The Writing Response in Studies of Topography-Based and Selection-Based Verbal Behavior

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THE WRITING RESPONSE IN STUDIES OF TOPOGRAPHY-BASED AND SELECTION-BASED VERBAL BEHAVIOR

Osborn Cresson, Ph.D.
Western Michigan University, 1994

The position taken in this paper is that the observable world is the only one needed in our analysis, that behavior is a reaction to the environments in which it occurs, and that language is more behavior that can be studied effectively as a dependent variable that varies as a function of independent variables manipulated by the experimenter.

Our goal was to study topography-based and selection-based verbal behavior with emphasis on the writing response and then to produce a report that would serve as a guide for other students of behavior and environment.

Sixteen undergraduate college students participated in 115 sessions. They learned an artificial language consisting of 16 classes, each made up of a nonsense syllable, a visual pattern and a Japanese Katakana symbol (written or selected). The instruction was accomplished with simple, table-top methods available to anyone.

Topography-based tasks resulted in fewer errors than selection-based tasks in nine of 11 stages of the experiment. The acquisition stage yielded statistically significant comparisons but not the later review and testing stages. During training there were also significant differences due to several confounding variables such as the phases of the experiment, the sequence of instruction and the sensory modes employed.
These results provided a basis for discussion of the general features of topography-based and selection-based verbal behavior as well as implications for education and suggestions for future studies.

The report ends with a message to the student: we need people who play with behavior (B) and environment (E), with the ongoing stream of BEing as revealed by experiment. Early scientists took the motto, "Nullius in Verba" which they translated as "Take nobody's word for it; see for yourself." (Boorstin, 1983) As the wise man said, "Know what is in thy sight, and what is hidden from thee will be revealed to thee." (Jesus, quoted by Thomas Didymos, in Guillaumont, Puech, Quispel, Till, & Abd al Masih, 1959)
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The writing response in studies of topography-based and selection-based verbal behavior

Cresson, Osborn, Ph.D.

Western Michigan University, 1994

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First of all, this dissertation is a response to environments created by my parents, Osborne Coates Cresson and Rebecca Shannon Cresson, my other relatives, and many friends and neighbors in Monteverde, Costa Rica and Kalamazoo, Michigan.

A great deal of help was received from the students and staff in the schools I attended. Especially important were the environments arranged by my science teachers: Mr. Moore, Donald Kingsbury, Clayton Farraday, William Stephenson, Hugo Moser and William Ulrich.

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To all of you, and to anyone else who helped provide the occasion for writing the words that follow: this reinforcement is for you!

Osborn Cresson
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INTRODUCTION

The Analysis of Verbal Behavior

The position taken in this paper is that the observable world is the only one needed in our analysis, that behavior is a reaction to the environments in which it occurs, and that language is more behavior. What our students say and how they write and how they respond to what we say can be treated effectively as a dependent variable that varies as a function of the independent variables manipulated by the experimenter. In what sense treated effectively? We will categorize language behavior and study it in a standard environment that permits precise demonstrations of how it is learned and remembered and extended to novel situations.

Our goal, then, is to design a study of verbal behavior and describe it in a way that helps other students of behavior. To start with, what does the traditional approach offer?

Traditional Treatments of Language

Most people who talk about language, professional and amateur alike, do so in ways that specifically contravene the precepts of behavior analysis. Consider these features that are characteristic of traditional treatments of language:

They rely on circular definitions; for instance, in one dictionary knowledge is defined in terms of information which itself is defined in terms of knowledge and communication which in turn is defined in terms of meaning whose definition refers back to communication. (Webster's New Collegiate Dictionary, 1969)
Language is a question of passing meaning, ideas, knowledge or information from one person to another. Words are held to contain meaning (the dualism of structure and content). We are said to make mental representations of reality. Words have referents: they are substitutes for what they represent. Words are like tools; they are linguistic devices we use in language. Memory is treated as a type of a filing system: messages are something we receive, encode and store; later we search, retrieve, decode and read this stored information.

The treatment of language is otherworldly; it emphasizes concepts that are not observed such as mind, idea and consciousness. Traditional approaches are concerned with what is behind what we see, with something that requires a different set of terms and a different analysis than the ordinary observable world; there is a hypothetical, metaphorical inner person operating with representations of the outer world.

Speakers are treated as autonomous agents: a speaker selects, chooses or composes what will be said. Speaking and listening are held to represent the same underlying process, as do speaking and writing, pointing to a symbol and making a sign and so on. Traditionally, all this is said to be the product of a special physiological capacity that is uniquely human; it is the defining characteristic of our humanity. Language is beyond behaviorism because it is covert and cannot be observed, it is creative and thus inexplicable, it is much more than what we see or hear, it is the inferences and insights and emotions that it evokes, it is common across cultures thus there is a physiological basis inherent in the human genome, it shows purpose and behavior analysis is not adequate for that, it cannot be treated in an artificial laboratory setting, it requires a special analysis that goes beyond that of stimulus and response.
We see that the traditional approach thus involves the specific rejection of the behavioral position; it is a catalogue of what we oppose and are struggling to confront in education and psychology and in society in general.

We need a fresh approach and for that we need a special vocabulary.

A Vocabulary for the Study of Verbal Behavior

The words or phrases we will define are behavior, environment, behavior analysis, verbal behavior, selection-based and topography-based verbal behavior, verbal operants, discrimination, acquisition, retention, generalization and equivalence.

Behavior is anything an organism does, its motions and actions. We know of this behavior because it affects us directly or it affects the environment which affects us. What an organism does happens in a context; ours is a functional analysis in which behavior is treated as a function of environment.

Environment is anything that affects an organism, that can be shown to control some of its behavior. Controlling environments can be considered as coming before or after the behavior (although the consequences are really antecedents for a later repetition of the same behavior). These antecedents and consequences that do not control behavior can acquire it through pairing with other antecedents and consequences.

Behavior analysis is the study of the relations of behavior and environment, the systematic formulation of general principles that are effective in the prediction and control of behavior. Although we speak of particular bits of behavior (B) and environment (E), we are dealing with ongoing chains of E which control B which produces E: behavior analysis is a science of BEing, particularly human BEing.
Verbal behavior is established by social convention. It is behavior reinforced by people specifically trained to behave in this way so as to reinforce verbal behavior. Several other characteristics are commonly considered special signs of language: it is often a very large collection of relations, there are multiple connections among the language elements, and the behavior is called creative in that it appears in novel combinations.

In this paper the word "language" is used as a synonym for "verbal behavior." The problem with the traditional term is that it ignores the role of the environment and is inevitably wedded to the traditional approach that is inimical to the behavioral program. "Stimulus" and "environment" are also synonyms, as are "behavior" and "response."

There are two main types of language. In topography-based (TB) language, a characteristic response is made in the presence of a characteristic stimulus (as in answering an essay question). In selection-based (SB) language, a general response is made in the presence of two or more characteristic stimuli (as in pointing to the answer on a multiple-choice exam). These two classes of verbal behavior are compared in the experiment reported below. More discussion of this important distinction follows on page 8.

The elementary verbal operants are the different possible combinations of verbal and nonverbal controlling variables and responses that together constitute language (Michael, 1993, pp. 95-97). Each type of elementary relation appears in a topography-based and a selection-based form. Three of these relations concern us here: (1) in tacts the stimulus is nonverbal and the response verbal (e.g., writing or pointing to "WATER" in the presence of a picture of water), (2) in intraverbal relations both the stimulus and response are verbal (e.g., writing or pointing to "WATER" in the presence of the auditory word "water"), and (3) in duplic behavior
the stimulus is verbal and the response product has the same form as the stimulus; specific types are echoic behavior (e.g., saying "water" in response to the auditory word "water") and copying a text (e.g., writing "WATER" in the presence of the visual word WATER). We will also study manded stimulus selection, an operant that is closely related to verbal behavior. In this case the stimulus is verbal and the response is pointing to a nonverbal stimulus (e.g., pointing to water in the presence of the auditory word "water"). The remaining verbal operants, not involved in the present experiment, are various kinds of codic behavior in which the verbal stimulus and response product share point-to-point correspondence but no formal similarity and mands in which the verbal response is controlled by a motivational variable.

Discrimination involves stimuli that evoke behavior because the effective consequences were different in the presence than in the absence of the stimulus. In conditional discrimination the control exerted by one stimulus depends on the presence of another stimulus. SB language is conditional in this sense (we point to water and not to food when we are thirsty). The control in TB verbal behavior is often simple and not conditional (saying "water" when we are thirsty) but conditionality can be added (saying "water" when we are thirsty only if someone is there to get us a glass of water, or saying it in English or Spanish depending on our audience).

Acquisition, in this paper, means the establishment of controlling relations and it is measured by total number of errors, percent correct or errors to criterion.

Retention, in this paper, means performance on a test after an interval of time has elapsed since the last training sessions. It is measured by number of errors or percent correct on the test.

Generalization refers to behavior under conditions that were not present during training. There are two examples of this in the experiment described here.
Generalization across response modalities involves training someone to point to a word and then testing whether they can write it, and vice versa.

The other kind of generalization we will deal with involves the combinations of tasks that demonstrate equivalence relations. These are stimulus-response relations that are not directly taught but come about as a result of training on other tasks. The relations we will deal with are called symmetry, transitivity and reflexivity (Sidman & Tailby, 1982). First we teach the student, when shown a member of set A, to point to the corresponding member of set C. Symmetry is demonstrated if the student, with no additional training, when shown a member of set C points to the corresponding member of set A. We can also teach the same student, when shown a member of set B, to point to the corresponding member of set C. Transitivity is demonstrated if the student, with no additional training, when shown a member of set B points to the corresponding member of set A or vice versa. (In this example of a transitive relation the common component is the comparison stimulus pointed to; there are other transitive relations in which the common component is the sample stimulus in the presence of which a comparison stimulus is selected, or the common component can be a comparison stimulus in one task and a sample in the other.) We can also teach the student, when shown a member of set A to point to another example of that member of set A instead of members of other sets. Reflexivity is demonstrated if the student, with no additional training, does the same thing with sets B or C. The corresponding members of sets A, B and C are said to form equivalence classes if symmetry, transitivity and reflexivity have all been demonstrated. These relations have been extensively researched, notably in the work of Murray Sidman (e.g., Sidman, 1971b; Sidman & Cresson, 1973; Sidman, Cresson & Willson-Morris, 1974).

