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HYPOTHESIS ON RESEARCH COMPREHENSION IN SEARCH OF CLASSROOM VALIDATION

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In the past two decades we have witnessed a virtual explosion of theories and research in the psychology of reading. This explosion came after the topic of reading had almost disappeared from psychological investigations. This up-and-down status of reading reflects the revolutionary changes that have occurred in the field of psychology over the past 100 years. Some landmark research conducted over the last 100 years, shown in Table 1, depicts these changes.

TABLE 1
Psychological Research on Reading
From 1879 to 1980

1879	Javal	Eye movement behavior during reading consists of saccades and return sweep movements.
1886	Cattell	Adults perceive a word more rapidly than its individual letters.
1908	Huey	*Psychology and Pedagogy of Reading*
1917	Thorndike	Analyses of responses in reading leads to definition that reading is reasoning.
1922	Buswell	Eye movement behavior in reading changes over grades 1-12 by becoming more rhythmical, shorter in pause duration, and longer in span of perception.
1922	Judd & Buswell	During silent reading, readers vary their eye-movement behavior according to the difficulty of the material and their purposes in reading.
1932	Bartlett	*Remembering:* Successive recall of Indian story, "War of the Ghosts," demonstrates that reading is a constructive process and recall is a reconstructive process based on interaction between the text data and the readers' schemata and beliefs.
1946	Thurstone	High school reading tests consist of two factors: Word recognition and reasoning.
1952	Anderson & Dearborn	*Psychology of Reading.* Learning to read consists of formation of S-R associations and then using these associations to perceive printed words.
1953	Holmes	Reading consists of two interrelated components: speed and power. Underlying each component is an interrelated hierarchy of substrata factors. These factors are mobilized to solve problems in reading according to the readers' purposes and the demands of the task stimuli.
1957	Chomsky	*Syntactic Structures.* Differentiates competence and performance. Kernel sentences generated by phrase structure rules; transformation rules operate on syntactic structures to express different types of sentences. Attacks S-R explanations of language acquisition.

1960	Ausubel	Advance organizers are abstract knowledge structures which assimilate information in text.
1966	Goodman	Reading consists of psycholinguistically determined expectancies or hypotheses used by the reader and the text, and sampling of print to test and confirm hypotheses.
1970	Singer & Ruddell	*Theoretical Models and Processes of Reading.* Perceptual, linguistic and cognitive processes explain reading.
1972	Bransford & Franks	Readers chunk semantically related information across sentences.
1972	Winograd	"World Knowledge," information stored in long term memory, is necessary for comprehending texts.
1974	Kintsch	*The Representation of Meaning in Memory.* Meaning is represented by given and inferred propositions.
1975	Meyer	*The Organization of Prose and Its Effects on Memory.* Texts are represented by hierarchically organized propositions stored in memory.
1975	Rumelhart	A grammar for a well organized story, such as a fable, consists of a set of recursive rules that include plot, character, problem, situation, and resolution.
1976	Gough	Information processing model accounts for psychological data on reading.
1976	Rumelhart	Reading consists of an interaction between text-based data and reader-based resources.
1977	Schank & Abelson	Scripts, sequences of events stored in long term memory, are necessary for explicating and assimilating texts and culturally determined situations ("Mops" have replaced scripts).
1977	LaBerge & Samuels	Model of automaticity in processing print describes skilled readers' performance.
1977	Anderson, Spiro, Montague	*Schooling and the Acquisition of Knowledge.* Role of schemata, defined as knowledge structures with variable slots, explains assimilation of text data, construction of text interpretation, and inferential reconstruction upon recall.
1977	Van Dijk & Kintsch	Texts are represented in memory by macrostructures and microstructures.
1979 & 1980	Tierney & Spiro; Tierney & LaZansky	Comprehension of a text consists of a band of acceptable interpretations that vary on a continuum of text-based and reader-based interactions.

At the turn of the century, reading was a central topic in psychology. Javal (1879) had already discovered and measured eye-movement behavior in reading. Wundt's first American doctoral candidate, Cattell (1886), had found that adults perceived a word more rapidly than its individual letters. Huey (1908) proclaimed in his *Psychology and Pedagogy of Reading* that the understanding of reading would be the acme of a psychologist's achievement. In 1917, Thorndike defined reading as reasoning. Although his definition changed the goal of reading, it may have also deterred some psychologists from studying reading comprehension as such.

With the advent of Watson's behaviorism, psychological studies of reading focussed on eye-movement behavior in reading. Buswell (1922) recorded developmental changes over grades 1 to 12 in eye-movement behavior during reading. Judd and Buswell (1922) demonstrated that, during silent reading, readers varied their eye-movement behavior according to the kind and difficulty of material, and their purposes in reading. Although some research was done on reading in the content areas during this time (Bond, 1938; Strang, 1942;

Robinson and Hall, 1941), psychologists limited their work mostly to visual perception and eye-movement behavior in reading. Consequently, Anderson and Dearborn's book on the psychology of teaching reading, published in 1952, consisted mostly of research on visual perception, eye-movement behavior in reading, Olson's organismic age concept for determining expectancy in reading achievement, and S-R explanations of methods of teaching reading. This research was atheoretical and contained hardly any studies on comprehension. Indeed, the prevailing conception was that reading consisted of word perception; all else was thinking (Buswell, 1952). This conception was supported by Thurstone's (1946) factor analysis of reading tests into two factors: word meaning and reasoning.

