narrative and expository prose have different styles and functions, and accordingly require different skills on the part of the reader as interpreter. We feel intuitively that this is true, and several studies support this proposition. Robinson and Hall (1941), for example, find low correlation between reading scores in art, fiction, geology, and history, even when text selections were prepared by the same editor. However, such studies do not point toward the factors of similarity or dissimilarity accounting for these correlations or lack of correlations. Our own materials, in which we vary text subject while holding vocabulary and sentence complexity relatively constant, will hopefully provide further insights into this issue.

In this paper we have tried to state our intuitions about primary reading acquisition in the form of detailed and testable propositions. At the moment, we lack similarly detailed propositions supporting our intuition about the linguistic, psychological and pedagogical features which distinguish styles, functions, and interpretations of various types of narrative and expository prose. It is our hope that the

program we have outlined, in conjunction with accompanying programs for data collection and analysis, will suggest such propositions in this relatively unexplored area.

Summary.

Some contemporary views on the role of linguistic science in the design of reading materials and the teaching of primary reading were contrasted. Four areas of linguistic study relevant to reading were briefly examined: 1) the structure of the speech system, 2) the structure of the graphic system, 3) the relationship of graphology to phonology, and 4) the comparative syntax of spoken and written English.

Psycholinguistics and applied linguistics were viewed as possible interfaces between the specific inquiries of linguistics and the specific requirements of instruction in reading. Some classical arguments as to the relationship of linguistic description and psychological function were reexamined in terms of problems in design of an initial reading curriculum. The adaptation of the curriculum to the individual learning characteristics of the student participants was viewed as a central problem of education and of computer-assisted instruction (CAI) particularly. The Stanford curriculum in computer-assisted instruction in beginning reading was introduced as consequent of the preceding considerations. Seven psycholinguistic propositions of the Stanford curriculum, in the form of tenets, were proposed and discussed in terms of 1) contemporary pedagogical opinion, 2) related empirical research, 3) experimental investigations by the Stanford group, and 4) practical consequences in the curriculum materials.

TABLE 1

LESSON SEQUENCE

LEVELS	vc	cvc	ccvc	cVcɇ ccVcɇ cccVcɇ	cV ccV	cvcc ccvcc	cvvc ccvvc	cvv ccvv cccvv	cccvc cvccc
I	ac	cac							
II	ic	cic	ccac						
III	ec	cec	ccic	cAcɇ ccAcɇ	cA*				
III'		aw ir ar ix ax	ir ax ar ix aw	Arɇ Alɇ Akɇ Arɇ		ack ell ick ill eck ass all ess			
IV	oc	coc	ccec	cIcɇ ccIcɇ	cI cY cE ccY ccE	cacc			
IV'				Irɇ Ikɇ Ilɇ Ivɇ ive		oss ŏlt ard oil ark arm ock art ŏst arn	ai oo ight	ay	
V	uc	cuc	ccoc	cEcɇ cOcɇ ccOcɇ cUcɇ ccUcɇ	cO ccO	cicc cecc ccacc ccicc ccecc			ccc a/i/e c c a/i/e ccc
V'		ur ox or ux er	ur ux or ox er	Okɇ Uvɇ Ovɇ Ulɇ Olɇ Urɇ Orɇ Ukɇ ŏve ŏme	ang īld eng ōld ing alk ung ōst īnd ort	ee-ea ou-ow oa-ow au-aw oi ea	ow ee ea ew oy		
VI			ccuc		cu*	cucc cocc ccucc ccocc	ie ei		cccuc cucccc

REFERENCES

Anderson, I. H. and Dearborn, W. F., The Psychology of Teaching Reading. New York: Ronald Press, 1952.

Atkinson, R. C. and Hansen, D. N., Computer-assisted instruction in initial reading: The Stanford Project, Reading Research Quarterly, Vol. II, No. 1, Fall, 1966.

Berko, J., The child's learning of English morphology, Word, XIV, 1958, 150-77.