Functional equivalence refers to stimuli that control the same response and then are treated as members of the same class. First we teach the student, in the
presence of a member of set A, to emit a characteristic response and to emit the same response in the presence of a member of set B. Functional equivalence is demonstrated if the student, with no additional training, when shown a member of set A points to the corresponding member of set B or vice versa.

Equivalence is important in education because so much can be accomplished by adding a new stimulus-response relation to a verbal repertoire. For instance, I count 40 tasks that involve the auditory, vocal and written forms of the word SHOE as well as pictures, nonverbal actions and verbal actions related to shoes (all of these taken as stimuli or responses). If you are taught one new relation (e.g., pointing to SHOE in the presence of ZAPATO), then 33 other tasks snap into place with no additional instruction (you can say "ZAPATO" when you want a shoe and so on). The equivalence literature offers many examples of this sort of extension, such as teaching 16 tasks and observing 112 additional relations that had never been reinforced (Saunders, Saunders & Spradlin, 1990) or, in a study of conditional ordering responses, the emergence of 120 indirectly trained stimulus sequences from 8 trained sequences (Wulfert & Hayes, 1988).

It turns out that most of what we know was established indirectly by the extension of the effect of instruction to new relations not involved in the original training. Just as the mechanical advantage of a pulley multiplies our muscular power, equivalence provides a teaching advantage that multiplies our educational power.

This, then, is how we will talk about verbal behavior. The concepts are operationally defined. Our verbal behavior about verbal behavior is limited to what we observe and nothing else.

That said, we now consider the topic that we will study.
Comparing Topography-Based and Selection-Based Verbal Behavior

The Two Basic Classes of Verbal Behavior

All verbal behavior may be classified in two main categories. Topography-based tasks involve a response that is different in every linguistic instance; the person makes a characteristic motion in response to a stimulus. Selection-based tasks involve pointing to a verbal stimulus; the response itself is a general one and is not characteristic of the two stimuli in the presence of which it occurs (Michael, 1993, pp. 105-108).

In either type of language a linguistic example will have two characteristic features: a stimulus and a response in the TB case or two different stimuli in the SB case.

Some Examples

Examples of topography-based verbal behavior include speaking, writing and signing. In education, answering an essay question is an example of TB responding.

Examples of selection-based verbal behavior include using a communication board or finding items in a supermarket that correspond to one's shopping list. An artist selecting a tube of paint by the label is matching a name and a color (or the product of a response to a color). In education, multiple choice questions are SB.

SB responding is a conditional discrimination and simple TB behavior is not, but layers of conditional control can be added to either type of verbal behavior. For instance the basic task of map reading can be TB (when it leads to speaking) or SB (when followed by pointing in the presence of the visual stimuli of a road intersection). Extra levels of conditional control enter the paradigm when you add
road signs that control responses to the other stimuli, or motivational stimuli or audience control (is there reason to lie or to respond in Spanish instead of English?).

There are some behaviors that fall in a gray area between the two categories, either because we don't know what is actually happening or because both kinds of relation are present, such as typing (that may be under the control of the position of the key or the letter that is inscribed on it) or tactile behavior (in which a person selects a stimulus after making characteristic exploratory motions).

Traditional Treatment of This Issue

One of the first steps in bringing a behavioral analysis to such complex topics as language is to provide operational definitions of traditional terms. The examples above are often called productive (TB) and receptive (SB) language. The problem with these words is that they are not defined in terms of observable behavior and environment, do not treat behavior as a function of environment and are inextricably linked with treatments of language that are contrary to the behavioral approach as described in this paper. The distinction is often given as active vs. passive, but obviously both types of language involve activity on the part of the organism. Productive language involves reception and receptive language involves expression. These words need to be defined in terms of what is happening and the situations in which it happens.

The words productive and receptive could be defined operationally, but unfortunately they are too closely tied to the whole traditional program. Productive has to refer to an autonomous inner agent. Receptive implies a receiving screen observed by this cognitive homunculus. To see the metaphysical roots of these words just ask yourself, "What is expressed or received?" The answer is "ideas" or
"information" or "the meaning of words." These are not neutral terms. If we simply translate them people will say the right words for the wrong reasons. It is better to invent new terms that do not feed bad intellectual habits.

The traditional view is that both SB and TB language represent the same underlying linguistic processes and it is SB. TB behavior is really a question of an inner person selecting a stimulus from storage (thinking of the answer) and then copying it (writing the answer you have thought of). The TB task is a SB task that has been moved from the table-top into the mind.

Another common feature of the traditional analysis is that it treats language similarly from the perspective of the speaker and listener (which is logical enough if language is defined as the transmission of information). Thus it is irrelevant whether the verbal stimulus for the listener is a visual word pointed to or the same word spoken. The behaviorist views behavior from the standpoint of the individual behaving, so TB and SB verbal behavior are very different.

The Differences Between TB and SB Verbal Behavior

There are at least eight differences in these two classes of language that might be relevant to variables such as acquisition, motivation, confusion among controlling stimuli, and so on. For this analysis I am indebted to Jack Michael (1993), Ellen Shafer (1993), and Carl and Mark Sundberg (1990, 1993).

1. In TB language one stimulus controls the response. In the SB case the control is conditional; which stimulus controls depends on another stimulus.

2. In TB language there is a point-to-point correspondence between the response and the response product that serves as a stimulus for the listener. In the SB
case the specific muscular activity is largely irrelevant to the listener. Many types of response may designate the second stimulus.

3. SB language requires effective scanning behavior. It can only be accurate if all the stimulus options present at any one time participate in the control of the response. There is no comparable feature of TB language.

4. SB language requires material support such as a set of stimuli to point to or a computer. TB language can be emitted without such support. There is an effort underway to develop SB stimuli that are easy to use, portable and limited to specific situations (such as shopping or eating breakfast). Computers may also be useful in this regard.

5. There is a difference in the response-produced stimuli that are available to the person behaving. In SB language the discriminative stimuli after each response are the visual stimuli associated with the picture or object indicated (all other stimuli are not differentially related to the response). In the TB case the visual stimuli are produced by the behaving person's body movements and there are proprioceptive and kinesthetic accompaniments.

6. SB procedures allow an overt response as the incorrect comparison stimuli are excluded (holding a finger against them, moving them, and so on). In the TB case the exclusion is done covertly.

7. TB languages have an advantage when the task involves a long delay between the presentation of the first stimulus and the second stimulus (in SB) or characteristic response (in TB). This is because the TB response can be used to mediate the delay interval, an option not available in the SB case.

8. SB languages have an advantage when computers are used in education because it is difficult to get a computer that responds to the student's TB responses (spoken, written or signed).
Why the Distinction is Important

These are the two basic classes of verbal behavior. They are very different and it is reasonable to expect that one or the other might have an advantage and this might vary with the conditions (Shafer, 1993; Sundberg, 1993).

This issue is especially important for students who have problems learning. This can include students who are developmentally disabled, very young or old, with histories of drug use (including alcohol, nicotine and caffeine), stressed, distracted, under aversive control and so on. Many student variables can interfere with language performance and in these circumstances the difference between SB and TB verbal behavior may be very important.

The search for effective teaching methods requires the analysis of these two primary classes of verbal behavior.

The comparison of these two forms of language is also relevant to the question of whether they represent one underlying process as the cognitivist would have it. The traditionalists would be comfortable with no or little difference in the two performances and would have to stretch their arguments to account for large differences.

Research Comparing These Two Classes of Verbal Behavior

TB and SB verbal behavior has been the topic of a series of studies done at Western Michigan University during the last four years. There are only a few other articles on this issue in the behavioral literature. A list of references to this work is found in Appendix I.

Carl Sundberg's thesis compared acquisition of the following four tasks (with developmentally disabled subjects): signing in response to an object or a sound, and
pointing to a symbol in the presence of an object or a sound (Sundberg, 1990; Sundberg & Sundberg, 1992). The two TB tasks combined to allow an equivalence test, which was pointing to the object in response to the sound. The SB tasks, run with different stimuli, did likewise. Sundberg found that the TB tasks were easier to learn and provided the basis for a better equivalence performance.

Riad Wraikat repeated this with seven subjects and got the same results (Wraikat, 1991a). For his dissertation he developed a method to address the loss of subjects for whom the tasks were too easy or too difficult — he adjusted difficulty by varying the number of stimuli in each set (two or three) or mixing training and already trained trials to provide acquisition data (Wraikat, 1991b; Wraikat, Sundberg, & Michael, 1991). His results also showed that TB language was easier to learn than SB language and led to better performance on equivalence tasks.

Sundberg and Wraikat used simple stimuli presented across a desk. The next two studies were done with subjects working on Macintosh computers programmed for these experiments with Hypercard software.

Matthew Stratton asked whether the number of classes established during training (five or 20) would affect the performance on TB and SB tasks (saying a Japanese word or pointing to a Kanji symbol in the presence of an auditory English word) (Stratton, 1992). College students were used as subjects. No equivalence testing was possible because only one task was taught to each student (a cross-groups design instead of the within-subject design of the earlier studies). The results were somewhat surprising. When only five stimuli were used both tasks were learned at about the same rate, but when the stimulus set included 20 stimuli the SB task was easier to learn than the TB task.

Robert Wallander speculated that the SB task in Stratton's study was made easier because many of the visual Kanji symbols could be construed as looking like
the objects represented by the English words used as samples, whereas in the TB case no mediating association was possible between the auditory English and vocal Japanese sounds (Wallander, 1993). For instance one word was "turtle" and it was not hard to imagine that the associated Kanji symbol looked like a turtle. To check this Wallander gave college students SB tasks in which the visual sample stimulus was either a familiar English word or an unfamiliar Katakana symbol (the comparison stimuli in both cases were Kanji symbols). Acquisition was better when the task involved a familiar stimulus. (Again, equivalence was not tested because no one student received both kinds of instruction.)

Barry Lowenkron has written about the possible basis for SB nonidentity matching and for the emergence of indirectly taught behavior. His position is that there must be a characteristic response under the joint control of the SA and the CO. Thus, SB verbal behavior would be TB at the covert level. (Lowenkron, 1991; Lowenkron & Colvin, 1992).