Two notable exceptions to S-R type research occurred during the behavioristic era. Influenced by gestalt psychology, Bartlett (1932), an English psychologist, studied the dynamics of memory. He had readers recall an Indian story, entitled "The War of the Ghosts." Bartlett found that readers constructed an interpretation of the story, and, over time, their recall of the story occurred as an inferential reconstructive process based upon their schemata. Some 40 years later, when the zeitgeist had changed to favor cognitive psychology, American psychologists were to hail Bartlett's research as a pioneering investigation.

The other exception was the multiple regression studies conducted by Holmes (1948, 1953, 1954) to test the central hypothesis of his substrata factor theory of reading. He found that a multiplicity of factors accounted for individual differences in general reading ability and for predictors of this ability. Holmes theorized that these factors functioned at various substrata levels, but were mobilized and organized into momentary working systems according to the reader's changing purposes and the demands of the reading task.

During the 1950s, the dominant experimental paradigm for studying verbal learning was paired-associates. "Reading," which had been the title of a chapter in Woodworth's (1938) book *Experimental Psychology,* was reduced to only a topic in his 1954 revision (Woodworth and Schlosberg, 1954). This narrow scope of research in reading changed dramatically after Chomsky (1957) wrought his revolution in linguistics and after his severe attack on S-R psychology (Chomsky, 1959). Apparently influenced by Chomsky's arguments, many pschologists abandoned the paired-associates paradigm with its S-R explanations and shifted their research to sentence comprehension with cognitive explanations. Then, research in psycholinguistics began to flourish and greatly affected the field of reading. Goodman (1966), for example, drew upon expectancy theory and psycholinguistics to explain the process of reading.

However, psychologists soon discovered that Chomsky's linguistic theory presupposed rather than predicted meaning. So they changed their research to focus on meaning (Van Dijk and Kintsch, 1977). Ausubel (1960) had already formulated his theory of comprehension, which features advance organizers—abstract knowledge structures that assimilate information lower in the knowledge hierarchy, and can be modified to accommodate new information. Bransford and Franks (1974) discovered that syntax was necessary to get meaning correctly into long-term memory where it was chunked across semantically related sentences.

Some psychologists argued that meanings were stored in memory in the form of propositions, and began to use propositional analysis to represent the text-based input (Kintsch, 1974; Meyer, 1975; Frederiksen, 1975). They also began to investigate the effects of text variation on reader's speed of processing

text and on the reader's construction of macrostructures and microstructures (Kintsch, 1980; Meyer et al., 1980). They have assumed that propositional meaning is sufficient for comprehension of a text. But they have not yet determined normative levels of inference nor the developmental conditions under which these inferences are made (Singer, 1980a).

Another source of impact on reading came from the use of computers. During the 1960s, computers became readily available and began to be used for studying artificial intelligence, including simulation of reading comprehension. Winograd (1972) discovered that he had to program into computers "world knowledge" to simulate the information readers had accumulated in their long-term memories and had to mobilize in order to explicate and comprehend printed materials. Schank and Abelson (1977) added the concept of "scripts" which represent the common knowledge for sequences of events that readers acquire and mobilize for guiding their behavior and interpreting situations. (I understand Schank has substituted for "scripts" the concept of "mops" which are memory organization points.)

A boon to research in reading comprehension came from another source. In the 1970s, federal funds began to emphasize research on reading comprehension. The National Institute of Education established a Center for the Study of Reading at the University of Illinois under the very able direction of Richard Anderson. The Center has been productive in studies on the role of schemata for assimilating, interpreting, and comprehending printed materials. This view of reading comprehension is presented in the book *Schooling and the Acquisition of Knowledge* (Anderson, Spiro, and Montague, 1977).

Many of the new concepts in reading were incorporated into Rumelhart's (1976) interaction model of reading. After criticizing LaBerge and Samuel's (1976) model on automaticity and Gough's (1976) model on information processing, Rumelhart presented his interaction model. In this model, readers allocate attention between text-based data and reader-based resources. The resulting information is integrated and funneled through the reader's limited capacity processor. A corollary to the interaction model is that reading comprehension consists of a band of acceptable interpretations that vary on a continuum of text-based and reader-based interactions (Tierney and Spiro, 1979; Tierney and LaZansky, 1980). These interpretations are represented in memory by macrostructures and microstructures (Van Dijk and Kintsch, 1977).

Thus, in the last 20 years, psychology has restored reading to a central position. This renewed status of reading is exemplified by such books as *Basic Studies on Reading* (Levin and Williams, 1970), *Language by Ear and by Eye* (Kavanagh and Mattingly, 1972), *The Psychology of Reading* (Levin and Gibson, 1975). *Theoretical Models and Processes of Reading* (Singer and Ruddell, 1970, 1976), *Basic Processes in Reading: Perception and Comprehension* (LaBerge and Samuels, 1977), *New Directions in Discourse Processing* (Freedle, 1979), and *Perception of Print* (Tzeng and Singer, 1981).