Betts, E. A., Inter-relationship in reading and spelling, Elem. English, 22, 1945, 13-23.

Bever, T. and Bower, T., How to read without listening, Project Literacy Reports, 6, Jan. 1966, 13-25.

Bloomfield, L., Language. New York: Henry Holt, 1933.

Bloomfield, L. and Barnhart, C. L., Let's Read: A Linguistic Approach. Detroit: Wayne State University Press, 1961.

Bolinger, Dwight L., Visual Morphemes, Language, 22, 1946, 333-40.

Brown, R. and McNeill, D., The "tip of the tongue" phenomenon, Jour. of Verb. Learn. and Verb. Behav., 5, 1966, 325-37.

Carroll, J. B., The analysis of reading instruction: Perspectives from psychology and linguistics, in the 1963 Yearbook of the National Society for the Study of Education, 1963.

Carroll, J. B., Language and Thought. Englewood Cliffs: Prentice-Hall, Inc., 1964.

Carterette, E. C. and Jones, M. H., Phoneme and letter patterns in children's language, in Proceedings of Symposium on the Psycholinguistic Nature of the Reading Process, Wayne State University. In Press, 1965.

Coleman, E. B. and Blumenfeld, J. P., Cloze scores of nominalizations and transforms, Psych. Reports, Dec. 1963, 651-654.

Dechant, E. V., Improving the Teaching of Reading. Englewood Cliffs: Prentice-Hall, Inc., 1964.

Edan, Murray, On the formalization of handwriting, Proceedings of Symposia in Appl. Math., 12, Providence, 1961, 83-88.

Ervin, S. M., and Miller, W. R., Language development, Chap. III, 62nd Yearbook of the National Society for the Study of Education, 1963, 108-43.

Farnham, G. L., The Sentence Method of Teaching Reading, Writing, and Spelling, A Manual for Teachers. Syracuse, New York: C. W. Bardeen, 1881.

Fodor, J. A. and Katz, J. J. (eds.), The Structure of Language: Readings in the Philosophy of Language. Englewood Cliffs: Prentice-Hall, Inc., 1964.

Fries, C. C., Linguistics and Reading. New York: Holt, Rinehart, and Winston, 1963.

Fries, C. C., The Structure of English. New York: Harcourt, Brace, and World, Inc., 1952.

Garrett, M., Bever, T., and Fodor, J., The active use of grammar in speech perception, Perception and Psychophysics, 1, 1965, 30-32.

Gates, A. J. and Chase, E. H., Methods and theories of learning to spell tested by studies of deaf children, Jour. Ed. Psych., 17, 1926, 289-300.

Gelb, I. J., A Study of Writing: The Foundations of Grammaticology. Chicago: The University of Chicago Press, 1952.

Gibson, E. J. (et al), Gibson, J. J., Pick, A., and Osser, H., A developmental study of the discrimination of letter-like forms, Jour. Comp. Physiol. Psychol., 55, 1962, 897-905.

Gibson, E. J., Pick, A., Osser, H., and Hammond, M., The role of grapheme-phoneme correspondence in the perception of words, Amer. J. Psych., 75, 1962, 554-70.

Gibson, E. J., Osser, H., and Pick, A. D., A study of the development of grapheme-phoneme correspondences, Jour. Verb. Learn. and Verb. Behav., 2, 1963, 142-146.

Gleason, H. A., An Introduction to Descriptive Linguistics. New York: Holt, Rinehart and Winston, 1955.

Goodman, K. S., The psycholinguistic nature of the reading process, Proceedings of Symposium on the Psycholinguistic Nature of the Reading Process. Wayne State Univ., In Press, 1965.

Goodman, Y. M. and Goodman, K. S., Spelling ability of a self-taught reader, Elem. School Jour., 64, 1963, 149-54.

Greenberg, J., Some generalizations concerning initial and final consonant sequences, Linguistics, 18, 1965, 5-34.

Greenberg, J. H. and Jenkins, J. J., Studies in the psychological correlates of the sound system of American English, Word, 20, 1964, 157-177.

