Thinking Through Text Comprehension II: Analysis of Verbal and Investigative Repertoires

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Abstract

Reading comprehension can be considered a complex human performance involving two integrated repertoires: a verbal repertoire and an investigative (generative) repertoire. This paper describes an analysis of these repertoires in terms which can ultimately inform the design of programs to teach them, using the analysis and design of Headsprout® Reading Comprehension as an example.

Keywords

reading comprehension; content analysis; concepts; strategies

> *If one, in front of a room full of people, wrote on the blackboard, "look at the ceiling," some may verbalize, "look at the ceiling," while others may tilt their heads and look up. The ones looking up demonstrate comprehension.*
>
> *—Goldiamond and Dyrud (1966) as cited in Layng, Sota, and Leon (2011)*

Though true, the above quote describes only the beginning of an analysis of comprehension which will ultimately lead to instruction that successfully teaches learners how to comprehend text. Comprehension is not a monolithic concept. It is not something that someone either has or does not have. It is not something that someone either can do or cannot do. Reading comprehension is what we call it when particular responses are made in the presence of particular textual stimuli. Often, it refers to public events as well as private events which we would typically call thinking or reasoning (see Layng, Sota, & Leon, 2011). When we say that a learner can comprehend what he or she has read, we are making a generalization statement based on a large pattern of stimulus-control topographies (Ray & Sidman, 1970). These topographies vary across passages, questions, and responses. For example, reading material may vary in terms of the passage's length, the reading level at which it is written, and its subject matter, as well as its style, sentence structure, vocabulary, and so on. A question about the passage read may vary in terms of length, structure, and vocabulary as well as the response required. Questions may be multiple-choice or open-ended. They may require a spoken response or a written one. These differences represent differences in stimulus-response relations and, ultimately, in the programing involved in building a reading comprehension repertoire. The first step in the design of a program, then, is analysis of these stimulus-response relations in terms which will lead to determining what repertoires to teach. This paper describes the types of analysis that informed the design of Headsprout® *Reading Comprehension* and which were based on an analysis of textual comprehension as described in Layng, et al. (2011).

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CONTENT ANALYSIS

The first problem in designing a program to teach reading comprehension involves determining what to teach. Several factors must inform this decision, including factors related to the current market, technologies, and resources, as well as factors related to the repertoire itself. All of these factors were considered in the design of Headsprout® *Reading Comprehension*. The current market was analyzed in terms of reading comprehension products available and the needs of schools, and technological and resource limitations and affordances were considered. Initial learner analysis was also conducted in order to determine the entering repertoires of our target learners (see Twyman, Layng, Stikeleather, & Hobbins, 2004, for a description of Headsprout's design process).

The initial analyses of the program itself focused on two major questions: (1) what is measured in school systems across states and publishers—or, more precisely, what are the stimulus-control topographies that, if present, will make an observer or examiner conclude that the learner has demonstrated reading comprehension, and (2) what is the structure of the domain in terms of composite and component repertoires, including prerequisite and coordinate skills (see Johnson & Layng, 1992). Answering these questions involves content analysis: identifying the repertoires to be taught and analyzing these repertoires into their components, including the type of learning involved, the learning hierarchy, and the relations of one skill to another (Tiemann & Markle, 1990; Twyman, et al., 2004).

ANALYSIS OF READING COMPREHENSION MEASURES

We say that a learner comprehends what he or she reads when reading a text is followed by an evaluated change in referent behavior (see Layng et al., 2011). This behavior could involve selecting an answer to a multiple-choice question, constructing an answer to an open-ended question, or doing something (engaging in a task, following a procedure, and so on) that could not or would not have been done prior to reading the text.

One of the first steps in our analyses of content involved examining tests of reading comprehension currently used in schools to determine what was being measured. Thus, we gathered and examined tests of reading comprehension for third and fourth grade (the grade levels of our target population) from several states in different regions across the country[1].

We analyzed these tests to determine:

1. What stimuli and responses make up the stimulus-control topographies being evaluated?
2. In what different ways can these relations be categorized?
3. Which categorizations hold the most promise for program development?

When a student is reading, several stimulus-response relations are in effect (see Layng et al., 2011). In answering a question, the response is guided by stimuli including: (1) the passage read, (2) the question asked, and (3) possible answers, if the question is a multiple-choice question. All of these serve to restrict response alternatives along specific dimensions—that is, if guidance by the passage and question is present, some classes of responses become more probable than other classes of responses upon reading. For example, upon reading about a birthday party, responses related to birthdays that are already in the repertoire of the reader become more probable. A question about a cake may increase the likelihood that responses related to cakes will be made (Skinner, 1957). In order for a learner to do well on a test of reading comprehension, however, it is not enough that reading about a birthday party results in an increase in related responses. His or her behavior must meet the contingency requirements specified in the question. The questions, then, became our first basis for categorization.