But the explosion of knowledge in the field of reading has primarily been on the psychology, not on the pedagogy of reading. Although some researchers, such as Dave Pearson and Rob Tierney at the Center for the Study of Reading, are conducting research on teaching comprehension, the gap between knowledge of reading and application of this knowledge to instruction for the development and improvement of reading comprehension is great and is growing greater. We need to close this gap by testing implications derived from psychological theories and

research in classroom settings. We need to determine whether these implications are developmentally valid, and if so, whether they can be translated into instructional strategies that can improve reading comprehension in normal classroom settings. I shall summarize a list of some research-based hypotheses and implications that need to be tested and validated at the classroom level. The list is shown in Table 2.

TABLE 2
List of Research-Based Hypotheses for Testing and Devising Strategies for Improving Comprehension at the Classroom Level

1. *Input stimuli.* Modify input materials so that they fit readers' abilities; then develop readers to higher levels of ability on the relevant variable.
   a. *Shift conceptual levels from abstract towards concrete*
      (1) *word meaning:* substitute high for low frequency words (Marks, Doctorow, and Wittrock, 1974).
      (2) *sentence comprehension:* concretize sentence (Anderson, 1976); this modification reduces sentences from more abstract levels and may enable readers to then generate instantiations and consequently comprehend the sentences. In some cases, sentences may be reduced from general to particular statements that tend to make them more imageable and hence more memorable (Levin, 1976). For example, compare these sentences: The regulations annoyed the salesman vs. The *parking* regulations annoyed the salesman.
      (3) *passage sequence:* construct concrete passages to develop advance organizers that precede more abstract passages (Royer and Cable, 1975).
   b. *Modify syntax*
      (1) *Syntactic level:* use syntax in print that corresponds with the syntax employed by readers in their oral language (Ruddell, 1965).
      (2) *Syntactic complexity:* combine sentences to explicate their causal relationships, which will make the sentences longer. But, in contrast to the readability hypothesis which asserts that shorter sentences are easier to comprehend, some longer sentences with the causal relationship explicated will be easier to comprehend (Pearson, 1976). For example, compare these sentences: Mary went to the store. She bought a loaf of bread vs. Mary went to the store *to* buy a loaf of bread.
      (3) *Embedded clauses:* whenever choice can be exercised, use right branching (clauses embedded after the main verb) to reduce memory load on short-term storage and hasten storage in long-term memory (Gough, 1976).
   c. *Verb voice*
      For ease in processing print, use the active over the passive voice, but when the passive has to be employed, do so with agent expressed (Wanat, 1976).
   d. *Text organization*
      (1) *paragraph organization:* explicate situational contexts close to the beginning of a passage so that a global representation can be attained early in the passage and used for interpreting events (Bransford and Johnson, 1972).
      (2) *clarity:* explicate macrostructure and microstructure relationships (Van Dijk and Kintsch, 1977).
      (3) *density:* increase redundancy in text so that a higher proportion of text can be relevant to a particular instructional objective (Rothkopf and Kaplan, 1972).
      (4) *information:* explicate information needed for making inferences (Marshall, 1975).

(5) *signaling terms:* include these terms in texts (Meyer et al., 1980; Robinson, 1975) and teach students to use them.

2. *Mediational processes.* Use instructional procedures that promote development of cognitive processes for encoding, storing, and retrieving information.
   a. *Questioning strategies*
      (1) *direct questioning:* question students on those passages they are to learn, remember, and recall on a comprehension test (Anderson and Biddle, 1975).
      (2) *objectives or goals:* explicitly state specific objectives, purposes, or goals that are related to statements in the text (Rothkopf and Kaplan, 1972).
      (3) *self-questioning and self-selection of goals:* have students generate their own questions (Manzo, 1970; Frase and Schwartz, 1975; Singer, 1978) and formulate their own reading goals. Probably self-formulation of goals will have benefits similar to the advantages of self-questioning; used in combination, the interaction of the two processes may even result in a greater degree of comprehension, or at least in more efficient attainment of comprehension.
   b. *Verbalization.* Teach students to summarize and paraphrase text (Wittrock et al., 1975).
   c. *Knowledge*
      (1) *Structure of knowledge:* teach students a wide range of organized information through a broadly based liberal arts curriculum.
      (2) *Mental encyclopedia:* develop a broad repertoire of information through direct and vicarious experience (Winograd, 1972). Teach students to use their background information (Hansen and Pearson, 1980).
   d. *Word meanings, concepts, and schemata:* have students develop within the limits of their increasing capacities a lexicon that has range, altitude, and depth (Russell, 1956), and organize it into a hierarchical structure (Rumelhart, 1975; Anderson et al., 1977).
   e. *Morphemes:* teach students to analyze printed words into their morphemic constituents (Ruddell, 1976; Singer, 1976).
   f. *Imaging:* teach and encourage students to transform meanings expressed in print into images (Levin, 1976, 1977).
   g. *Purposes*
      (1) counsel students to be initiators, that is, establish their own comprehension goals (deCharms, 1972).
      (2) develop students' self-confidence and independence (Athey, 1976).
   h. *Reasoning about print*
      (1) teach students to analyze sentences into given and new information and compare it with information already in their mental encyclopedias (Clark and Clark, 1977).
      (2) have students learn and practice generation of concrete scenarios from their abstract structures; have students also generate examples or hypotheses for superordinate schemata (Anderson et al., 1976).
      (3) teach students to form new schemata by having them abstract and generalize from direct and vicarious experiences using a teaching process such as Taba's questioning sequence (Taba, 1965).
3. *Output Products:* use the type of measurement that corresponds with the reader's purpose, mode of processing, and demands of the material.
   a. *Letter-by-letter:* reading that follows more closely to the sensory-driven level of the processing continuum is more likely to occur when the exact meaning of the author is sought. At the extreme level, letter-by-letter processing (Gough, 1976) or direct perception (McConkie and Rayner, 1976) occurs, but does not actually involve processing all the letters, only those needed to identify the word (Strange, 1979). For this mode of processing and reader goal, verbatim scoring of a recall protocol is appropriate.
   b. *Hypothesis and sampling of print:* a mode of reading that is closer to the concept-driven level is more likely to occur when (a) the reader only wants to extract the general meaning of the passage or (b) the material is familiar or (c) the material only demands extraction of a general idea. Then the reader is more likely to hypothesize, sample the print, and confirm or disconfirm hypotheses (Goodman, 1976; Wanat, 1976). The same type of processing may occur when the contextual situation is missing or has not been stated yet and the reader is testing out ways of conceptualizing the input and consequently shifts from one hypothesis to another (Rumelhart, 1978). For this type of reading, gist or lax scoring would be more relevant than verbatim or exact scoring (Nicholson, 1977).
   c. *Level of Macrostructures and Microstructures:* use text bases that specify macrostructures and microstructures which are appropriate to students' developmental levels. Teach students to form these structures, and supplement them with strategies for processing various types of expository text (Kintsch, 1980; Singer, 1980a).
   d. *Coherence in Teaching and Testing:* make sure that the readers' purposes, information in text and ways of processing them, and goals or tests cohere. Or stated in another way, determine whether the directions and tasks given the reader fit the information provided in texts and the questions asked on comprehension tests (Rothkopf, 1980; Singer, 1980b).