Hansen, D. N. and Rodgers, T. S., An exploration of psycholinguistic units in initial reading, Technical Report No. 74, Institute for Mathematical Studies in the Social Sciences, Stanford University, 1965. Also to appear in Proceedings of Symposium on the Psycholinguistic Nature of the Reading Process. Wayne State Univ., In Press, 1965.

Hansen, D. N., Rodgers, T. S., Wilson, H. A., et al, A Reading Curriculum for a Computer-Assisted Instructional System: The Stanford Project, Institute for Mathematical Studies in the Social Sciences, Stanford University, 1966.

Harris, Z. S., String Analysis of Sentence Structure. The Hague: Mouton, 1962.

Hill, A. A., An Introduction to Linguistic Structures: From Sound to Sentence in English. New York: Harcourt, Brace, and World, 1958.

Humboldt, W. von, Verscheidenheit des Menschlichen Sprachbaues (Berlin, 1836).

Ibeling, F. W., Supplementary phonics instruction and reading and spelling ability, Elem. School Jour., 62, 1961, 152-56.

Irwin, O. C., Language and communication, Handbook of Research Methods in Child Development. New York: John Wiley and Sons, 1960, 487-516.

Iverson, W. J., The age of the computer and reading. To appear in the Yearbook of the Claremont Conference, Feb. 1967, Claremont, Calif.

Jakobson, R., Kindersprache, Aphasie, und allegemeine lautgesetze, Uppsala Universitets Årsskrift, 9, 1942.

Jakobson, R., Two Aspects of Language and Two Types of Aphasic Disorders. S'Gravenhage: Mouton, 1956.

Jakobson, R. and Halle, M., Phonology and phonetics, Fundamentals of Language. S'Gravenhage: Mouton, 1956.

Johnson, N. F., The psychological reality of phrase structure rules, Jour. of Verb. Learn. and Verb. Behav., 4, 1965, 469-75.

Kenyon, J. S., Cultural levels and functional varieties of English, College English, No. 10, 1948, 31-36.

Kolson, C. J., The Vocabulary of Kindergarten Children. Ph.D. Diss., University of Pittsburgh, 1960.

Labov, W., Some sources of reading problems for Negro speakers of non-standard English. Paper presented at N.C.T.E. Spring Inst. on New Directions in Elementary English, Chicago, March 5, 1966.

Lefevre, C. A., Linguistics and the Teaching of Reading. New York: McGraw Hill, 1964.

Leopold, W. F., Speech Development of a Bilingual Child, (4 vols.). Northwestern University Studies in the Humanities. Evanston: Northwestern University, 1939-49.

Levin, H. and Watson, J., The learning of variable grapheme to phoneme correspondences. (mimeo) New York: Cornell University, 1961(a).

Levin, H. and Watson, J., The learning of variable grapheme to phoneme correspondences: variations in the initial consonant position. (mimeo) New York: Cornell University, 1961(b).

Levin, H., Baum, E. and Bostwick, S., The learning of variable grapheme-to-phoneme correspondences: comparison of English and Spanish speakers. (mimeo) New York: Cornell University, 1963.

Liberman, A. M., Ingemann, F., Lisker, L., Delattre, P., Cooper, F. S., Minimal rules for synthesizing speech, Jour. of Acoust. Soc. of Amer., 31, No. 11, Nov. 1959, 1490-1499.

McNeil, J. D. and Stone, J., Note on teaching children to hear separate sounds in spoken words, Jour. of Ed. Psych., 56, No. 1, 1965, 13-15.

Meillet, A., Linguistique Historique et Linguistique Général, Vol. 1, Paris, 1926.

Menyuk, P., A preliminary evaluation of grammatical capacity in children, Jour. of Verb. Learn. and Verb. Behav., 2, 1963, 429-439.

Miller, G. A., Galanter, E., and Pribram, K. H., Plans and the Structure of Behavior. New York: Henry Holt, 1960.