CATEGORIZATION OF READING COMPREHENSION QUESTIONS

Categorization based on question asked. The analysis of questions led to defining several different categories, or types, of questions, each of which required a different response on the part of the learner. Questions could require the learner to (1) identify the most prominent theme (main idea) in a passage (e.g., "What is this story mostly about?"), (2) derive the meaning of a word or phrase from the surrounding context (e.g., "What does __ most likely mean?"), (3) answer a question when the answer has a point-to-point topographic correspondence with words in the passage, or (4) answer a question when the answer has a thematic but not a point-to-point topographic correspondence with words in the passage. We categorized each of these types, respectively, as (1) summative, (2) vocabulary or derived meaning, (3) literal or factual, and (4) inferential.

Categorization based on response type. Another major division between questions involved whether the question required a selection response (multiple-choice) or a constructed response (open-ended). Answering questions across these two response categories involves different repertoires. For example, answering open-ended questions involves skills of composition and writing in addition to the skills needed to determine the answer to the question. When instruction is delivered via a computer, typing skills are also necessary. Furthermore, answering open-ended questions involves absolute matching, which requires a criterion to be set by a learner's reinforcement history (see Goldiamond & Thompson, 1967/2004). If learners do not have this history, then it would need to be provided for them—that is, built into the instructional program. These considerations as well as others, such as issues in evaluating varied responses with the current software capabilities available in the industry, entered into the decision to focus on only multiple-choice questions in the online program, with extension to open-ended questions left for offline transfer and extension activities. Therefore, the analysis described in the current paper will focus on the class of questions requiring a selection response.

ANALYSIS OF THE DOMAIN STRUCTURE

The initial analyses (the analysis of target learners' entering repertoires combined with initial content analysis) determined the overall objective of the program: to build the repertoires needed for learners to correctly answer multiple-choice questions across literal/factual, inferential, summative, and derived-meaning/vocabulary question types (see Leon, Layng, & Sota, 2011, for a discussion of program design). We also determined that the reading level of the text in the program would range from mid-second to mid-fourth grade. The next step was to further analyze these skills in terms of the relations that make up the necessary repertoire.

The matrix in Figure 1 displays categories of learning in terms useful for closely analyzing a repertoire in order to design programs to teach it. The columns encompass three broad types of learning: differentiated relations (or psychomotor), discriminative relations (or simple cognitive), and extended relations (or complex cognitive). The rows order these types by complexity—moving from single-skill units in the bottom row to complex combinations of units and sequences of units at the top. Differentiated relations (the leftmost column) refers to relations chiefly involving the execution of muscle movements. The middle column, discriminative relations, includes relations involving specific stimuli and responses, as found in paired associate learning at a basic level and verbal repertoires at the highest level. The rightmost column, extended relations, includes categorical relations as its basic unit and generative repertoires as its most complex. Extended relations involve responses to novel stimuli—for example, those relations involved in abstraction would be considered to lie in the extended relations or complex cognitive column of the matrix (Skinner, 1957; Tiemann & Markle, 1990).

Many types of relations enter into a complex performance such as that demonstrated by what we call reading comprehension. Identifying the relations involved helps to determine what to teach; what not to teach, and instead to assume the learner can already do; and how to teach, in terms of the procedures best suited to the type of learning involved. In designing Head-

1 Analyzing these tests as a starting point was not a judgment of the appropriateness of these tests as measures of reading comprehension. Rather, it was a practical judgment related to the current needs of schools and learners.