HYPOTHESES FOR CLASSROOM TESTING

The first set of hypotheses deals with the modification of input stimuli to fit readers' abilities. These hypotheses refer to levels of abstraction, syntactic complexity, and organization in text, including discourse and rhetorical devices, lexical choices, and explication of propositions. Such modification may lead to the determination that an input variable is related to comprehension. After this determination has been made, it is necessary to try to improve the process or knowledge entailed by this variable so that readers can comprehend the more difficult and more varied material. This type of improvement is necessary if the claim is made that variation in the input stimuli has improved comprehension.

The second set of hypotheses focuses on improvement of mediational processes. These hypotheses refer to acquisition of self-questioning and verbalization strategies, development of information and knowledge structures and their use in reading, improvement of students' lexicons and morphological ability, instruction in use of imagery in processing print, and emphasis on teaching students to vary their purposes in reading and increase their ability to reason about print.

The last set of hypotheses refers to the assessment of comprehension. The main point in these hypotheses is that the type of assessment used should correspond with the reader's purposes, mode of processing, and level of reasoning abilities. In general, there should be coherence among the reader's task, the information in the text, the test for assessing comprehension, and the teacher or adjunct aids that affect each of these components for reading and learning from text (Rothkopf, 1980; Singer, 1980b).

In testing these hypotheses and in teaching for the improvement of comprehension, we have to observe some principles and avoid some pitfalls in reaching conclusions based on classroom instruction. These principles and pitfalls are summarized in Table 3.

TABLE 3

Principles and Pitfalls in Testing Hypotheses on Teaching Reading Comprehension at the Classroom Level

1. *Phase out the Teacher and Phase In the Student While Teaching a Process of Comprehension.*
   Example: Active Comprehension: From Answering to Asking Questions (Singer, 1978, 1979)
2. *Transfer of Training Test:*
   Negative Example: Wittrock, Marks, and Doctorow (1975) Comprehension strategy of summarizing paragraphs—not tested in a transfer paradigm.
3. *Developmental Validity of Hypotheses:*
   Example: Instantiation hypotheses, confirmed at the college level (Anderson et al., 1976) did not generalize to grade school level (Dreher, 1980).
4. *Develop schemata in a broadly based curriculum which stresses development of vocabulary, concepts, and range of information:*
   Example: Prediction that, all else being equal, narrowing the curriculum is likely to reduce reading comprehension.
5. *Devise and Test Strategies for Development of Schemata: Example:* Hayes (1979) used baseball analogies to develop schemata for comprehending cricket.
6. *Teach and Test for Improvement of Cognitive Processes: Example:* Hansen and Pearson (1980) devised prediction strategy for teaching second graders to use spontaneously their background knowledge for making inferences from text.
7. *Ascertain that materials of appropriate reading difficulty are used for testing hypotheses on both the good and poor readers:*
   Example: Taylor (1979) inferred that fifth graders whose reading ability was at a third-fourth grade level could use knowledge-based or reader-based strategies when reading familiar material, but were reduced to text-based strategies for unfamiliar material.
8. *Use downward adaptation of materials to fit readers' abilities to test relevance of a particular variable; then instructionally intervene to develop that variable in students and determine whether comprehension improves as a result:*
   Negative example: Ruddell's (1965) match of sentence syntax in texts to students' oral syntax.
9. *Use an assessment measure that is appropriate and sensitive to the research or instructional strategy:*
   Examples:
   a. Tierney and Spiro (1979) and Tierney and LaZansky (1980): Band of acceptable responses for continuum of text-based and reader-based interactions.
   b. Level of inference for macrostructures and microstructures have to be developmentally appropriate (Singer, 1980a).
   c. Direct perception (McConkie and Rayner, 1976); Gough, 1976) occurs when the reader's purpose is to be precise. Scoring can be verbatim.
   d. Hypothesis or expectancy sampling and confirmation (Goodman, 1966; 1976) occurs when the material is familiar and/or reader's purpose only requires construction of a general idea (Nicholson, 1977).
   e. Ethnic texts assessed by scriptural comprehension show comprehension advantage for ethnic minorities (Rogers-Zegarra, 1980).
   f. Probe after free recall to test for (a) treatment effects (Hansen and Pearson, 1980); (b) perspectives (Pichert and Anderson, 1977; Anderson and Pichert, 1977).
   g. Use tests that have curricular and instructional validity. They should also have research validity, that is, be sensitive to experimental treatment (Katz, 1980). In short, provide for coherence among readers' purposes, text information, and criterion referenced goals, and the effect of teacher or adjunct aids on these components of reading and learning from text (Rothkopf, 1980; Singer, 1980b).
10. *The instructional fallacy is the assumption that if students do not learn, the difficulty lies with the students, not the method or the instruction. To try to avoid this fallacy, during an experiment, test to determine the relevance and effectiveness of experimental or instructional conditions for the learner's aptitudes, abilities, and motivation.*[2]