Newman, E. B. and Gerstman, L. J., A new method for analyzing printed English, Jour. Exp. Psych., 44, 1952, 114-25.

O'Connor, J. D. and Trim, J. L. M., Vowel, consonant and syllable - a phonological definition, Word, 9, 1953, 103-122.

Osgood, C. E. and Sebeok, T. A. (eds.), Psycholinguistics: A Survey of Theory and Research Problems. Bloomington: Indiana University Press, 1953.

Patten, D. H., How to correct spelling errors, Education Today, Bull. No. 54, Columbus, Ohio, Charles E. Merrill Books, Inc. Reprinted in Readings in the Language Arts, Anderson et al (eds.). New York: MacMillan, 1964, 216-219.

Peake, N. L., Relation between spelling ability and reading ability, Jour. Exp. Ed., 9, 1940, 192-193.

Pickett, J. M., Perception of compound consonants, Lang. and Speech, 1, 1958, 288-304.

Pike, K. L., The Intonation of American English. Ann Arbor, Michigan: The University of Michigan Press, 1946.

Plessas, C. D. and Ladley, D. M., Spelling ability and poor reading, Elem. School Jour., 63, 1963, 404-08.

Postman, L. and Rosenzweig, M. R., Perceptual recognition of words, Jour. Speech and Hearing Disorders, 22, 1957, 245-253.

Postman, L. and Rosenzweig, M., Practice and transfer in the visual and auditory recognition of verbal stimuli, Amer. Jour. Psych., 69, 1956, 209-225.

Roberts, P., English Sentences. New York: Harcourt, Brace, and World, 1962.

Roberts, P., English Syntax. New York: Harcourt, Brace and World, 1964.

Robinson, F. P. and Hall, P., Studies in higher-level reading abilities, Jour. Ed. Psych., 32, 1941, 241-52.

Rodgers, T. S., Computer assisted instruction (CAI) and the teaching of economics, New Developments in the Teaching of Economics, K. Lumsden (ed.), Prentice-Hall, 1967.

Rodgers, T. S., On measuring vocabulary difficulty: An analysis of item variables in learning Russian-English vocabulary pairs. Submitted for publication to International Review of Applied Linguistics, 1967.

Rothkopf, E. Z., Stimulus similarity and sequence of stimulus presentation in paired-associate learning, Jour. Exp. Psych., 56, 1958, 114-122.

Russell, D. H. and Fea, H. R., Research on teaching reading, Gage, N. L. (ed.), Handbook of Research on Teaching. Chicago: Rand McNally, 1963.

Sapir, E., Language. New York: Harcourt, Brace and Co., 1921.

Sapir, E., Sound patterns in language, Lang., 1, 1925, 37-51.

Saporta, S., Relations between psychological and linguistic units. In Osgood and Sebeok, 1953, 60-65.

Sebeok, T. A. (ed.), Style in Language. Cambridge, Mass.: The Technology Press, 1960.

Sholes, R., Grammaticality of phonemic strings: With reference to pre-vocalic consonant clusters in American English, I.B.M. Research Paper, 307, New Jersey, 1964.

Silberman, H. F., Exploratory Research on a Beginning Reading Program. Technical Memo. System Development Corp., Santa Monica, 1964.

Soffietti, J. P., Why Children Fail to Read: A Linguistic Analysis. Har. Ed. Rev., XXV, 1955, 63-84.

Strickland, Ruth G., The language of elementary school children: Its relationship to the language of reading textbooks and the quality of reading of selected children, Bull. of the School of Education, Vol. 38, No. 4, Bloomington, Ind., Indiana University, 1962, 131 pp.

Švačkin, N. X., Razvitie fonematičeskogo vosprijatija reči v rannem detstve (The development of the phonemic perception of speech in early childhood), Izvestija, APN, RSFSR, Vol. 13 (1948). Abstract in Slobin, D. I., Abstracts of Soviet Studies of Child Language, in Smith and Miller (eds.), The Genesis of Language, Cambridge: M.I.T. Press, 381-82.