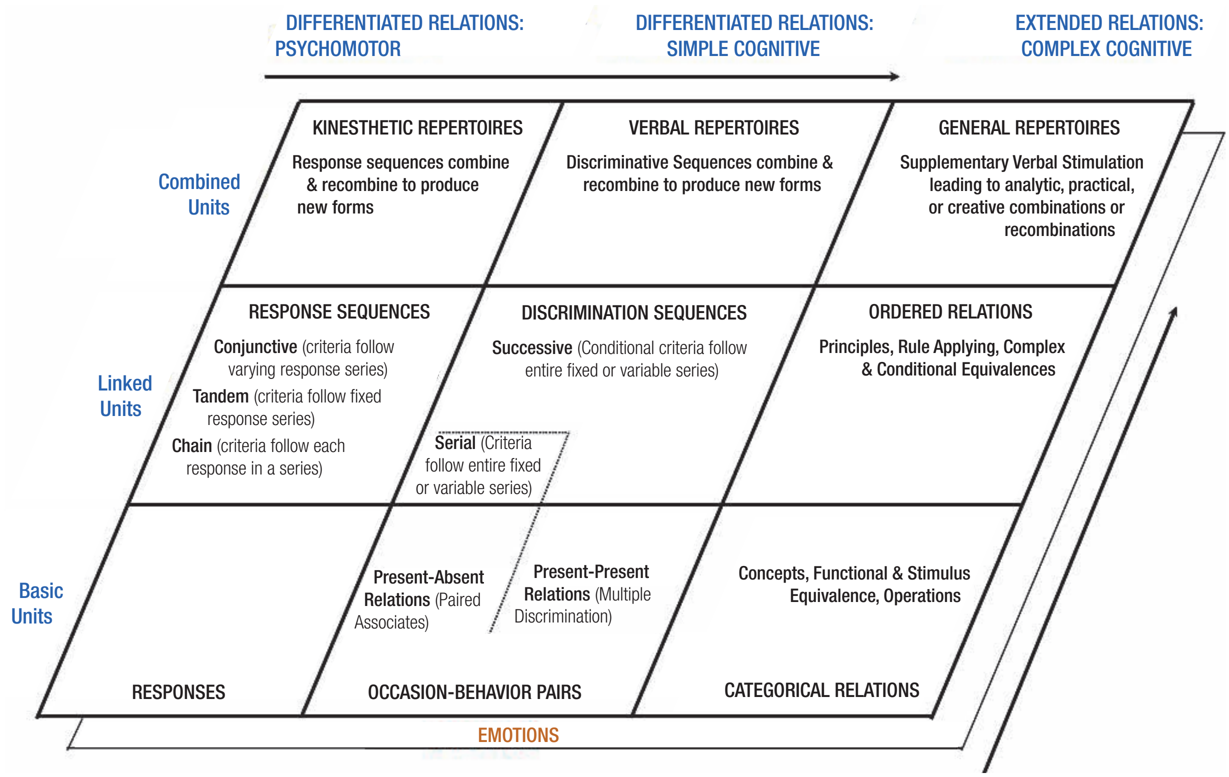

Figure 1. Types of learning as described by Tiemann and Markle (1990) and further refined by Layng (2005, 2007).

sprout® *Reading Comprehension,* we assumed that learners already had a repertoire involving the motor skills necessary to move and click the computer mouse (the input device that would be used with the program). However, discriminative and extended relations are involved in reading comprehension in different ways. Examining these relations and how they enter into reading comprehension is essential to designing programs that will effectively establish the necessary repertoires. The following sections examine each of these areas in greater detail.

Discriminative relations: simple cognitive. The basic units in the discriminative relations column are occasion-behavior pairs. These occasion-behavior pairs are involved in paired associate and multiple discrimination learning.

When occasion-behavior pairs are linked, they form serial or successive discrimination sequences. At the top of the simple cognitive column are verbal repertoires. A verbal repertoire involves a large number of occasion-behavior pairs and sequences of those pairs that combine and recombine in novel ways, but it remains in the simple cognitive column because it is based on specific occasion-behavior pairs. What is tested, in other words, is the same as what is taught (Tiemann & Markle, 1990).

Discriminative relations of major interest in reading comprehension include intraverbal repertoires. By the time learners come in contact with the program, they have extensive intraverbal repertoires as a product of the contingencies set up by their verbal communities. When learners read a passage and a comprehension question about it, changes in response probabilities occur based on stimulus guidance (after Donahoe & Palmer, 2004) developed throughout the learners' history. The ultimate task for us in designing Headsprout® *Reading Comprehension* was to build on and take advantage of learners' current verbal repertoires in a way that increased the likelihood that learners would make correct responses to reading comprehension questions.

Extended relations: complex cognitive. The extended relations, or complex cognitive, column is concerned with extension to novel stimuli.