PRINCIPLES AND PITFALLS IN TESTING HYPOTHESES ON READING COMPREHENSION AT THE CLASSROOM LEVEL

Phase Out the Teacher and Phase in the Student While Teaching a Process of Comprehension

A multiplicity of strategies has been constructed to facilitate attainment of comprehension. The Directed Reading Activity (DRA), which is used in most basal readers, was the first strategy to gain widespread use. Others are Robinsons' SQ3R (1946, 1961), Ausubel's advance organizer (1960), Herber's reading guides (1970), Earle and Barron's overview guides (1973), and marginal glosses (Singer and Donlan, 1980). Rothkopf's (1966, 1980) research on adjunct aids, consisting of directions to the reader, questions embedded in text, and selection of reading goals in the form of relevant test questions has provided considerable knowledge on teaching students to comprehend printed materials, as has Frase's (1967, 1970) work on the effect of questions, text organization, and document design. Richard Anderson and W. E. Biddle (1975) have theorized that teacher-posed questions serve to transfer information from short-term to long-term memory. Recently Tom Anderson and Bonnie Armbruster (1980) reported that a study technique such as outlining or underlining, is only effective to the extent that it leads the reader to concentrate time and effort on the reading task.

However, the goal of instruction is reader independence. In other words, instruction should teach students to utilize strategies on their own. For example, teachers should aim to teach students to formulate and read to answer their own questions.

I have referred to self-questioning as a process of active comprehension, which is a continuous process of asking and answering questions during reading (Singer, 1978, 1979). To attain this goal, we (Singer and Donlan, 1980) have advocated a phase-out/phase-in strategy. In this strategy, the teacher takes the first step by modeling questions that are appropriate to the content. The teacher also begins to develop students' knowledge of the content. We know that each content area has questions that are specifically appropriate to it (Broudy, 1977) and that knowledge of content is necessary for appropriate question-generation (Miyake and Norman, 1979). Furthermore, text-types, such as expository prose, have their own question strategies, frequently cued by signaling words (Smith, 1964a, 1964b; Robinson, 1975; Meyer et al., 1980). As students acquire some knowledge of the content, the teacher takes the next step of forming them into groups to ask each other questions. Eventually the teacher can take the final step of having them ask and answer appropriate questions on their own.

Can students learn to generate their own questions? Rosenthal, Zimmerman, and Durning (1970) used comprehension of pictures to demonstrate that sixth graders could learn to imitate their teacher's questions. But the students did not simply copy their teacher's questions, as shown by the student's ability to transfer their learning to asking questions for comprehending new pictures. However, the investigators did not determine whether improvement in self-questioning transferred to comprehension of text.

Frase and Schwartz (1975), however, did investigate the use of a self-questioning technique for comprehending a text. They reported that 48 students who studied by asking each other questions, mostly verbatim questions, attained significantly higher recall scores than students who studied alone. The experimenters also found that college students attained higher scores on text pages for which they generated questions than on alternate pages which they only studied.

Self-questioning for learning from text also works at the elementary level. Conducting their research at the fifth grade level, Helfeldt and Lalik (1976) found that the reciprocal questioning group performed significantly better on a Van Wagenen interpretation test than a unilateral, teacher-posed question group. The reciprocal question group was allowed to ask the teacher a question for each teacher-posed question they answered.

Self-questioning was also superior in a remedial reading program for students whose ages ranged from 7 to 25. In this program, Manzo (1970) had trained teachers tutor students through use of a technique called "ReQuest." The technique consists of the teacher requesting students to ask questions. The results indicated that the "ReQuest" group performed significantly better on two standardized comprehension tests than a control group which had been taught by the Directed Reading Activity which features teacher-posed questions.

It is possible that good readers at the high school level have learned self-questioning techniques on their own. This interpretation would explain why Andre and Anderson (1978-1979) found that training high school students in self-questioning was more effective with the lower than with the higher verbal ability students.