Reviews of the TB versus SB research have been published by Ellen Shafer (1993) and Mark Sundberg (1993). They emphasize practical considerations for the teacher seeking teaching methods that suit the student. The authors give many variables to be considered such as the student's motor skills and prerequisite skills, the degree of iconicity in the symbols, the possibility of arranging the visual stimuli conveniently and so on. The experiment described in the present report focuses on the control at work during TB and SB responding rather than the application of this in the classroom (although some implications for education are discussed on p. 97).

There is a large traditional literature on productive versus receptive language but it is difficult to interpret. The studies are cast in a vocabulary rich in traditional allusions and short on operational specificity. They usually look for relationships...
among global measures of language arts rather than studying particular instances of verbal behavior. Consider this comment by Jolly (1980):

Reading and listening...are both receptive skills through which information comes to the person. On the other hand, speaking and writing are productive skills through which information goes out from the person. It makes sense intuitively that reading and listening skills should reinforce each other and writing and speaking skills should reinforce each other. In addition, it seems reasonable to suppose that there might be some relationship between the receptive and productive skills. Although it has regularly been shown that high abilities in the various language arts skills of reading, writing, listening, and speaking frequently go together, the literature is much more mixed in discussing causality. It is not clear, for example, that learning listening skills will make students better readers; nor is it clear that reading more helps improve students' writing. While it would seem that improving one language arts skill would have a positive effect on the other skills, researchers have not been able to demonstrate these relationships conclusively, though some researchers and some teachers have reported such an effect in their experience (pp. 664-665).

There are several studies in the behavioral literature that compare what can be called receptive and productive behaviors. Generalization from production to reception was more successful than the reverse (Keller and Bucher, 1979). Bucher and Keller (1981) studied some conditions affecting transfer from receptive to productive tasks. Bucher (1984) taught children to speak a word in one language in response to an auditory word in another language and then he tested for transfer in the direction opposite to that trained (using familiar English words and unfamiliar nonsense syllables). Backward transfer was better when the training involved an English stimulus and a novel response than vice versa. Guess (1969) and Guess & Baer (1973) showed that receptive training did not necessarily lead to productive speech (although their developmentally disabled subjects had not been trained to emit spoken responses before they were required on the tests). Lee (1981) also found functional independence in the productive and receptive repertoires of retarded subjects, but other studies have shown the emergence of indirectly taught oral naming
Robert Stromer (1991) concluded, "The variables responsible for broad-based learning outcomes from training either receptive or productive performances are largely unknown."

Thus, comparison of TB and SB language is a fruitful area of research. How might the topic be usefully extended? Most of the previous work has used signing or oral naming as the TB response. What about another type of TB responding, one that is particularly important in our lives? What might be the role of writing in studies of TB and SB verbal behavior?

Writing and Human Culture

Writing is a critical behavior in the history of our culture and in our histories as individuals. Without writing our culture would be limited to the knowledge we can pass on orally and we as individuals would be limited to the time and place we live.

Writing is verbal behavior that produces visual verbal stimuli. It can be part of any of the elementary verbal operants, whether tact, mand or a relation that is intraverbal, codic or duplic. In education, writing is one of the three main goals of early education; it is even central to learning the rest of the "Three R's" ('riting helps us learn to read, and an important part of 'ithmetic is 'riting numbers).

Behavior Analytic Research on Writing

A survey of the behavioral literature produced 30 articles that involved the writing response. Comments on each of these will be found in the annotated bibliography in Appendix H. Four of the articles were on techniques for shaping the response topography. In 12 of them writing was the dependent variable (usually in a
generalization test after SB training or as one of the tests in an equivalence paradigm.) Two studies employed writing as the independent variable and in one case it was part of the setting. There were eight publications involving the writing of whole sentences or passages, one article on writing theory and two on its application in the classroom.

This survey of the behavioral literature also turned up 62 articles on topics related to our study of writing. These are listed in Appendix I under six headings: TB versus SB verbal behavior (these articles are described on pp. 12-14), constructed-response spelling (a SB version of writing also called anagram naming, it involves moving letters into position to construct a word), sequencing behavior, functional equivalence (in which a stimulus class is formed when two stimuli control the same response), naming and signing.

Considering the importance of writing in our culture and our lives, it has been the topic of relatively little research by behavior analysts.

This, then, was the topic of the experiment reported in this paper: using the writing response in comparisons of TB and SB verbal behavior.

An Overview of the Experiment

TB and SB verbal behavior were compared with the arrangement of tasks shown in Figure 1. It was modeled on that of Sundberg (1990) and Wraikat (1991b). The TB tasks involved writing something in the presence of a stimulus called the sample (SA). The SB tasks involved pointing to one of an array of comparison stimuli (CO) in the presence of a SA. The stimuli in this experiment were labeled A (visual quilt patterns), B (auditory nonsense syllables represented by consonant-vowel-consonant trigrams), C (Japanese Katakana symbols written by the S) and D (Japanese Katakana symbols pointed to by the S). Subjects received TB training (writing
symbols in the presence of either sounds or patterns) or SB training (pointing to symbols in the presence of either sounds or patterns) and then equivalence testing (pointing to the patterns in the presence of the sound) and generalization testing (the SB version of the TB training tasks or vice versa). Training was done with reinforcement (praise) or correction (repetition in the presence of a cue) and testing was done without any differential consequences. Next, the subjects were given the other two training tasks (with other subsets of sounds, patterns and symbols) and tested again. Finally, all four training tasks were reviewed and a test was given that incorporated all the training and test tasks given previously.

From the viewpoint of a behaviorist, what general methods would be appropriate for this experiment?

Methods for the Study of Verbal Behavior

The methods suited to our behavioral program will be considered with specific regard to the experimental design, the subjects, the apparatus and the procedures.
The Experimental Design

We concern ourselves with the behavior-environment relations of individual organisms. If we compare what a student does before and after the application of the independent variable the result is a study of individual subjects who serve as their own controls. Comparisons are made between groups of subjects who were exposed to slightly different procedures to see if these confound the comparison of TB and SB instruction. When such secondary effects are present we rely on comparisons between groups of subjects that are similar with regard to the confounding variables but different with regard to the type of instruction.

Our analysis of the pattern of behavior-environment relations can be guided by a common sense exploration of the possibilities rather than speculation about hypotheses that we then test. This is one of the many ways in which a behavioral approach is down-to-earth instead of theoretical.

The Subjects

Our goal is to describe general principles uniting behavior and environment and, to some extent, these will be independent of particular characteristics of the subjects. To that degree we will be able to use methods that are convenient for the experimenter. College students are easy to recruit as subjects and are generally cooperative, as in scheduling appointments and following instructions including the request that they do as well as they can.

College students have a further advantage: they have extensive verbal histories. If a variable is found that affects performance on TB and SB tasks in these subjects, then it would be likely to be even more important with students for whom the stimulus
control is tenuous. (Michael, 1993, p. 108). Although generalization to other populations will have to be checked, college students are good subjects for a study of these two classes of language.

The Apparatus

Since one of the main goals of this study was to make it easy for other students to do this kind of research, it seemed obvious that the apparatus should be one that was available to anyone. Also, the behavioral approach emphasizes parsimony: for the analysis to be simple the demonstration of it should be as simple as possible. It is a pleasant challenge to find out how to do more research with less equipment.

Simple hand-operated apparatus has been used in a lot of excellent research. The scientific study of behavior was born in simple apparatus (e.g., Hull, 1920; Lashley, 1938; Pavlov, 1927/1960; Skinner, 1956; Thorndike, 1911; Yerkes, & Watson, 1911) This kind of equipment is still used. Ronald Lazar put cards in a rack in front of the subject to do his pioneering work on functional classes that involved sequencing responses (1977) and, in the Pigeon Parlance Project, TB and SB verbal behavior was studied with pigeons by simply presenting colors or patterns and reinforcing characteristic response topographies or pecks on a stimulus display (Michael, Whitley, Hesse, & Cresson, 1983; Sundberg, 1985).

Automated computer operated equipment is useful when many subjects or many trials are required, when the timing of the experiment is critical (e.g., latency studies), when extensive data analysis is required, when inadvertent cues are a serious problem and when the program is more complex than a person could keep track of (e.g., some studies of schedules of reinforcement). Clearly there are situations when this sort of equipment is appropriate.
Simple apparatus has an advantage in the design phase of an experiment. For good reason prototypes are built with flexible, easily manipulated materials in psychology, education, architecture and industry. It is helpful to extend the design phase on into the experiment itself to allow the discovery of apparatus that is precisely adapted to the conditions.

This is especially true when there are many procedural varieties of the basic TB and SB paradigms. Details of positioning of the stimuli can spell success and failure, especially when control is tenuous in the first place. Technologically advanced equipment is often locked a limited range of options and these are often determined by the needs of the equipment builder rather than the student. To some extent experimental environments can be designed for the convenience of the experimenter because general principles of behavior pertain over a range of settings, but some procedural varieties will feed into error tendencies and others will help establish the desired control and this can change during the experiment.

Automated equipment is touted as a way to get more research done, but it doesn't address many of the factors that limit how much research is done (such as the time it takes to analyze one session's data and the time it takes to get the grant to pay for it). A good way to increase research is to increase the population of researchers by removing the apparatus barriers that keep people out. Also, research can be increased by having senior experimenters supervise student researchers.

Clearly, there are some experiments that can not be done with simple equipment but the point is that a huge range of fine possibilities remain. To some extent, our success with technically advanced equipment has blinded us to the advantages of simplicity.

For all these reasons it was important to use the present research to test the extent to which useful experimental work can be done with simple equipment.
The Procedures

The general problem in designing the procedures for this experiment was to develop methods that were maximally effective in teaching the two different repertoires, to remove any distractions and any biases in the methods that would differentially affect one or the other type of task. However, the data would be useful only if they included a substantial number of errors in acquisition or retention or on the two kinds of tests. Ironically, the procedures had to teach well and produce errors.

Another general requirement was that all actions of both the experimenter and the student would be recorded as well as the complete contexts in which they happened. This means reporting precisely what stimulus was in each position on every trial of the experiment (with only some clearly defined exceptions). This was done by having detailed scripts describing what was to be presented on each trial and methods of making records on paper, audio tape, camera film and by observers.

It was necessary that the sequence of events on each trial be precise and maximally effective. It was also necessary that the actions of the experimenter be ones that almost any dedicated college student could master. This was accomplished by continuing to perfect the apparatus and procedures before and during the experiment.