Trager, G. L. and Smith, H. L., An outline of English structure, Studies in Linguistics: Occasional Papers, 3. Norman, Okla., 1951.

Trubetskoy, N. S., Grundzüge der Phonologie. Prague, 1939.

Vigostsky, L. S., Thought and Speech, (Trans.). Gosisdat: Moscow, 1934.

Wallace, B. J., A Quantitative Analysis of Consonant Clusters in Present Day English. Unpublished Ph.D. Diss., University of Michigan, 1951.

Yasui, M., Consonant Patterning in English. Tokyo, 1962.

(Continued from inside front cover)

36 G. H. Bower. Response strengths and choice probability: A consideration of two combination rules. December 19, 1960. (In E. Nagel, P. Suppes, and A. Tarski (Eds.), Logic, Methodology and Philosophy of Science: Proceedings of the 1960 International Congress. Stanford Univ. Press, 1962. Pp. 400-412)

37 G. H. Bower. Application of the all-or-none conditioning model to the learning of compound responses. June 7, 1961.

38 P. Suppes and M. Schlag-Rey. Test of some learning models for double contingent reinforcement. August 15, 1961. (Psychol. Rep., 1962,

39 P. Suppes and R. Ginsberg. A fundamental property of all-or-none models, binomial distribution of responses prior to conditioning, with application to concept formation in children. September 20, 1961. (Psychol. Rev., 1963, 70, 139-161)

40 J. Theios. A three-state Markov model for learning. September 22, 1961. (Simple conditioning as two-stage all-or-none learning, Psychol. Rev., 1963, 70, 403-417)

41 G. H. Bower. General three-state Markov learning models. September 26, 1961.

42 R. C. Atkinson. A variable threshold model for signal detection. November 17, 1961.

43 R. C. Atkinson. Mathematical models in research on perception and learning. December 25, 1961. (In M. H. Marx (Ed.), Theories in Contemporary Psychology. New York: Macmillan Co., 1963. Pp. 551-564)

44 P. Suppes. Towards a behavioral foundation of mathematical proofs. January 2, 1962. (In K. Ajdukiewicz (Ed.), The Foundations of Statements and Decisions: Proceedings of the International Colloquium on Methodology of Sciences, September 18-23, 1961. Warszawa: PWN-Polish Scientific Publishers, 1965. Pp. 327-341)

45 P. Suppes and J. L. Zinnes. Basic measurement theory. March 15, 1962. (Chapter I in R. R. Bush, E. H. Galanter, and R. D. Luce (Eds.), Handbook of Mathematical Psychology, Vol. I. New York: John Wiley, 1963)

46 R. C. Atkinson. E. C. Carterette, and R. A. Kinchla. Sequential phenomena in psychophysical judgments: a theoretical analysis. April 20, 1962. (Institute of Radio Engineers Transactions on Information Theory, 1962, IT-8, S 155-162)

47 R. C. Atkinson. A variable sensitivity theory of signal detection. May 18, 1962. (Psychol. Rev., 1963, 70, 91-106)

48 R. C. Atkinson and W. K. Estes. Stimulus sampling theory. July 1, 1962. (Chapter 10 in R. R. Bush, G. H. Galanter, and R. D. Luce (Eds.), Handbook of Mathematical Psychology, Vol. II. New York: Wiley, 1963)

49 P. Suppes, E. Crothers, R. Weir, and E. Trager. Some quantitative studies of Russian consonant phenome discrimination. September 14, 1962.

50 R. C. Atkinson and R. C. Calfee. Mathematical learning theory. January 2, 1963. (In B. B. Wolman (Ed.), Scientific Psychology. New York: Basic Books, Inc., 1965. Pp. 254-275)

51 P. Suppes, E. Crothers, and R. Weir. Application of mathematical learning theory and linguistic analysis to vowel phoneme matching in Russian words. December 28, 1962.