An hypothesis to explain the effects that student-posed questions have upon learning and comprehension is that self-questions focus attention and emphasize text passages that answer these questions. The answers, stored in long term memory, are then retrieved by test questions that contain verbatim cues. But, unlike teacher-posed questions, student-posed questions can be asked continuously throughout the text. Consequently, students are more likely to perform better on the criterion test because they have asked and answered more questions as they read. This explanation assumes that teacher modeling was used to teach the students which questions were relevant to the content and that the students had acquired some knowledge of the content prior to generating their own questions. Under these conditions, active comprehension is likely to lead to more review, more mathemagenic behavior, and more storage in long-term memory of information gained from text.

To Claim that Learning Has Occurred, Test for Transfer of This Learning to New Passages

Another principle is that a transfer test should be used to determine whether students have learned a strategy or a process for improving their comprehension. Otherwise, the conclusion of a classroom experiment should not refer to what the

experimental group did or did not learn. We shall review a research study to illustrate this principle.

Wittrock has theorized that reading is a two-stage process. In the first stage, the reader uses input data, including the semantic, syntactic, phonetic, and episodic characteristics of words in a specific context to reduce uncertainty in the identification of previous experiences stored in long-term memory. In the second stage, the reader generates or constructs from the identified previous experience one or more distinctive representations of an event or situation consistent with the words of the sentence. This actively constructed representation, induced from memory of prior events, is the psychological meaning of the sentence. Testing an hypothesis from this theory, Doctorow, Wittrock, and Marks (1978) asked fifth and sixth grade students to generate sentences that would summarize the meaning of paragraphs in a story. They found that these students doubled their comprehension on the criterion-referenced test that accompanied the story they had summarized. But the experimenters did not attempt to determine whether the students could transfer the summarization strategy to another story without experimenter guidance.

Another principle we should apply before we use a psychological hypothesis as a basis for devising an instructional strategy to improve reading comprehension is this:

Determine the Developmental Validity of the Hypothesis

Hypotheses are frequently validated on college samples. But the developmental generality of the hypothesis also has to be tested on an elementary sample before basing instruction upon it. For example, Anderson et al. (1976) validated the instantiation hypothesis on a college sample by demonstrating that these students substituted and stored in memory an instantiated term for a general term. They found for the sentence, "The woman was outstanding in the theater," that the instantiated term "actress," was a better retrieval cue for the object noun of the sentence, "theater," than was "woman," the general term that had actually occurred in the sentence. Dreher (1980) tested the generality of this hypothesis at the fifth and eighth grades. In the first part of the experiment she requested the students to generate for each sentence a particular term for the general term; the students were able to comply. But, under the direction to read and remember the sentences, another sample of students did not *spontaneously* instantiate the sentences.

Whether students can learn to instantiate spontaneously remains to be seen. In the meantime, children's lack of spontaneity in this process is consistent with Brown's (1977) theory on developmental changes in cognitive or executive control. Apparently the development of executive control for instantiation does not occur until sometime after the eighth grade.

What does increase developmentally and cumulatively is the knowledge students gain from their curriculum experiences. This fact leads to this principle for improving reading comprehension:

To Improve Comprehension, Use a Broadly Based Curriculum which Intentionally and Systematically Develops Vocabulary, Information, and Schemata

Are schemata currently being developed and organized hierarchically in students? They are, but not exclusively in instruction on comprehension. They

are mostly being developed in the content areas of the curriculum, but probably not intentionally nor in a hierarchical organization. Nevertheless, we would expect that a person who had been educated in a broadly based curriculum, all other things being equal, would have better comprehension over a greater range of content than a person who had been educated in a narrower curriculum. The more broadly educated individual would have gained a wider range and depth of information. Thus, we conceive of the entire curriculum, including all the direct and vicarious experiences that students gain in and out of school, as contributing to the range, depth, and altitude of an individual's schema hierarchy and knowledge of the world. These schemata, stored in the reader's mental encyclopedia, enable readers to explicate passages, make inferences, and assimilate information. They are a major contributor to the individual's reading comprehension.

Conversely, we would predict that when schools narrow their curriculum, students' comprehension is likely to go down. The San Diego Unified School District, in an attempt to satisfy a court order to raise reading achievement from the 30th to the 50th percentile rank in some 17 inner city schools over the next three years, is complying by increasing instruction in reading, math, and language, and decreasing it in other areas of the curriculum, such as science, history, and geography. We predict that this narrowing of the curriculum is likely to lead to a decrement, not an improvement in reading comprehension. Consequently, we suggested to San Diego's director of research and evaluation that San Diego conduct an experimental test of this prediction by randomly assigning half of the schools to the narrower curriculum and the other half to the present or perhaps to a broader curriculum. At this time, we do not know whether this naturalistic type of experiment will be conducted.

If our prediction is confirmed, we would attribute it to (1) acquisition of new schemata as a result of instruction and learning in various content areas and (2) use of new and previously acquired schemata for assimilation of information and construction of meaning during reading and for inferential reconstruction upon recall.