One final requirement of this experiment was that it help other students do theses and dissertations in this area. This is a more specific version of the general requirement that science be communicated in a way that leads to replication and extension. One of the goals of the student who did the research reported here is to make life easier for the students who follow.
METHODS

Describing this experiment requires a special terminology. The reader will find a glossary in Appendix B. The terms the reader will need are: answer sheet, auditory stimulus, comparison stimulus, comparison sheet, correction, correction-repeat, cover, criterion, cue, equivalence test, final interview, full review, full test, generalization test, initial interview, intertrial interval, order, pattern, phase, preparatory task, response definition, response sheet, review during training, sample stimulus, sensory mode, scoresheet, selection-based, sequence, series, session, set, student plan, sound, subset, symbol, task, topography-based, training task, trial, visual stimulus, window and written response.

Subjects

The subjects (S's) were 16 undergraduate college students. When talking with them they were called "students" rather than "subjects."

These S's were recruited by posting an announcement on various doors, walls and bulletin boards of the building in which the experiment was run (Appendix A). This helped us get people who would be in the building anyway. The possibility of earning money was displayed prominently in the announcement and, in fact, many of the S's said they volunteered because of the money.

Any student answering the announcement was accepted unless he or she met one of these four exclusion criteria: (1) severe reading or writing disorders or visual or auditory problems; (2) a knowledge of written Sanskrit, Japanese, Chinese or
Korean; (3) unwillingness to work at least two or three times a week; or (4) previous participation in experiments similar to this one.

The human rights of these S's were protected by first getting permission for this research from Western Michigan University's Human Subjects Institutional Review Board. A consent form, signed by all the S's before research began, informed the students about the research and its risks and benefits, the protection of their confidentiality, the people they could report complaints to and the fact that they could withdraw from participation in the experiment at any time (Appendix A). Visitors and the experiment's trained observer signed pledges not to reveal the identities of the S's (also in Appendix A).

Confidentiality was maintained by using two-letter codes for each subject on all documents except for one: a list of names and codes was kept in a locked file cabinet. These codes were used during the experiment. When the data were written up each code was replaced by a common name.

Setting

The experiment took place in an office in Wood Hall at Western Michigan University. There were two desks, eight chairs, and a cabinet. The setting and some of the materials are shown in Figures 2 and 3.

The S sat behind one of the desks with the experimenter (E) seated opposite. There were chairs for materials to the E's right and left. Other materials were placed in and on top of a small file box, further to the left. The setting can be seen in Figures 2 and 3.

The office was cleaned up before every session so that it looked almost the same every time the S walked in.
Figure 2. Photographs of the Experiment: #1.
Figure 3. Photographs of the Experiment: #2.
Sessions were held two or three times a week. Each of the three phases was completed within the space of five days. As much as possible, sessions were scheduled at the S's convenience. The E accepted any time suggested as long as it did not conflict with other sessions already scheduled or with already scheduled activities of the E (which were kept to a minimum).

Apparatus and Materials

The apparatus and materials were made of typewriter paper, manila folders or cardboard. Marks were made on them with black ball point pen or black magic marker. Printed materials were typed on a DEC laptop computer (using Times New Roman typeface) and printed with a Canon Bubble Jet printer. The originals were photocopied to provide the many copies required in this work.

The apparatus and materials can be seen in Figures 2 and 3. Copies of the experimental materials are included in Appendix C. On the desk where the S and E worked were a clock, voice activated tape recorder (with one cassette in the machine and a blank replacement tape beside it), two black ball point pens and a cardboard box to shield the sample stimuli (SA) from the view of the subject. The box (12 by 12 by 14 inches) had two shelves. Response sheets were taped to the floor of each shelf to create four columns of four squares each; these were numbered from one to eight to accommodate four sets of SA stimuli. Attached to the front of the desk (out of view of the S) were a diagram of a comparison (CO) sheet with the window numbers marked and two clamps to hold the two answer sheets. On the side of the desk was another diagram of the window numbers where the observer could see it but not the S. Along the edge of the desk in front of the E were two stacks of CO sheets (those to be used and those already used, both face down). The box with the samples was kept at
the corner of the desk at the E's right; it's back was always kept turned to the S. On
the surface of the desk were pieces of clear tape marking the appropriate place for CO
sheets (14 inches in front of the S) and the box. There was also an index card with the
words "ERROR" and "CORRECT". The subjects could stop a trial after a response if
they hit the word "ERROR" before the E delivered a consequence or started the next
trial. This protected the S from "accidental" errors that could be immediately
corrected. The word "CORRECT" on the card was not used.

On the chair to the E's right was a copy of the vocal instructions given before
each task, a ball-point pen and the scoresheets already labeled for the tasks scheduled
for that session. A small plastic card was sometimes used to mark the line on the
scoresheet that described the stimuli due to be presented next. On the chair to the E's
left was a sheet of cardboard (16.5 by 18 inches) with horizontal strips made of two
layers of cardboard 4.5 inches wide that held the edges of the CO sheets up in the air
to make it easy to slide the one that had just been used to the bottom of the stack).
The small file box further to the left held the experimental stimuli not in use; blank
response sheets were kept on top of the box. These were for written responses; they
were 8.5" x 11" sheets of paper marked with three rows of four squares, each 2.75"
square (see Appendix E). The cover was also kept on the box when not in use; this
was a 19" by 11.75" piece manila folder paper with a notch cut out of the bottom
center just the size of a square on the response sheet (2.75" on a side). It covered
previous written responses during a TB task so that only blank squares were visible.

On the other desk in the room were a calendar for scheduling appointments,
slips to give the students reminding them of our next session (and giving E's telephone
numbers), the list of announcements to be made to all S's and an envelope with $5
bills (to pay S's at the end of each session). On the cabinet was a clipboard and
labeled scoresheets for use by the O. In the cabinet were the student data files,
scoresheets for the O, summary data charts, a list of any errors made by the E, and files with blank forms.

On the outside of the door was a "Do Not Disturb" sign (taped to the back of the door when a session was not in progress) and a calendar listing upcoming sessions.

Elsewhere in the building was a locked file box for the list of S names and codes and for copies of all the data (in case the originals were lost). The only people with keys were the author of this paper and his principal advisor.

Many forms were used to organize this experiment (Appendix D). These included: Steps to Take With New Students, Consent Form, Student Information Sheet, Group Assignment List, Student Telephone List, Preparing for a Session, To Do List, Instructions for Each Task, Answer Sheets, Student Plan, Scoresheets, Session Summary, Student Summary, Experiment Summaries, E Errors, Announcements, Appointment Cards, Questions for the Final Interview, Confidentiality Pledge for O's and Visitors, General Description of the Experiment for O's, O-E Disagreements, Students' Codes List and List of Documents.

Experimental Design

Logic of the Experiment

This research was an example of a multiple baseline design that varied across subjects. (Johnston & Pennypacker, 1993, pp. 278-282) The effects on the dependent variables were compared before and after the presentation of the independent variables. The crucial test was whether the effect of the independent variable on the dependent variable correlated with its presentation to each successive subject. This was a within-subject design in which each subject produced his or her own control
data, supplemented by statistical analysis of grouped data produced by the different treatment conditions (using t-tests).

It was assumed that the subjects would perform at chance levels on any of the experimental tasks before training began because none of them had any prior access to the experimental materials (the list showing what groups they were assigned to and the answer sheets showing the stimulus relations pertaining to those groups).

Overview of the Research

The arrangement of tasks is diagrammed in Figure 1. It generally followed that of Sundberg (1990) and Wraikat (1991b). The setting is shown in Figures 2 and 3. The sequence of sessions and the stages of the experiment are given in Figures 4 and 5. The tasks are described in Figure 6 and typical trials are shown in Figure 7. Each task was represented by two letters; the first was the SA set and the second was the CO set (in a SB task) or response set (in a TB task). Subscript numbers after a letter indicated which of the two subsets of that stimulus was used.

The experiment had three phases: two TB (or SB) tasks were trained and equivalence and generalization tests given during the first phase and the same was repeated with the other type of language in the second phase. During the third phase there were full reviews of the preceding training and a full test. A random balancing procedure assigned the students to different groups defining the sequence in which they received the TB and SB phases, the order in which the two training tasks were given within each of these phases and the subsets of the stimuli that would be used (which is to say the answer sheet used).

A TB phase began with three preparatory tasks that introduced the stimuli and responses. The student, (a) pointed to a visual pattern in the presence of another
<table>
<thead>
<tr>
<th>SESSION #1</th>
</tr>
</thead>
</table>
| Introductory Interview  
--- PHASE 1: ---  
Preparatory Tasks  
First Training |

<table>
<thead>
<tr>
<th>SESSION #2</th>
</tr>
</thead>
</table>
| Review First Training  
Second Training  
Equivalence Test  
Generalization Test |

<table>
<thead>
<tr>
<th>SESSION #3</th>
</tr>
</thead>
</table>
| --- PHASE 2: ---  
Preparatory Tasks  
First Training |

<table>
<thead>
<tr>
<th>SESSION #4</th>
</tr>
</thead>
</table>
| Review First Training  
Second Training  
Equivalence Test  
Generalization Test  
--- PHASE 3: ---  
Preparatory Tasks |

<table>
<thead>
<tr>
<th>SESSION #5</th>
</tr>
</thead>
</table>
| Review Phase 1 Training  
Review Phase 2 Training |

<table>
<thead>
<tr>
<th>SESSION #6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full Test</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SESSION #7</th>
</tr>
</thead>
</table>
| Follow-up Tests  
Final Interview |