52 R. C. Atkinson, R. Calfee, G. Sommer, W. Jeffrey and R. Shoemaker. A test of three models for stimulus compounding with children. January 29, 1963. (J. exp. Psychol., 1964, 67, 52-58)

53 E. Crothers. General Markov models for learning with inter-trial forgetting. April 8, 1963.

54 J. L. Myers and R. C. Atkinson. Choice behavior and reward structure. May 24, 1963. (Journal math. Psychol., 1964, 1, 170-203)

55 R. E. Robinson. A set-theoretical approach to empirical meaningfulness of measurement statements. June 10, 1963.

56 E. Crothers, R. Weir and P. Palmer. The role of transcription in the learning of the orthographic representations of Russian sounds. June 17, 1963.

57 P. Suppes. Problems of optimization in learning a list of simple items. July 22, 1963. (In Maynard W. Shelly, II and Glenn L. Bryan (Eds.), Human Judgments and Optimality. New York: Wiley. 1964. Pp. 116-126)

58 R. C. Atkinson and E. J. Crothers. Theoretical note: all-or-none learning and intertrial forgetting. July 24, 1963.

59 R. C. Calfee. Long-term behavior of rats under probabilistic reinforcement schedules. October 1, 1963.

60 R. C. Atkinson and E. J. Crothers. Tests of acquisition and retention axioms for paired-associate learning. October 25, 1963. (A comparison of paired-associate learning models having different acquisition and retention axioms, J. math. Psychol., 1964, 1, 285-315)

61 W. J. McGill and J. Gibbon. The general-gamma distribution and reaction times. November 20, 1963. (J. math. Psychol., 1965, 2, 1-18)

62 M. F. Norman. Incremental learning on random trials. December 9, 1963. (J. math. Psychol., 1964, 1, 336-351)

63 P. Suppes. The development of mathematical concepts in children. February 25, 1964. (On the behavioral foundations of mathematical concepts. Monographs of the Society for Research in Child Development, 1965, 30, 60-96)

64 P. Suppes. Mathematical concept formation in children. April 10, 1964. (Amer. Psychologist, 1966, 21, 139-150)

65 R. C. Calfee, R. C. Atkinson, and T. Shelton, Jr. Mathematical models for verbal learning. August 21, 1964. (In N. Wiener and J. P. Schoda (Eds.), Cybernetics of the Nervous System: Progress in Brain Research. Amsterdam, The Netherlands: Elsevier Publishing Co., 1965. Pp. 333-349)

66 L. Keller, M. Cole, C. J. Burke, and W. K. Estes. Paired associate learning with differential rewards. August 20, 1964. (Reward and information values of trial outcomes in paired associate learning. (Psychol. Monogr., 1965, 79, 1-21)

67 M. F. Norman. A probabilistic model for free-responding. December 14, 1964.

68 W. K. Estes and H. A. Taylor. Visual detection in relation to display size and redundancy of critical elements. January 25, 1965, Revised 7-1-65. (Perception and Psychophysics, 1966, 1, 9-16)

69 P. Suppes and J. Donio. Foundations of stimulus-sampling theory for continuous-time processes. February 9, 1965.

70 R. C. Atkinson and R. A. Kinchla. A learning model for forced-choice detection experiments. February 10, 1965. (Br. J. math stat. Psychol., 1965, 18, 184-206)

71 E. J. Crothers. Presentation orders for items from different categories. March 10, 1965.

72 P. Suppes, G. Groen, and M. Schlag-Rey. Some models for response latency in paired-associates learning. May 5, 1965. (J. math. Psychol., 1966, 3, 99-128)

73 M. V. Levine. The generalization function in the probability learning experiment. June 3, 1965.

74 D. Hansen and T. S. Rodgers. An exploration of psycholinguistic units in initial reading. July 6, 1965.

75 B. C. Arnold. A correlated urn-scheme for a continuum of responses. July 20, 1965.

76 C. Izawa and W. K. Estes. Reinforcement-test sequences in paired-associate learning. August 1, 1965.

77 S. L. Blehart. Pattern discrimination learning with Rhesus monkeys. September 1, 1965.

78 J. L. Phillips and R. C. Atkinson. The effects of display size on short-term memory. August 31, 1965.

79 R. C. Atkinson and R. M. Shiffrin. Mathematical models for memory and learning. September 20, 1965.

80 P. Suppes. The psychological foundations of mathematics. October 25, 1965.

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(Continued from inside back cover)