Although the accommodation process for the acquisition of new schemata is germane to education in general, we know very little about the process. For example, we need to know whether we can apply the accommodation process in classroom situations. If so, what strategies result in acquisition of schemata and under what conditions? Therefore, we recommend this principle for those researchers concerned with the improvement of reading comprehension:

To Conduct Research on the Improvement of Reading Comprehension, Devise Strategies for Development of Schemata

Hayes (1979), who completed a doctoral dissertation under the direction of Rob Tierney, conducted a study that fits this principle. Using baseball analogies for learning schemata about cricket, he found that the analogies affected recall of the text in different ways, depending on when the analogies were given. Analogies given in advance led to more recall of explicitly stated text-based information. Analogies embedded in text resulted in more reader-based information and more schema generalization as shown by transfer of learning to prediction of certain cricket match situations. Analogies given in advance *and* embedded in text led to greater schema specialization as shown by ability to discriminate between cricket and non-cricket information.

Hayes's findings have great relevance for construction of texts and for knowledge of the accommodation process. The evidence is clear that analogies facilitate learning from text. Whether readers can learn to use an analogy even more effectively and whether they can improve their learning from texts without advance or embedded analogies by learning to generate their own analogies are questions that still need to be answered. In short, researchers in education need to determine whether teachers can improve students' cognitive processes for attaining comprehension. To do so, researchers have to create instructional strategies, teach them to students, and assess their effect upon comprehension. The principle that fits this requirement for improving comprehension is:

Teach and Test for Improvement of Cognitive Processes for Encoding, Storing, and Retrieving Information

Operating according to this principle, Hansen and Pearson (1980) devised a prediction strategy to teach second graders to draw spontaneously upon their background knowledge in order to make inferences from text. The strategy asked the children to answer a question about their previous experiences related to ideas in the story and then to hypothesize or make predictions about something similar that might happen in the story. The experimenters hoped the strategy would teach the students to consciously try to integrate text and prior knowledge during reading. Another experimental group was given practice in answering inferential questions. Hansen and Pearson expected the practice either to improve the children's processes of inference or else to develop anticipation of questions which would lead them to focus on interpretation rather than on a literal level of comprehension. The results indicated no significant differences on a recall measure, but both experimental groups were superior to the control group on the 10 item open-ended literal comprehension questions and on the 10 item, open-ended inferential comprehension questions which required use of prior knowledge. Hansen and Pearson also found that on the *Stanford Achievement Test,* which requires inferential reasoning, the question group was superior. Although the experimenters demonstrated that their teaching strategies improved second graders' ability to integrate text with prior knowledge and make valid inferences, they did not test whether the strategy transferred to stories on which the students had no pretraining. However, the Question Method apparently did lead to generalized improvement in making inferences as assessed by the *Stanford Reading Achievement Test.*

Hansen and Pearson used the experimental-control group design. This paradigm does not lead to a pitfall sometimes encountered when the good vs. poor reader contrast is employed. In the latter experimental design, caution should be exercised lest an implication of deficit is drawn for the poor readers. The principle to follow is this:

Ascertain that Materials of Appropriate Reading Difficulty are used for Testing an Hypothesis on both the High and Low Reading Groups

This principle was violated in a recent study by Meyer, Brandt, and Bluth (1980). To test for the effect that structural signal words in a passage have upon recall of propositions, they gave a reading passage with and without structural signal words to good and poor ninth grade readers. The results revealed that

when the signal words were available in the text, the good readers used them to organize their recall but the poor readers did not do so; instead, they simply gave a list of propositions. But Meyer, Brandt, and Bluth did not give the poor readers a passage appropriate to their reading level to see whether they too could then use structural signal words to organize their recall. Instead, they implied that the poor readers had a deficit in their ability to organize recall of the text.

Downward adaptation of the text to the ability level of the students, however, should not be interpreted as an improvement in comprehension. Such a downward adaptation may be a way of determining whether a particular variable is adversely affecting a group's comprehension. The next step is to provide instructional intervention and then test for improvement in comprehension. The principle is:

Use Downward Adaptation of Material to Fit Readers' Abilities and to Test the Relevance of a Particular Variable for Comprehension; then Instructionally Intervene to Develop that Variable in Students and Determine Whether Comprehension Improves as a Result

An example of downward adaptation is Ruddell's (1965) matching of sentence syntax in printed materials to fourth graders' oral sentence syntax. The match resulted in better performance on a cloze text of comprehension. However, Ruddell did not go on to the next step to improve the fourth graders' use of syntax in comprehending printed materials. Consequently, he could not and did not attempt to claim that he had improved the students' general comprehension.

The cloze test was a sensitive and appropriate test to use in Ruddell's experiment. Indeed, a relevant test is necessary for any experiment or for assessment of any instructional effect. The principle is:

Use an Assessment Measure that is Appropriate and Sensitive to the Research or Instructional Strategy

Although we may be able to agree on this principle, carrying it out in practice is difficult, even more so because of the interaction concept of reading comprehension, and because we are aware of the role of schemata and inference in construction of meaning during reading and inferential reconstruction upon recall. For example, Tierney and Spiro (1979) and Tierney and LaZansky (1980) have pointed out that comprehension consists of a band of acceptable responses that vary on an interaction continuum from text-based to reader-based. Which end of the continuum is dominant depends on the readers' purposes, abilities, experiences, and the demands of the material. Moreover, for evaluating comprehension, we have to determine the level of macrostructures or inferences for a text-base that is developmentally appropriate (Singer, 1980).