Figure 4. Sequence of Sessions.
<table>
<thead>
<tr>
<th>INTRODUCTORY INTERVIEW</th>
</tr>
</thead>
<tbody>
<tr>
<td>questions</td>
</tr>
<tr>
<td>explanations</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PREPARATION (8 stimuli)</th>
</tr>
</thead>
<tbody>
<tr>
<td>identity matching: patterns</td>
</tr>
<tr>
<td>echoic responding: sounds</td>
</tr>
<tr>
<td>copying a text: symbols</td>
</tr>
<tr>
<td>OR</td>
</tr>
<tr>
<td>identity matching: symbols</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TRAINING: TASK #1</th>
</tr>
</thead>
<tbody>
<tr>
<td>with cues</td>
</tr>
<tr>
<td>without cues</td>
</tr>
</tbody>
</table>

| TRAINING REVIEW         |

<table>
<thead>
<tr>
<th>TRAINING: TASK #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>with cues</td>
</tr>
<tr>
<td>without cues</td>
</tr>
</tbody>
</table>

| EQUIVALENCE TEST        |

| GENERALIZATION TEST     |

| REPEAT STEPS LISTED     |
| ABOVE WITH THE OTHER    |
| TYPE OF TASK AND THE    |
| OTHER STIMULUS SUBSETS  |

<table>
<thead>
<tr>
<th>PREPARATION (16 stimuli)</th>
</tr>
</thead>
<tbody>
<tr>
<td>identity matching: patterns</td>
</tr>
<tr>
<td>identity matching: symbols</td>
</tr>
</tbody>
</table>

| FULL REVIEW              |

| phase 1 training tasks   |
| phase 2 training tasks   |

| FULL TEST                |

| Phase 1 Training Tasks   |
| Phase 1 Equivalence Test |
| Phase 1 Generalization Test |
| Phase 2 Training Tasks   |
| Phase 2 Equivalence Test |
| Phase 2 Generalization Test |

| FINAL INTERVIEW          |

| further testing          |
| questions                |
| explanations             |

Figure 5. Stages of the Experiment.
<table>
<thead>
<tr>
<th>TASK</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Pointing to a pattern in response to another copy of the same pattern (identity matching)</td>
</tr>
<tr>
<td>B</td>
<td>Repeating a sound said by the experimenter (echoic behavior)</td>
</tr>
<tr>
<td>C</td>
<td>Copying a symbol or writing it independently (depending on which stage of this task is being done)</td>
</tr>
<tr>
<td>AC</td>
<td>Writing a symbol in response to a pattern, with a cue or without a cue depending on the stage being presented (this is one of the two TB training tasks)</td>
</tr>
<tr>
<td>BC</td>
<td>Writing a symbol in response to a sound with or without a cue depending on the stage (this is the other TB training task)</td>
</tr>
<tr>
<td>AD</td>
<td>Pointing to a symbol in response to a pattern with or without the aid of cues (this is one of the two SB training tasks)</td>
</tr>
<tr>
<td>BD</td>
<td>Pointing to a symbol in response to a sound with or without a cue (this is the other SB training task)</td>
</tr>
<tr>
<td>AC review</td>
<td>The same as AC, given in the session after training on that task</td>
</tr>
<tr>
<td>BC review</td>
<td>The same as BC, given in the session after training on that task</td>
</tr>
<tr>
<td>AD review</td>
<td>The same as AD, given in the session after training on that task</td>
</tr>
<tr>
<td>BD review</td>
<td>The same as BD, given in the session after training on that task</td>
</tr>
<tr>
<td>BA test</td>
<td>Pointing to a pattern in response to a sound (an equivalence test, done by combining what was learned on the two training tasks)</td>
</tr>
<tr>
<td>ADBD test</td>
<td>Pointing to a symbol in response to a sound or a pattern, after being taught to write the appropriate symbol (SB generalization test following TB training)</td>
</tr>
<tr>
<td>ACBC test</td>
<td>Writing a symbol in response to a sound or a pattern, after being taught to point to the appropriate symbol (TB generalization test after SB training)</td>
</tr>
<tr>
<td>A,</td>
<td>Pointing to a pattern in response to another copy of the pattern with both subsets of patterns simultaneously present as comparison stimuli</td>
</tr>
<tr>
<td>D,</td>
<td>Pointing to a symbol in response to another copy of the symbol in the presence of all the symbols used in TB and SB training</td>
</tr>
<tr>
<td>ACBC review</td>
<td>Writing a symbol in response to a sound or a pattern (a review of the two TB training tasks)</td>
</tr>
<tr>
<td>ADBD review</td>
<td>Pointing to a symbol in response to a sound or a pattern (a review of the two SB training tasks)</td>
</tr>
<tr>
<td>(ABCD) test</td>
<td>A mixed set of the four training tasks, two equivalence tests and two generalization tests</td>
</tr>
</tbody>
</table>

Figure 6. Descriptions of the Tasks.
<table>
<thead>
<tr>
<th>TASKS</th>
<th>SB SAMPLE and COMPARISON STIMULI</th>
<th>TB SAMPLE STIMULUS and RESPONSE-PRODUCED STIMULUS</th>
<th>CUED TRIALS and CORRECTION TRIALS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td><img src="image1" alt="Sample Stimuli 8 stimuli" /></td>
<td><img src="image2" alt="Response-Produced Stimuli 16 stimuli" /></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td>&quot;ZAN&quot; (said by the experimenter) &quot;ZAN&quot; (said by the subject)</td>
<td></td>
</tr>
<tr>
<td>C</td>
<td><img src="image3" alt="Stimuli Image" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td><img src="image4" alt="Stimuli Image" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC</td>
<td><img src="image5" alt="Stimuli Image" /></td>
<td><img src="image6" alt="Stimuli Image" /></td>
<td></td>
</tr>
<tr>
<td>BC</td>
<td></td>
<td><img src="image7" alt="Stimuli Image" /></td>
<td><img src="image8" alt="Stimuli Image" /></td>
</tr>
<tr>
<td></td>
<td>Chart of the Tasks.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---------------------</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC</td>
<td>![Chart for AC]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BC</td>
<td>![Chart for BC]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AD</td>
<td>![Chart for AD]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BD</td>
<td>![Chart for BD]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BA</td>
<td>![Chart for BA]</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
example of the pattern (part of a quilt, set A), (b) emitted a vocal response in the presence of a similar sound as an auditory stimulus (nonsense syllables represented by a consonant-vowel-consonant trigram, set B), and (c) wrote a symbol in the presence of another example of the symbol and then wrote all 8 symbols without any cues (a Japanese Katakana symbol, set C).

Learning to write the Katakana symbols involved seven steps (the number of times each stimulus was presented during each step is explained on p. 49): (1) copying a cue that was present throughout the trial; (2) copying a cue that was only present for about one second at the start of the trial; (3) writing all eight symbols one time each in any order without using the cover; (4) writing all eight symbols one time each in any order with the cover (which was used in the next stages, too); (5) writing the eight symbols in a different order; (6) writing the eight symbols faster (in any order); and (7) writing the eight symbols as fast as possible. The usual consequences were provided after every trial used in stages (1) and (2) and after all eight symbols had been written or the student had given up in stages (3) through (7).

After preparatory training, two TB tasks were trained, writing a symbol (set C) in the presence of a visual pattern (set A) and writing a symbol in the presence of a nonsense syllable (set B). Which task came first was assigned to the different S's on a random basis. The first task was trained in the session before the second training task and the tests, so this session began with a review (called Review During Training). Then two tests were given. (During training, reinforcement and error correction were used but tests were done under extinction.) The two tests involved pointing to a visual pattern (set A) in the presence of a nonsense syllable (set B) (the equivalence test) or pointing to a Katakana symbol (set D) in the presence of either a visual pattern (set A) or a nonsense syllable (set B) (the generalization test -- a SB version of the TB training tasks).
The next phase involved the other type of verbal behavior (SB if the first phase was TB or vice versa). Each set of stimuli had been divided into two matched subsets; students received one subset in the TB phase and the other in the SB phase. The students received the different subsets according to a randomly balanced design (there were eight possible combinations of the two subsets of each of the three stimulus sets with an answer sheet to go with each).

A SB phase started with SB preparatory tasks that introduced the student to the stimuli and responses. The student, (a) pointed to a visual pattern in the presence of another example of the pattern (part of a quilt, set A), (b) emitted a vocal response in the presence of a similar sound as an auditory stimulus (nonsense syllables represented by a consonant-vowel-consonant trigram, set B), and (c) pointed to a symbol in the presence of another example of the symbol (a Japanese Katakana symbol, set D).

Then two SB tasks were trained, pointing to a visual Katakana symbol (set D) in the presence of a quilt pattern (set A) and pointing to a symbol in the presence of a nonsense syllable (represented by a consonant-vowel-consonant trigram, set B). The first task trained was reviewed at the beginning of the next session. Then two tests were given. The tests involved pointing to a visual pattern (set A) in the presence of a nonsense syllable (set B), the same equivalence test used in the previous phase, and writing a symbol (set C) in the presence of either a visual pattern (set A) or a nonsense syllable (set B). This last test was simply a TB version of the SB training tasks.

In Phase III the two training tasks from each of the earlier phases were combined into one set (the full reviews) and then all six tasks given in the first two phases were combined in a 144 trial full test.

During the experiment the S's were reminded not to practice between sessions.
In summary, comparisons were made between: (a) acquisition of TB and SB tasks, (b) generalization to a SB task after training on the TB version of the task and vice versa, (c) formation of stimulus classes in an equivalence test that involved the two stimuli that had served as samples in the two TB or SB training tasks, and (d) retention as shown by testing at the end of the experiment.

Experimental Stimuli

Antecedent Stimuli

These stimuli were presented by the E before the S responded.

Sample Stimuli

There were three classes of sample stimuli: patterns (set A), nonsense sounds (set B) and Japanese Katakana symbols (set C or D). The visual stimuli were 2.75" square pieces of paper made by photocopying quilt patterns (Safford & Bishop, 1972) or Katakana symbols (Mitamura, 1985). The SA stimuli were also used as cue stimuli. They were the same size as the squares on the CO sheets used in SB tasks and the squares on the response sheets used in TB tasks.

The pattern stimuli were complex because, in our artificial language, they took the place of objects to be named. They were selected so as not to have distinguishing features that would evoke the same name from many observers (e.g., a black X in the middle) and yet not to look so much like each other that they required detailed study to tell them apart. There were sixteen sample stimuli divided in two sets of eight matched for darkness and general type of pattern. See Appendix C for examples of the stimulus materials used in this experiment.
The auditory stimuli were enunciated by the E twice at the start of the trial. They were consonant-vowel-consonant combinations selected on either side of the point 0.6 of the way through a series of such sounds that has been graded from most to least meaningful. (Noble, 1961) Combinations were excluded if they sounded like English words. These sixteen sounds divided in two sets of eight each of which had an equal balance of vowels in the middle in the trigram and that did not repeat the first consonant.

The D samples (used as cues or in identity matching) were pieces of paper of the same size as the A samples (2.75" on a side). As in the case of the pattern stimuli, they were selected to be different enough not to be easily confused with each other and to not evoke a standard naming reaction. The sixteen stimuli were divided in two matched sets of eight. Matching was done by putting the stimuli in pairs on the basis of pattern and lightness or darkness.