Categorical relations form the most basic unit of this column. Categorical relations include concepts (Markle & Tiemann, 1969; 1974; Tiemann & Markle, 1990), functional (Goldiamond, 1962; 1966) and stimulus equivalence (Sidman, 1994), and operations (Engelmann & Carnine, 1991). A concept is a class of stimuli, each instance of which shares some properties with other instances of the class while varying across many other properties. The shared properties define the class. Rather than being essentially defined, these shared properties of a class are defined by contingency requirements resulting from the behavior of the verbal community. They are not defined *a priori* except in cases such as the scientific definition of categories. We say that a learner has learned a concept when he or she correctly identifies novel instances of the concept and correctly discriminates between instances that are and are not examples of the concept—that is, when his or her behavior is guided by the same instructional stimuli (S^Di) across changing dimensional stimuli (S^Dd) (see Goldiamond, 1966; Layng et al., 2011). We can classify this as an abstract tact (Skinner, 1957).

Ordered relations form the next level of the extended relations column. Ordered relations include principles (statements of the relationship between concepts) and complex and conditional equivalences.

Generative repertoires are at the top of the extended relations column. This is the level at which creative problem solving occurs—for example, employing strategies that result in new forms in art and science (Tiemann & Markle, 1990).

READING COMPREHENSION AS A COMPLEX COGNITIVE REPERTOIRE (EXTENDED RELATIONS)

Answering reading comprehension questions can be considered a problem-solving task in which two major repertoires are involved: (1) a verbal repertoire and (2) an investigative or strategy (i.e., generative) repertoire. A verbal repertoire is built gradually through years of speaking, listening, reading, and writing. Although a strategy repertoire is also complex, a series of strategies focused on answering reading comprehension questions can be learned relatively quickly and applied to a variety of problem situations. A strategy is essentially an organized procedure or series of general steps to be taken to solve a problem (see Robbins, 2004, 2011, for a more detailed discussion). Building a repertoire of strategies for use in situations in which the learner has to answer a question about what he or she reads can vastly increase the likelihood that the learner—given a passage–question–answer set that overlaps with the learner's verbal repertoire—answers that question correctly (see Layng et al., 2011).

Strategy analyses. Two sets of strategies were identified in analyzing the steps involved in answering reading comprehension questions: a general set of steps that can be applied across all questions and another set of steps specific to the type of question being asked (literal/factual, inferential, summative, or vocabulary/derived meaning). The general steps involve (1) reading the passage, (2) reading the question and possible answers, (3) determining which specific strategy to use based on the question, (4) applying the strategy by looking for specific information in the passage, and, finally, (5) answering the question. The analysis of question types led to the creation of a specific strategy for each type that formed the third and fourth steps within the overall strategy (determining which strategy to use and then applying that strategy). In the third step, the learner asks him- or herself, "What is the question asking me to do?" The answer to this question is a categorization response—a tact—which serves as a supplemental stimulus that occasions the next step in that particular strategy (see Layng et al., 2011; Leon et al., 2011).

The design of specific strategies for each question type was based on concept analyses that identified both (1) the attributes that differentiated one question type from another and (2) the attributes that differentiated a correct answer from an incorrect answer within a particular question type. The former informed programing related to the third step of the overall strategy—determining the type of question being asked and, therefore, which strategy to apply. The latter informed programing related to the fourth and fifth steps of the overall strategy—applying the strategy and selecting the correct response among alternatives. The following sections describe these concept analyses.

Concept analyses. As previously noted, the questions on tests of reading comprehension can be classified as four major types: literal/factual, inferential, summative, and vocabulary/derived meaning. Because questions can be categorized in terms of their type, they can be analyzed as abstract tacts. In concept analysis, instances of the concept are analyzed in terms of their critical features or attributes, or what attributes make the instance an example of that concept rather than a non-example, as well as their varying attributes, or what attributes vary among examples of the concept.

Critical attributes. The critical attributes of each question type are those attributes that make the question one type rather than another. In review, the features include point-to-point correspondence between the words in the answer and the words in the passage (literal/factual comprehension), thematic correspondence between the words in the passage and the words in the answer (inferential comprehension), questions about theme (summative or main-idea comprehension), and questions about the meaning of a word or phrase (derived-meaning/vocabulary comprehension).

When responding is guided by the critical features of the concept, instructional guidance has been established (see Goldiamond, 1966; Layng et al., 2011). Instructional guidance refers to guidance by instructional stimuli ($S^{D}i$)—those stimuli which restrict response alternatives along certain dimensions, making some responses in a learner's repertoire more likely than others. For example, when a learner tacts a question as a vocabulary question, some strategy-specific responses in his or her repertoire subsequently become more likely than other responses.[2]

In addition to the features that distinguish one question type from another, questions were analyzed in terms of what features make an answer to a question correct. Because the focus of the program is on multiple-choice questions, the possible answers and the answers themselves were part of the targeted intersecting stimulus-control topographies, along with the question and the passage read.