81 P. Suppes. Computer-assisted instruction in the schools: potentialities, problems, prospects. October 29, 1965.

82 R. A. Kinchla, J. Townsend, J. Yellott, Jr., and R. C. Atkinson. Influence of correlated visual cues on auditory signal detection. November 2, 1965. (Perception and Psychophysics, 1966, 1, 67-73)

83 P. Suppes, M. Jerman, and G. Groen. Arithmetic drills and review on a computer-based teletype. November 5, 1965.

84 P. Suppes and L. Hyman. Concept learning with non-verbal geometrical stimuli. November 15, 1965.

85 P. Holland. A variation on the minimum chi-square test. November 18, 1965.

86 P. Suppes. Accelerated program in elementary-school mathematics -- the second year. November 22, 1965.

87 P. Lorenzen and F. Binford. Logic as a dialogical game. November 29, 1965.

88 L. Keller, W. J. Thomson, J. R. Tweedy, and R. C. Atkinson. The effects of reinforcement interval on the acquisition of paired-associate responses. December 10, 1965.

89 J. I. Yellott, Jr. Some effects on noncontingent success in human probability learning. December 15, 1965.

90 P. Suppes and C. Groen. Some counting models for first-grade performance data on simple addition facts. January 14, 1966.

91 P. Suppes. Information processing and choice behavior. January 31, 1966.

92 G. Groen and R. C. Atkinson. Models for optimizing the learning process. February 11, 1966.

93 R. C. Atkinson and D. Hansen. Computer-assisted instruction in initial reading: Stanford project. March 17, 1966.

94 P. Suppes. Probabilistic inference and the concept of total evidence. March 23, 1966.

95 P. Suppes. The axiomatic method in high-school mathematics. April 12, 1966.

96 R. C. Atkinson, J. W. Brelsford, and R. M. Shiffrin. Multi-process models for memory with applications to a continuous presentation task. April 13, 1966.

97 P. Suppes and E. Crothers. Some remarks on stimulus-response theories of language learning. June 12, 1966.

98 R. Bjork. All-or-none subprocesses in the learning of complex sequences. June 22, 1966.

99 E. Gammon. The statistical determination of linguistic units. July 1, 1966.

100 P. Suppes, L. Hyman, and M. Jerman. Linear structural models for response and latency performance in arithmetic. July 29, 1966.

101 J. L. Young. Effects of intervals between reinforcements and test trials in paired-associate learning. August 1, 1966.

102 H. A. Wilson. An investigation of linguistic unit size in memory processes. August 3, 1966

103 J. T. Townsend. Choice behavior in a cued-recognition task. August 8, 1966.

104 W. H. Batchelder. A mathematical analysis of multi-level verbal learning. August 9, 1966.

105 H. A. Taylor. The observing response in a cued psychophysical task. August 10, 1966.

106 R. A. Bjork. Learning and short-term retention of paired associates in relation to specific sequences of interpresentation intervals. August 11, 1966.

107 R. C. Atkinson and R. M. Shiffrin. Some Two-process models for memory. September 30, 1966.

108 P. Suppes and C. Ihrke. Accelerated program in elementary-school mathematics--the third year. January 30, 1967.

109 P. Suppes and I. Rosenthal-Hill. Concept formation by kindergarten children in a card-sorting task. February 27, 1967.

110 R. C. Atkinson and R. M. Shiffrin. Human memory: a proposed system and its control processes. March 21, 1967

111 Theodore S. Rodgers. Linguistic considerations in the design of the Stanford computer-based curriculum in initial reading. June 1, 1967