Each SA slip was labeled on the back in pencil with a number designating the subset (1 or 2) and a number designating the SA (1 to 8). These marks were not visible from the front.

The series of stimuli presented were pseudorandomized; that is, randomized except for certain specified limits on acceptable sequences. To make the series of SA's used when presenting a task, the SA number was written on the same number of coins as SA's of this number would appear in the series and then these coins were placed in a large plastic container that was shaken ten times. Then the coins were removed one at a time without replacement, taking the first that was touched as the E tried to take the coin on top of the pile in the container without looking at the coins. A list was made of the numbers on the coins and printed on the scoresheets that guided the E in presenting SA's and CO's. The limits placed on the series were: (a) no three-in-a-row of the same number, (b) no three-of-four trials with the same number.
SA, (c) no three repeated pairs of numbers, and (d) no two series starting or ending with the same two numbers. If a coin was unacceptable it was replaced and the container shaken as before.

For the review tasks (that combined SA's from two sets) the SA numbers were determined in the same way except that no repetitions in SA number were allowed (so that equivalence relations would not be taught inadvertently, as when an A-3 trial was followed by a B-3 trial). The sequence of SA sets in a review set was determined by flipping a coin; the limits were: (a) no four-in-a-row of the same set, (b) no successive runs of three-in-a-row, and (c) no starting or ending a series with three-in-a-row from the same set. Finally, the review sets were inspected to see that no combination of set number and stimulus number appeared too often (three times) or not often enough (no times); i.e., each combination had to appear one or two times.

The final test set was made by cutting up a scoresheet for each component task, putting the slips in a bag, mixing them by hand for five minutes and drawing them without replacement. The limits on the sequence were: (a) no more than two-in-a-row of any one task, and (b) no more than two TB or four SB trials in a row. If a slip was unacceptable more slips were drawn until one that could be used was produced, then all the rejected slips were replaced and the contents of the bag mixed for two minutes.

Comparison Stimuli

Comparison sheets were made by placing the eight set A stimuli (patterns) or set D stimuli (Katakana symbols) around the outside of a 7.25" by 7.25" square. These locations, called windows, were numbered from left to right starting in the upper left corner (Appendix C). The stimuli were distributed in the windows in
sixteen pseudorandom sequences balanced so that each stimulus appeared in each window equally often. An effort was made to select combinations that were maximally different from each other (that did not share repeated sequences of stimulus positions). There are 50,200 ways to place eight stimuli on a CO sheet but most of these combinations are very similar to each other (e.g., differing in the position of just two stimuli).

Each CO sheet was labeled on the back in pencil with a letter designating the set (A or D), a number designating the subset (1 or 2) and a number designating the CO sheet (1 to 16).

The sequence of presentation of CO sheets was randomized by shuffling the stack of sheets three times before each presentation. If the series was only given once (which was often the case), then the CO sheets were used in the order numbered (which was itself random). After going through a stack of CO sheets, the same stack could be gone through in the reverse direction before reshuffling.

**Cue Stimuli**

The cues represented the stimuli to be produced by writing (in TB tasks) or to be pointed to (in SB tasks). The cue stimuli were the same pieces of paper used as samples.

During training, cues were present throughout the trial (Stage 1) or for one or two seconds at the beginning of the trial (Stage 2) or they were not used at all (Stage 3). Cues were also presented immediately after an error at the start of the correction procedure.

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Consequent Stimuli

These were stimuli presented by the E after the S responded.

Reinforcing Stimuli

Reinforcement was accomplished with confirmatory phrases, such as "Good," "Right," "That's it" and "Uh-huh," spoken by the E about one second after a response. The presentation of the sample for a new trial was also reinforcing because it always followed a correct response (see below for the correction procedure that followed errors). Reinforcement was given after every correct training trial but testing was done under extinction (a new trial was started whether the response was correct or not).

Another discriminative stimulus associated with correct responses was the prompt removal of the antecedent stimuli in front of the S (an error was followed by the presentation of a cue and the beginning of the correction procedure).

At the end of a session the E gave a $5 bill to the S. This helped maintain attendance at the sessions.

Punishing Stimuli

The error consequence was called "correction" or "correction-repeat." After an error during training the E said, "Actually this was the correct response" and then the E presented a cue stimulus representing what the S should have written or pointed to. The S then responded correctly (copying the cue or pointing to the same stimulus on the CO sheet). In the "correction-repeat" procedure the sample was presented again in a new trial giving the S the opportunity to respond correctly (in SB tasks the next CO
sheet for the next scheduled trial was used and then reused with the sample appropriate to the next trial).

Another discriminative stimulus associated with errors was the unusually long pause while the E checked to be sure it was an error and the motion as the E reached for the appropriate cue stimulus.

Independent Variables

The main independent variable was the type of language, TB or SB. These were contrasted during initial training, equivalence and generalization testing, full review and full tests.

Another set of independent variables was various aspects of the procedures themselves; we checked to see if the results were affected by the phase during which training was given, the sequence in which the two phases were presented, the sensory mode of the samples, the order of the two tasks during training and the stimulus subset used.

Time is an independent variable in the retention tests and the stage of the experiment is the variable when we look for persistence of the effects during the course of the experiment.

Dependent Variables

The number of errors under different conditions were listed for each subject and then totals and averages were derived. The numbers of students doing better with TB and SB instruction were also recorded.

These responses, either writing in a TB task or pointing in a SB task, are described here in greater detail.
Response Definitions

Writing

The S's wrote with a black ball-point pen on 8.5" by 11" sheets of paper marked with three rows of 2.75" squares (Appendix C). A cover was used to ensure that the S's didn't see their previously written responses. It was described on p. 28, above. The S moved this cover (or the paper beneath it) along each row of squares from left to right starting with the top row and then filling the lower rows in order. The first response was in the upper left-hand square and the last in the lower right-hand square. At all times all the visible squares were blank.

The response ended when the S moved the cover to expose the next blank square. This was an essential aspect of the response definition because before that the S might still change the response-product, so the E had to wait until the cover was moved before a consequence for the response was delivered.

Pointing

This response was defined by the contact of the S's finger with the 2.38" by 2.38" square containing the visual stimulus (the "window"). The eight stimulus CO sheets had nine of these windows arranged in a 7.25" by 7.25" square. They were numbered from 1 to 9 along the rows from left to right, starting at the top left and ending at the bottom right (window #5, in the middle was used for samples but was not a CO response window). The 16 stimulus CO sheets had 16 smaller stimulus locations (1.5" by 1.5") around the outside of a 7.5" by 7.5" square.
Response Measurement

Paper

Scoresheets were used to record whether a response was correct or not and/or the window that was pointed to in a SB task (Appendix C). These scoresheets also listed the SA and CO stimuli required for each trial and were used to guide the E through the scheduled presentations. At the top of the page were spaces for the S code, date, session number, people present, time the task was started and stopped, task name, tape number and the tape counter number at the start and finish of the task.

The response sheets for TB tasks (described on p. 28) were labeled on the back with the sheet number, S code, session number, task name and trial numbers. Since the squares were always filled in the same order, the trial number and SA correlated with each response-product could be identified by checking the scoresheet labeled with the same descriptors as the response sheet.

Audio Tape

An audio tape recording was made of the entire session using a small tape recorder (a Sony TCM-S68V). The recorder was voice activated so that only sounds reaching the microphone were recorded. This saved a lot of tape (because the experiment was run in silence except for the auditory SA's and the instructions) but it meant that the tape could not be used to time the events of the experiment.

Photography

A few sessions were photographed with a 35mm camera to record the general
features of the experimental environment (Figures 2 and 3). Also, a video tape was made of two sessions.

Procedures

Setting Up to Run a Session

The form, Preparing for a Session, lists everything that the E checked at the beginning of each session (Appendix D). There are 22 items on this list.

The appropriate SA and cue stimuli were laid out in the box and the CO stimuli were placed on the desk beside the box (for the first trial of the session) or on the chair to the left.

Consulting the Student Plan, the E gathered the scoresheets that would be required which were then labeled as completely as possible. An additional set was made for the observer.

What to Do With New Subjects

The form, Steps to Take With New Students, lists what the E did at the beginning of the first session (Appendix D). The S's were asked to read and sign the Consent Form and to fill in the Student Information Sheet. Then a long paragraph was read of general instructions. This contained a brief description of what we would be doing, the necessity of working in silence, of not discussing the experiment and of not working on the experiment in between sessions. The S's were reminded that they could end their participation at any time and that no specific number of sessions were guaranteed. Arrangements for payment were described. Then the first S and E moved to their positions across the desk from each other and the instructions for the first task were read.
Running a Typical Session

The session began with a few sentences about what had been happening since we last met. The tape recorder was turned on and the date, time, codes for people present, session number and task name were dictated.

Instructions

Each task began with the E reading the appropriate instructions from the form, Instructions for Each Task (Appendix D). This script was followed exactly.

The session was run in silence except for the vocal behavior involved in presenting stimuli, responding to them or providing consequences.

Presenting the Antecedent Stimuli

The order of presentation of antecedent stimuli was always CO stimulus first (if the task was SB), then SA and then cue (if it was Stage 1 or 2 of a training task). Details are given below for each type of task.

Topography-Based Tasks. At the start of each trial the E consulted the scoresheet for the task being presented. Then, about one or two seconds after the preceding trial ended, he picked up the designated SA from the box and placed it on the response sheet cover, 2" from the center of the notch in which the S would write a response, or, if the SA was an auditory stimulus, he said the nonsense syllable distinctly twice in immediate succession.

Selection-Based Tasks. At the start of each trial the E consulted the scoresheet for the task being presented. Then, about one or two seconds after the preceding trial
ended, he picked up the designated SA (and cue, if necessary) from the box with his right hand and the CO sheet with his left hand. In smooth succession he then placed the CO sheet on the desk (guided by the tape on the desktop), the SA in the center of the CO sheet and the cue 2" from the center of its top edge. If the SA was an auditory stimulus, he placed the CO sheet in front of the S and then said the nonsense syllable distinctly twice in immediate succession.

Waiting for the Response

The E sat motionless with two hands in his lap or one on the edge of the desk while waiting for the response. If the task was a test the E looked at the stimuli in the box, or the answer sheet or the scoresheet but not at the response sheet or CO sheet. If it was a preparatory or training task the subject might also look at the area just in front of the S. The E rarely looked at the S's face, and never made eye contact while a task was running.