Features which make one answer correct were analyzed for each question type. For literal questions and inferential questions, those two features were the same: (1) the answer or answer category must appear in the passage and (2) the answer must meet the requirements specified in the question. Consider the following example:

> Gus was working at the computer. He clicked, but nothing happened. He got worried and went to look for the teacher.
>
> How did Gus feel when he clicked and nothing happened?
>
> A. He turned off the computer.
>
> B. He was a little upset.
>
> C. He was a little happy.

Answer A, "He turned off the computer," has a thematic match with the paragraph. There is categorical overlap with categories such as "computers," "what one does when a computer is malfunctioning," and so on. In fact, turning off the computer could be a correct response to a question asking the learner to predict what the teacher might do or in what other ways Gus could

2 Learners may not be able to describe the instructional stimuli that guide their behavior. For example, a learner may be able to identify those items that are chairs and those items that are not chairs, but may not be able to say why one item is a chair and one is not (see Layng et al., 2011).

Table 1. The critical attributes and a sample of the variable attributes identified for inferential comprehension questions related to the passage–question–answer set. All attributes (both critical and variable) make up the dimensional stimuli. The critical attributes make up the instructional stimuli.

Critical Attributes ($S^{D}i$)			
1. Answer category appears in passage 2. Answer meets criteria specified in question 3. Answer does not have topographic correspondence with words in passage			
Variable Attributes ($S^{D}i$)			
Passage	4. Type a. Narrative b. Expository c. Poetic	5. Length a. One paragraph b. Two–three paragraphs c. Four+ paragraphs	6. Narrator a. First person b. Second person c. Third person
Question	7. Type of characteristic asked about a. Personal quality b. Sequence c. Actions d. Objects e. People/animals f. Places g. Events h. Time	8. Question word a. Why (reason for character's action) b. Why (cause/effect) c. When (temporal) d. When (conditional) e. What f. Where g. Which h. Who i. How (process) j. How (quantity) k. How (thoughts/feelings)	9. Phrasing a. Standard b. Exclusion c. Cloze d. Spatial
Answer	10. Response topography a. Selection b. Construction		

have tried to solve his problem. "He turned off the computer" has a predictive correspondence to the paragraph. The $S^{D}i$ guidance exerted by the thematic match between Answer A and the paragraph increases the probability that the learner will select Answer A.

The question, however, asks how Gus *felt*. The question specifies that the answer falls within the category of feelings. When only the question is considered, either Answer B, "He was a little upset," or Answer C, "He was a little happy," could be correct. Both fall into the category specified in the question.

The desired source of $S^{D}i$ guidance includes a combination of the passage, the question, and the possible answers. Answer B, "He was a little upset," is the correct answer. The category "negative feelings" appears in the passage and meets the criteria specified in the question. "A little upset" is a member of this category of feelings. Answer B has both attributes that make an answer correct. The answer category appears in the passage and it meets the criteria specified in the question. The incorrect answers each lack one of these attributes. The answer category of Answer A appears in the passage, but it doesn't meet the criteria specified in the question. Answer C meets the criteria specified in the question, but the answer category does not appear in the passage.

Variable attributes. In addition to critical attributes, concept analyses also identify variable attributes. Variable attributes are attributes that vary across questions of a particular type. For example, the passage could be a narrative piece, an expository piece, or a poem. It might be one paragraph, two paragraphs, or several paragraphs long. The question could begin with *who, what, when, where, why, how*, or another word. The question could ask about a character's feelings or actions, the time an event took place, the conditions under which something happened, or what might happen next. One sentence from the passage may be sufficient to find or derive the answer, two sentences may need to be combined, or an entire paragraph may need to be considered. Ensuring that these variable attributes are varied across the program is essential in programing for generic extension across novel passages, questions, and answers.

In analyzing concepts, the variable attributes are identified so that they may be varied systematically. This ensures that guidance by the instructional stimuli ($S^{D}i$) is maintained across changing dimensional stimuli ($S^{D}d$) (Goldiamond & Thompson, 1967/2004; Layng et al., 2011). In the case of Headsprout® *Reading Comprehension*, two different aspects of variable attributes were identified. First, there were those attributes which are relevant in establishing instructional guidance by question type. These variable attributes entered into the design of instruction that teaches learners to identify the question type, increasing the likelihood that they will use the correct strategy to answer the question. Second, there were those attributes that vary systematically across passage–question–answer sets. Learners must apply the strategy flexibly to new problems. Although this application is the same in that guidance by $S^{D}i$ is maintained

Table 2. A sample of the variable attributes identified for inferential comprehension questions related to the **relations between** items in a passage–question–answer set.