We also have to decide, for any comprehension measure, whether to use verbatim or lax scoring. We do have some criteria for solving this problem. If the reader's purpose is to get a precise meaning for a text, then McConkie and Rayner's (1976) direct perception hypothesis is tenable; so is Gough's (1976) position that readers "plow" through each word until the word is identified (Strange, 1979). For this reading purpose, verbatim scoring would be appropriate.

But, if the reader's purpose is to attain only the general meaning of a passage,

if the material is familiar, and if the demands of the material require construction and retention of only a general idea, then Goodman's (1976) position is defensible. His position is that readers hypothesize, anticipate meaning, sample print, and confirm or disconfirm hypotheses as they read. For this position, lax or gist scoring would be suitable (Nicholson, 1977).

Instructional conditions that move attainment of comprehension towards the reader-based end of the interaction continuum occur when ethnic texts are used and scriptal comprehension is assessed. Under these conditions, Rogers-Zegarra (1980) has found that the Mexican-American group scored higher than the Anglo group for the Mexican-American material and equalled the Anglos on the Anglo materials.

Whatever input text is used, we cannot rely upon free recall alone to find out whether groups differ; we must also probe, as Hansen and Pearson (1980) found they had to do in their study. We have to ask not only for literal recall, but also for text-based inferences and answers to reader-based scriptal questions, including questions on different perspectives for a text (Pichert and Anderson, 1977).

Another factor that affects the comprehension output is the time delay between the reading of a text and administration of a comprehension test. If we test immediately after the reading of a passage, we are more likely to get a reproduction of the text; but if we allow time to intervene before we test, we are likely to get more reconstructive intrusions.

In general we should use tests that provide for instructional validity, that is, there should be coherence among readers' purposes, text information, and criterion-referenced goals, and the effect of teacher or adjunct aids on these components of reading and learning from text (Rothkopf, 1980; Singer, 1980b).

Tests should also have research validity, that is, the tests used in a study should be sensitive to experimental treatments. For example, in retesting the hypothesis of the First Grade Studies which have been reported by Bond and Dykstra (1968), Katz (1980) constructed criterion-referenced tests for each method of supplementary instruction (graphophonemics, morphophonemics, semantics, and syntax) given to her four experimental groups. She found that the supplementary instruction did make a difference on the criterion tests and in the multiple regression equation for predicting comprehension. The variation in supplementary instruction had no differential effect on comprehension, but, in contrast to the First Grade Studies's conclusion, it did affect development of children's subsystems for attaining comprehension.

Because of the choices involved in assessing comprehension and because the particular assessment instruments used affect the results of an experiment so much, we should follow this principle in planning and publishing research on comprehension.

Use a Comprehension Measure that is Appropriate to the Condition of the Experiment or Instruction, and State the Rationale for the Test in Publishing Research Results

Finally, we come to our last pitfall in teaching comprehension, the instructional fallacy. This fallacy assumes that if students do not learn, the difficulty lies with the students, not with the method or the instruction.[2] But as Carroll (1963) has specified in his conditions of school learning, we have to consider the outcome of schooling as a function of variables in the student and variables in the

instructional or experimental situation. Hence, in addition to consideration of statistical power tests (Levin, 1975), validity of experimental designs (Campbell and Stanley, 1963), and robustness of treatments or instructional strategies, we also have to consider the instructional fallacy in evaluating classroom research.

We can try to avoid this pitfall by applying this principle:

During the Experiment, Test to Determine the Relevance and Effectiveness of Experimental or Instructional Conditions for the Learner's Aptitudes, Abilities, and Motivations. Then, in Reporting, State the Instructional Conditions for Both the Experimental and Control Groups, including the Rationale for the Criterion Test

Space permits me to provide only one example of what I mean by a test of experimental conditions. This test is one way to answer a perennial question: How long should instruction last until a criterion test is given? Borrowing from conditions for paired associate learning, Dan Donlan and I (1979) found that one answer to the question is to alternate teaching and test conditions. For example, we wanted to determine whether students could learn to use a problem solving schema for generating their own questions in comprehending short stories. For each story, we provided teacher-modeling of schema-based questions followed by criterion-referenced tests and plotted the difference each time between our experimental and control group. We reasoned that if the treatment was effective and students were learning to generate their own schema-based questions, the differences would accumulate. That is what we found. After five stories, we obtained a clear separation between our experimental and control groups on the criterion test.

SUMMARY AND CONCLUSIONS

Scientific revolutions in psychology have resulted in dramatic changes in research in reading. After almost a century of relatively few landmark studies in the psychological investigation of reading, an explosion of knowledge on reading acquisition and learning from text has occurred in the last 20 years.

However, the resulting hypotheses at the input, mediational, and output stages of reading still need to be tested at various school levels to determine their developmental validity. Instructional strategies then need to be created and tested to determine whether they can improve comprehension in ecologically valid settings.

This research is fraught with numerous pitfalls but the task of exploring and improving the mental cosmos from which reading comprehension emerges should be a challenge to competent and creative researchers. They will have to devise the strategies, avoid the pitfalls, follow certain principles for improving comprehension, and conduct research in classroom settings to determine the validity of the instructional strategies. We urge educational psychologists to concentrate their efforts on this task, the National Reading Conference to highlight these studies, educational journals to feature reports of this research, and funding agencies to support it. Together, these agencies can make the 1980s an era for research on instruction and improvement of reading comprehension.

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