Presenting the Consequent Stimuli

After a Correct Response. The E said "Good" or something similar (p. 41) within a second of a correct response and then reached to remove the antecedent stimuli.

After an Error. The E said "Actually this is the correct pattern (or symbol)" and presented the appropriate cue stimulus in its usual position. The E then responded correctly and the trial was ended. Then the next scheduled trial was presented or, if correction-repeat was in effect, the next trial was a repetition of the same SA with the next CO sheet in SB tasks. In this latter case, if the response was correct it was reinforced and the next trial presented exactly as scheduled.
Recording the Response

During preparatory or training tasks, the E scored the response by writing down a check or X, a smile or frown (rightside up or upside down U) or a dot to the left (correct) or right (error) of the number of the window to which the response was directed. The check and X were not used on tests because the E's motion might have indicated to the S whether the response was correct or not, which was not a problem with the other two scoring conventions. Response windows numbers were written down after errors during training and on any SB test trial.

During the Intertrial Interval

These intervals usually lasted from one to three seconds. They ran from the presenting of the consequent stimuli for one trial and the antecedent stimuli for the next trial. The E recorded the response (as described above) and returned the previously used SA and cue stimuli to their numbered positions in the box. The CO sheet was turned upside down on a discard pile to the left of the CO stack from which sheets were drawn at the start of each SB trial.

Then the E looked at the scoresheet to find out what would be presented on the next trial. The answer sheet might be checked to see what the correct response to the SA would be (or the E looked over at the cue of the same number). Sometimes a brief pause was inserted to check to be sure that everything was running as it should be. The required antecedent stimuli were picked up and the next trial was ready to begin. If the S's attention was distracted the E waited until the subject was motionless and looking at the desktop or the E.
Ending a Session

Sessions ended when the scheduled tasks were completed or when one hour had elapsed. Nothing more was said than something like, "Well, that's it for today." No comments were made about how the session had gone. The answer sheets and stimuli were covered or put away before the S walked around to where they would be seen.

Then the E and S arranged the scheduling of the next session and the S was paid $5 from the envelope of $5 bills on the desk. There were a few sentences of conversation about what was going to happen before the next session.

After Each Session

The materials were returned to their places in the file box (or in the student's file if they would be needed again by this S but not by other S's). The session number was recorded beside the tasks done in the Student Plan. The scoresheets and response sheets were put in order and the results copied onto the Session Summary, Student Summary and Experiment Summary sheets (Appendix D). Notes were made for the S file and the E errors list. Any disagreements between O and E were recorded on the list for that purpose.

Procedural Differences in Groups A, B, C and D

The 16 subjects were given a gradually more difficult series of procedures in order to generate enough errors to allow a comparison between the two types of language. The methods described above applies to all four groups with the following exceptions.
Group A (two subjects) received 24 trials on each preparatory task (except for the TB stages (3) through (7) that were the same for each group and involved writing each symbol one time). There were also 24 cued demonstration trials at the start of training. The error consequence was correction-repeat. There were either two or three full reviews before the full test.

Group B (six subjects) received 16 preparatory and 16 cued demonstration trials. The error consequence was correction-repeat. There was only one full review before the full test.

Group C (one subject) received 16 preparatory and eight cued demonstration trials. The standard instructions at the start of training had this additional sentence: "Move the cover (or point to the symbol) when you finish studying it." The error consequence was correction (without the repetition of the trial missed). There was only one full review before the full test.

Group D (seven subjects) received the same treatment as the Group C subject without the added instruction about taking as long as the student wanted. There were 16 preparatory and eight cued demonstration trials. The error consequence was correction and there was only one full reviews before the full test.

The Final Interview

The S was asked nine questions: (1) How did you do each of the tasks? (2) Did you have names for any of the stimuli we used? (3) How did you do the tests that were not directly taught? (4) Did you have any particular history with any of the stimuli? (5) Have you ever listened to Dr. Jack Michael lecture on the topic of selection-based and topography-based language? (6) Which tasks were particularly easy or hard and fun or unpleasant? (7) If you had the time, would you participate in
another experiment similar to this one? (8) Would you like to hear an explanation of this experiment, why we did what we did and what we hope to learn? (9) Did you study the experimental relations on your own between sessions at any time during the experiment?

The S and E then conversed in general about the design of the experiment and what happened during the sessions. This was recorded on audio tape.

Reliability Measures

An observer (O) is used to verify that what the E says happened during the experiment did happen.

Specifically, the job of the O was to verify that: (a) the E followed the sequence of tasks and trials that had been planned beforehand, (b) the E's record of the S's behavior was accurate, (c) the E did not supply differential consequences on the tests, and (d) the E did not give inadvertent cues.

Training the Observer

During an initial interview the O, Kendra Pearsall, read the form titled "A General Description of the Experiment" (Appendix D). The importance of the O's role was explained and the different experimental tasks were demonstrated. They were shown the O-E Disagreements form and its significance explained. The mechanics of deciding what sessions to observe was discussed. When the trainee decided to become an O she was asked to sign a pledge to maintain the confidentiality of the S's (Appendix A).

Then there was a training session during which the E went through the motions of running the various tasks and the O kept a record.
Finally, the O recorded actual sessions until her record agreed consistently with the E's record. After that she was considered to be trained.

Observing a Session

The O had two roles, to observe the behavior of the S or that of the E. There were chairs behind the person to be observed. In either case she was alert for inadvertent cues, errors in reading instructions, errors of response definition and errors of timing (order and timing of presentation of CO and SA and cue, timing of response and consequence, and timing of the intertrial interval). The O used the same scoresheets as the E.

Observing the Student

Selection-Based Tasks. During the trial the O recorded: (a) the window number pointed to on each trial, and (b) whether or not the response was correct.

Topography-Based Tasks. During the trial the O recorded: (a) the number of the TB trial in final tests that combined SB and TB trials in one set, and (b) whether or not the response was correct. After the response sheets were completed and labeled the O checked that the sheet had the correct sheet number, S code, session number, task name and trial numbers.

Observing the Experimenter

Selection-Based Tasks. Before the series started the O checked the label at the top of the scoresheet. During the trial the O recorded: (a) the CO sheet number, and
(b) the SA number and cue number if used, and (c) the consequence that the E delivered.

**Topography-Based Tasks.** Before the series started the Q checked the label at the top of the scoresheet. During the trial the Q recorded: (a) the SA number and cue number if used, and (b) the consequence that the E delivered. After the response sheets were completed and labeled the Q checked that the sheet had the correct sheet number, S code, session number, task name and trial numbers.

**Calculating Agreement**

Percentage agreement scores were calculated by dividing the number of instances on which Q and E agreed by the total number of instances on which they agreed and disagreed, and then multiplying this quotient by 100. That is, the scores represented the percent of opportunities that were recorded in the same way by the Q and the E.
RESULTS

In most cases, these results are presented in terms of average errors committed by the 16 subjects as they worked on the task in question. Test results (where the number of trials is the same in each case) are given as percent correct when this aids interpretation. Training results are reported in terms of the number of errors instead of trials to criterion or percent correct because these latter measures are severely distorted by just when the errors came within the series of trials. For instance, on the two full reviews Alexis made the same number of errors each time but his score rose 6%, while Maria Jesus cut her errors in half but her scores only changed 3% (Alexis: 38/47=81% and 61/70=87%; Maria Jesus: 53/61=87% and 38/42=90%).

Statistical significance was determined by two-sample t-tests unless otherwise noted. The probability value is reported when it meets our definition of significance (p less than or equal to 0.05). The probability value is not reported when the t-tests indicate statistically insignificant differences, unless the value is between .05 and .10 in which case it is reported even though it does not reach the level of statistical significance.

Two-sample Mann-Whitney tests were also done because these nonparametric, rank-based tests use medians instead of means and are not as affected by extreme values. The probabilities computed with the Mann-Whitney were only reported when the two tests disagreed, which happened once (p. 61).

The tables presenting the data are collected in Appendix F rather than being embedded in the text. This was done to make it easier for the reader to compare the average scores on the successive stages, to study the patterns in the data by moving
back and forth among the tables, and to follow the performance of individual subjects through the experiment. To help the reader the subjects are always listed in the same order (determined by the number of errors during training).

First, the overall performance of these subjects will be described. We next consider the effect of five variables that might confound our analysis. SB and TB tasks are then compared. Then other observations are presented on equivalence and generalization testing, the effects that we expected to see, ceiling effects and retention, followed by data on error analysis, methodology and reliability.

Overall Performance

There were eight kinds of tasks in this experiment: (1) Preparation, (2) Training, (3) Review During Training, (4) Equivalence Tests, (5) Generalization Tests, (6) Full Reviews, (7) Full Test, and (8) Final Interview Tasks. The performance on these different tasks will be summarized here (see Table 1 for the data on overall performance).

Preparation

No errors were made in the tasks used to introduce the students to Phases I, II and III (that is, identity matching, echoic behavior and copying a text).

Training

The 16 subjects learned two TB tasks that involved writing Japanese Katakana symbols in response to auditory nonsense syllables or visual patterns. During acquisition of these eight stimulus relations, there was an average of 8.1 errors (Table 5).
The subjects also learned two SB tasks with Katakana symbols as CO's and auditory nonsense syllables or visual patterns as samples. 16.2 average errors were made during acquisition of these eight stimulus relations (Table 5).

The students averaged 12.2 errors during acquisition of a training task.

**Review During Training**

The first training task had to be reviewed because it was taught one session before the second training task was presented and tests given. Few errors were made: there were an average of 1.4 errors during each one of these reviews (Table 8).

**Equivalence Tests**

The students successfully demonstrated equivalence relations based on the combining of the two training tasks. No differential reinforcement was delivered during this test. Auditory nonsense syllables were the samples and visual patterns the comparisons. An average of 2.8 errors was made during each of these equivalence tests.

**Generalization Tests**

After TB training the students were tested with the SB version of the training tasks. Likewise, TB testing followed SB instruction. Generally these tasks were no problem; the students averaged 2.3 errors on each of these tests (done without differential reinforcement).
Full Reviews

These reviews were made by combining the two training tasks into one set. The criterion was met with an average of 6.3 errors per test.