Passage-Question Relation	11. Degree to which question & passage share characteristics a. Literal b. Interpretive: word/phrase meaning c. Interpretive: sequence d. Interpretive: prediction e. Interpretive: likelihood f. Interpretive: author's purpose g. Interpretive: category h. Interpretive: multi-step	
Passage-Answer Relation	12. Number of sentences in passage needed to derive full answer a. One b. Two c. Three+	13. Degree to which answer & passage share characteristics a. One-category variation: word/phrase meaning only b. One-category variation: sequence c. One-category variation: prediction d. One-category variation: likelihood e. Two+ category variation f. Absence g. If-then determinations/computations

across changing S^Dd, the response is different (i.e., identification of the strategy to use versus application of that strategy to the current problem).

The variable attributes include attributes of the passage, the question, and the answers, as well as attributes of the relations between the passage and question and the passage and possible answers. Tables 1 and 2 list the critical attributes and some of the variable attributes identified for inferential comprehension questions.

Let's take a closer look at the previous example:

> Gus was working at the computer. He clicked, but nothing happened. He got worried and went to look for the teacher.
>
> How did Gus feel when he clicked and nothing happened?
>
> A. He turned off the computer.
>
> B. He was a little upset.
>
> C. He was a little happy.

In this example, the passage is one paragraph long, it is a narrative, and it is written in third person. The question is a "how" question about feelings, and it is written in a standard format (i.e., it begins with a question word and ends with a question mark).

Now, let's look at the passage–question and passage–answer relations. In this question, there is a topographic correspondence between some of the words in the question and words in the passage. Learners read "when he clicked and nothing happened" in the question and can find those exact words in the passage. This makes it a "literal" inferential question in terms of the question–passage pair (note that it is an inferential question based on the answer not sharing a one-to-one topographic correspondence with words in the passage). Two sentences are required to derive the full answer, and the category of the answer overlaps with the category of the relevant portion of the passage in terms of word meaning: "He was a little upset" and "He got worried."

Now consider the following, slightly modified, set. The passage and answers are the same, but the question has changed:

> Gus was working at the computer. He clicked, but nothing happened. He got worried and went to look for the teacher.
>
> How did Gus feel when his mouse didn't work?
>
> A. He turned off the computer.
>
> B. He was a little upset.
>
> C. He was a little happy.

Here, the learner follows the same strategy—the same general set of steps. However, these steps must be modified from the ones taken in the previous example. Nothing in the passage explicitly states that Gus's mouse failed to work. The question is interpretive (see Passage-Question Relation in Table 2). That is, the learner must locate words in the passage that are related to "when his mouse didn't work." In order to do so, the learner must apply the steps of the strategy flexibly to the new problem.

BUILDING VERBAL REPERTOIRES

So far, the analysis described has focused on strategies. Of course, in order to answer a comprehension question correctly, the learner's verbal repertoire must have extensive overlap with the text (see Layng et al., 2011). Regardless of a learner's ability to apply reading comprehension strategies, for instance, the likelihood of the learner answering a question correctly if the passage, question, and answers were presented in an unfamiliar foreign language would be very low.

Building a verbal repertoire is an extensive and ongoing task.

Table 3. Relations involved in vocabulary.

Type of Relation	Example
Discriminative	
Paired Associates	S^D: word Response: say/write/select definition
Extended	
Stimulus Equivalence	S^D: word Response: select definition
	S^D: definition Response: select word
	S^D: word Response: select picture
	S^D: definition Response: select picture
	S^D: picture Response: select word
	S^D: picture Response: select definition
Concepts (abstract tacts)	S^D: example including critical features of the concept S^Δ: non-example lacking one or more of the critical features Response: identify examples

In designing Headsprout® *Reading Comprehension*, we felt it was important to build learners' verbal repertoires in addition to strategy repertoires and, also, to ensure that we provided the necessary help on occasions where the text presented did not overlap with the learner's repertoire. The following sections describe the analysis that formed the basis of programing designed to build and take advantage of learners' entering verbal repertoires.

To teach vocabulary effectively, several different issues must be considered. First, what is meant by "vocabulary?" What does it mean to know a word? The relations one is after must be specified. Table 3 presents a list of relations produced by an analysis of vocabulary, in terms useful for the programing of vocabulary instruction.

DISCRIMINATIVE RELATIONS.

Paired Associates. Words and their definitions may simply be occasion-behavior pairs. Upon seeing the word, the learner says or selects the definition. When the definition is only associated with that word, the word-definition pair remains a single paired associate. Upon the occasion of the word, the definition is said or selected. However, words in the definition may enter into many other relations already in the learner's repertoire (for example, intraverbal relations and tactual relations). It is these relations which allow a program to telescope (Goldiamond, 1966) a learner's history and rapidly establish guidance by a new word.

EXTENDED RELATIONS.

Stimulus Equivalence. Stimulus equivalence refers to the emergence of arbitrary relations which are not directly taught (see Figure 2). For example, if a learner learns to select a definition (B1) upon seeing a word (A1), and then selects the word (A1) upon seeing the definition (B1), the relation between the word and the definition shows *symmetry*. If the learner then learns to select a picture (C1) upon seeing the definition (B1) and as a result then selects the picture (C1) upon seeing the word (A1), the relation between the word and the picture shows *transitivity* (Sidman, 1994). The stimuli and responses that make up an equivalence class are arbitrary. That is, the stimuli gain their relation to one another from the pairing procedure, not from shared features. The contingency defines the class, and the relations arise out of associations between dimensional stimuli.

Concepts. The concept (or abstract tact) is a relation in which cer-

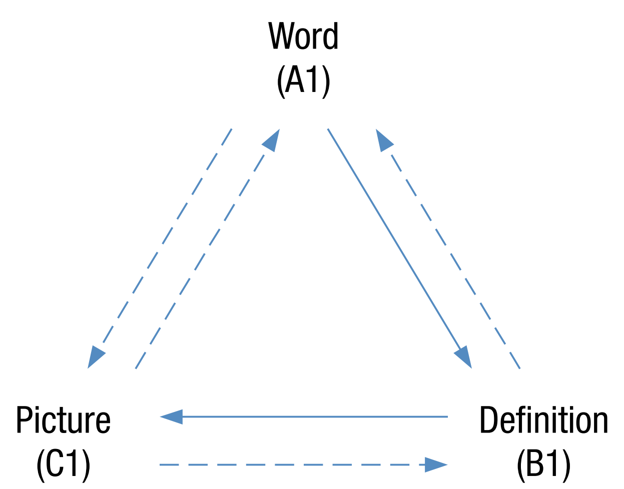

Figure 2. Relations involved in stimulus equivalence among a word, definition, and picture. Solid lines indicate taught relations, while dotted lines indicate emergent relations.

tain features of a stimulus (critical or defining features) guide the response to that stimulus, while other features vary. In the presence of a novel instance of the concept, responding guided by the presence of these critical or defining features would be reinforced. In the presence of a stimulus that lacked one or more of these features, responding in the same manner would not be reinforced. After a program of this type, if a learner responded to new stimuli that included the critical features and not to stimuli that lacked one or more of these features, the behavior would constitute an abstract tact and would be under the instructional guidance of the critical attributes.

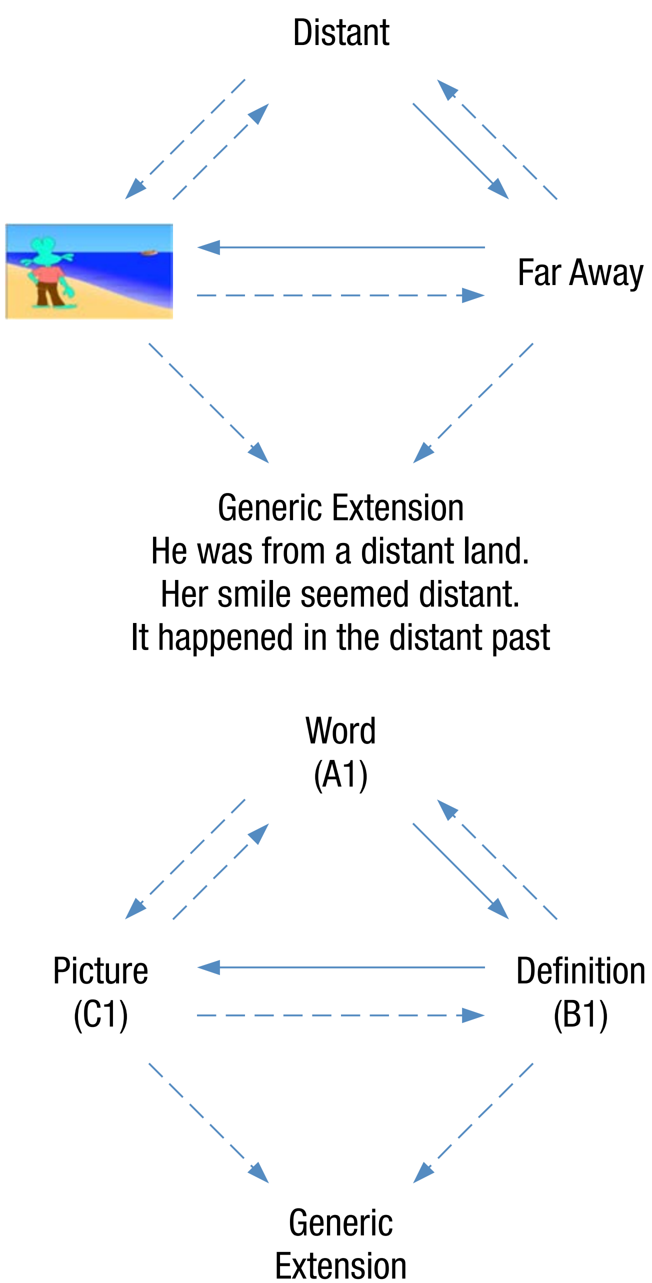

Figure 3. An illustration and example depicting potential generic extension as a result of a stimulus-equivalence procedure that includes a picture and definition already in the learner's repertoire.

Combinations of Discriminative and Extended Relations. Pairing a word and a definition can have a substantial effect on the learner's repertoire if the words in that definition enter into other relations within the reader's repertoire (see Figure 3). When they do, teaching a definition increases the likelihood that the target vocabulary word also then enters into these relations. For example, if the word is an abstract tact, and the words in the definition are already part of the learner's repertoire (i.e., the words in the definition already guide responding by the relevant instructional stimuli), then pairing the word and the definition can tap into the instructional guidance that already exists. When the abstract tact is part of a conceptual network including superordinate and subordinate concepts, defining the new concept in terms of an already established superordinate concept can allow the learner to respond to the new concept in terms of the features of its superordinate category. For example, classifying a new animal as a "mammal" within a definition allows features of mammals to guide responding to the new animal (Markle, 1978).

Figure 3 displays stimulus-equivalence relations, with potential relations resulting from generic extension based on the definition and the picture included in stimulus-equivalence training. For example, imagine that the target vocabulary word is "distant." The definition (likely to be in the learner's verbal repertoire) is "far away." The picture illustrates both "distant" and "far away" in a scene that is likely to be familiar to the learner. Both "distant" and "far away" tact the same relation—specifically, a difference between two points that is measured as greater relative to some standard. This difference is illustrated by the picture. Properties among instances of this concept also vary. "Far away," for example, can tact the relation between two points in space, time, or social relations.

To the extent that the features that define a concept enter into relations with already-known words, the concept itself is not completely "new" to the learner. In addition, to the extent that definitions and pictures overlap with the learner's entering verbal repertoire, stimuli that enter into equivalence relations are not necessarily new. Therefore, instruction can be designed to test for, extend, and refine relations rather than build entirely new relations from scratch. This is an important distinction to make, as it ultimately guides the programing involved in building the verbal repertoire. Where the learner's verbal repertoire can be utilized in the program, it can be extended and reorganized with a minimum of instruction. Where the verbal repertoire cannot be utilized (for example, in the case of certain scientific concepts for which learners have a less established, or no, entering repertoire), instruction would need to be very different if the targeted outcome was establishing a tactual relation rather than a paired-associate or equivalence relation.

CONCLUSION

Analyzing a repertoire for the purpose of designing instruction begins with determination of the overall goal or objective of instruction. This goal or objective is then further analyzed in terms of the relations that make up the necessary repertoire. In the case of reading comprehension, two integrated repertoires were identified and analyzed: a verbal repertoire and an investigative (generative) repertoire. These repertoires are made up of both public and private events, such as those which we typically call "thinking" (Layng et al., 2011). Further analysis identified the discriminative and extended relations involved in each of these repertoires.

Although the current paper has focused almost exclusively on analysis of content, it should be clear that analysis of learners' entering repertoires is also essential to programing instruction. Instruction must start from where the learner is (the learner's current repertoire) and bring that learner to where he or she needs to be (the goal of the program). Analysis both of learners' entering repertoires and the content served as the basis for this programing, which is described in the next paper in this series (Leon et al., 2011).

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