Full Test

The ten tasks done during the experiment (not including the preparation tasks) were given in one long set of 144 trials. On average 22.6 errors were made during one of these tests. Expressed as percent correct, the scores were highest on the training tasks (88%) and lower on the equivalence tasks (77%). The scores on the generalization tasks based on TB training was 90% correct and generalization after SB training was 84% correct.

Final Interview Data

At the start of the last session some other indirectly taught tasks were presented as demonstrations. During each test the 8 or 16 stimuli involved were presented one time each. These are reported in Table 14 and include: (a) the written spelling of the sounds presented during TB and SB training, (b) sorting the experimental stimuli into two sets corresponding to Phase I and Phase II, (c) written spelling or vocalizing of the sounds in response to the symbols or patterns, and filling in a chart with representations of the patterns, sounds and symbols. As seen in the table, the students made few errors. No contrasts were apparent between the performances on the different versions of these tasks, except that sorting the stimuli into two sets by pointing to the printed trigrams representing the sounds was more successful than by writing letters representing the sounds (10 vs. 46 errors by 10
students), and sorting by pointing to the Katakana symbols was more successful than by writing the symbols (8 errors vs. 15 by the same 10 students).

Some Effects

Before we compare TB and SB scores we have to look at the effects of the general experimental procedures. If any of these is statistically significant, then the TB-SB comparison has to be made separately for the two sets of data. The five effects we will consider here are those due to phase, sequence, sensory mode, order and stimulus subset.

The Phase Effect

Each subject received two phases of instruction, first TB and then SB or vice versa (Figure 1). During training there were an average of 18.8 errors in Phase I and 5.6 errors in Phase II, a difference that is significant (p < .05, Table 5).

This phase effect was not seen later in the experiment -- that is, in the review trials given during training, the equivalence and generalization tests and the full tests (Tables 4, 8, 9 and 10). In the full review there were more errors in the Phase I review than in that of Phase II (8.1 vs. 4.4, Table 11, not a statistically significant difference), but it should be remembered that the Phase II training intervened between Phase I and its review whereas only the Phase I review came between Phase II and its review.

Sequence Effect

There was a strong effect of the sequence of the two types of training. Six of the top eight students received TB training first followed by the SB tasks, and six of the bottom eight students had their instruction in the reverse order, SB-TB (Table 5).
This comparison was significant during training (p < .05), but not in any of the later stages of the experiment (Table 4).

The Sensory Mode Effect

There were fewer errors during training when the samples were auditory rather than visual (3.4 vs. 8.8, Table 4). This difference was statistically significant (p < .05), as was the difference between the two types of tasks during the full test (1.1 vs. 4.7, Table 4, p < .05). As seen in Table 4, auditory samples were handled better than visual samples in all the other tasks during this experiment, although these differences did not rise to statistical significance.

Order Effect

Sometimes the task with an auditory sample came first (the Intraverbal) and sometimes the visual sample was presented first (the Tact). The effect of order was not statistically significant. During TB training the students did better when the auditory sample came first, but during SB training the situation was reversed (Table 7). During the first phase the error scores were lower when the auditory task came first; during the second phase the students did slightly better when the visual task came first (Table 7).

Stimulus Subset Effect

Differences in the performances with the two subsets of each stimulus were not statistically significant, with one exception. During Phase I one subset of nonsense syllables was mastered with fewer errors than the other subset. The trigrams done especially well were CUV, GEP, KEF, NEM, PAF, TEV, WEX and ZAN while
more errors were made with BIJ, DAC, JEG, MIP, NOY, REZ, VEC and YAT. The means were 2.5 and 0.6 errors per task and this difference is statistically significant (p < .05).

It should be noted that, although the students were assigned to stimulus subsets randomly, those who worked with the first group of syllables were the three most successful subjects in the experiment while the other students were ranked 4, 7, 9, 11 and 16. Also, when these same two subsets of auditory stimuli were used with the other eight students in their second phases the mean performances were quite similar: 3.7 vs. 2.8 errors per task (not a significant difference).

Comparison of Topography-Based and Selection-Based Verbal Behavior

We will look at this comparison in the following stages of the experiment: training, review during training, equivalence test, generalization test, full review and full test.

Training

In comparing TB and SB training we have to look at one phase at a time (because of the significant phase effect) and one sensory mode at a time (because of the significant sensory mode effect). The significant sequence effect (that the TB-SB sequence was more effective that the SB-TB sequence) meant that only Phase I could be used (that being before sequence had its effect).

Looking at Phase I, visual TB training was done significantly better than visual SB training (7.8 vs. 19.1, p < .05, Table 4). In the Phase I auditory training there were fewer errors on TB than SB trials but this just missed statistical significance (1.0 vs.
9.6 average errors, .10 < p < .05, Table 4). A Mann-Whitney test of this difference found it to be significant (p < .05, see discussion on p. 54).

Another way to analyze these data is to ask how many students did better with TB as compared to SB instruction (column 2 in Table 2 and the column headed "TB minus SB" in Table 5). Eight subjects did better on the TB tasks and seven did better on the SB tasks (one did not make any errors). The two types of language instruction came out about even. However, a distinction appears when we look at the high and low performers (see the first line of Table 3). Of the top eight students, two did better on the TB tasks and five did better on the SB tasks (one made no errors). Of the bottom eight students, six did better on the TB tasks and two did better on the SB tasks. Those who made few errors did better with SB instruction and those who made many errors did better with TB instruction.

Of course, the combination of strong phase and sequence effects could produce a result like this.

Review During Training

The few errors made during the training reviews came slightly more often during TB rather than SB review (1.6 vs. 1.2, Table 8). This difference is not statistically significant. When the data are separated by phase, we see that the most errors in Phase I occurred on the SB reviews and in Phase II the most errors were on the TB reviews (Table 8).

About the same number of students did well with each of the two type of instruction during this review (Tables 2 and 3). This was true of both the upper and lower half of the data.
The students in Tables 2 and 3 are ranked according to their performance on the task in question. Very similar results were obtained when the ranking achieved during training was used for the analysis on all the subsequent tasks (see p. 65 for more discussion of the students' relative performances).

**Equivalence Test**

There were no statistically significant differences between equivalence tests after TB and SB instruction (2.1 vs. 3.5 average errors, Table 9). The corresponding percent correct after TB training was higher than the percent after SB training: 86% vs. 78%.

About the same number of students did best on their equivalence tests that followed TB training as did best on their tests after SB training (Tables 2 and 3). This was true of both the upper and lower half of the data.

**Generalization Test**

The students had slightly more success pointing to the correct symbols after written instruction than writing them after training that involved pointing (1.8 vs. 2.8 average errors, Table 10). In terms of percentages this was 92% compared to 88%. These differences were not statistically significant.

The students did better generalizing from TB to SB tasks (9 students) than vice versa (6 students, Tables 2 and 3). This difference was due to the poorer performing students who favored TB instruction by a margin of 6 to 2, while the top students did better slightly with on the SB tasks (4 to 3, with one tie).
Full Review

The errors during these reviews of the four training tasks showed the same pattern as the errors in training and in the reviews during training. That is, TB had the advantage in Phase I and SB in Phase II although this was not statistically significant (Table 11).

About as many students did better with TB as did better with SB instruction, but when the data is ranked, the top students did better with SB and those who were not so successful were slightly more successful with the TB tasks (Tables 2 and 3).

Full Test

Since the auditory tests were done significantly better than visual tests, the data in Table 12 is separated according to sensory mode (Table 13). In the auditory mode, TB had the advantage over SB during training (0.2 vs. 0.6 average errors) and generalization (0.4 vs. 1.0) and, in the visual mode, TB had the advantage during generalization (2.0 vs. 2.9). The only instance in which SB had the advantage was in the visual training trials (2.2 vs. 2.3), although this represented a difference of only one error. In the equivalence tests (that all involved auditory samples) the performance established by TB training was slightly more successful than that established SB training (5.3 vs. 5.6, Table 13).

The TB versus SB comparison on the full test training tasks is similar to what we saw for the original training data: taken together the students did about as well on one as the other but, ranked by performance, the better students favored the SB tasks and the students who made more errors did better with the TB tasks. On the equivalence tests, there was a tie: an equal number of students scored better with each type of language when considered together and when separated according to
performance. On the generalization tests, the pattern we saw during the original performance was repeated: treated as one population, more students scored best when generalizing from TB to SB but, looking at the students above and below the 50th percentile, there was a tie in the top students while the lower performing students accounted for the overall TB advantage (Tables 2 and 3).

Other Observed Effects

Data was also produced on retention, persistence of differences through the experiment, ceiling effects and expected effects (those that these procedures are expected to produce).

Retention

The students did well when re-exposed to a task taught in the previous session making an average of 1.4 errors on review tasks given during training (Table 8). They also did well on the full review of the two Phase II training tasks, averaging 4.4 errors (these reviews came an average of 2.6 days after completion of Phase II training). Their retention of the Phase I training was not as successful: they averaged 8.1 errors on the Phase I review that followed training by an average of 6.6 days during which Phase II training had been done (Table 11). The question of whether the difficulty in the Phase I review was due to the passage of time or to the interference of Phase II training was revealed by one subject who took a vacation after the full reviews so that they had to be repeated. First, Marco scored 80% on the Phase I review (6 days after training) and 95% on the Phase II review (5 days after training). He then left town. When he came back 6 days later, the Phase I and II reviews were repeated and his scores were 91% and 94%, respectively.
Persistence Through the Experiment of Differences in Training Performance

In Table 1 the subjects are ranked according to the number of errors they made during acquisition of the four training tasks. This same order is maintained in the subsequent tables to facilitate the inspection of individual performances. Did this ranking during training correlate positively with their performances later in the experiment -- that is, in review during training, equivalence and generalization testing, full review and full tests? First, two columns were made of the training errors of each of the 16 subjects and the combined errors each of them made in the subsequent stages of the experiment. These two columns were ranked and the columns of ranks were correlated with Spearman's rho. There was a significant positive correlation between performance in training and in the rest of the experiment ($r = 0.768$). No significant rank correlations were found between training and each of the other tasks considered separately.

Ceiling Effects

The subjects received four different versions of the procedures, each change designed to increase the errors produced (see p. 49). The overall percent correct achieved by Groups A, B and D dropped from 93% to 91% to 88% (Table 15). Group C was one subject (Rebeca) who received the same treatment as Group D except for the following sentence at the end of the instructions just before the cued demonstration trials: "Move the cover (or point to the symbol) when you finish studying it." She spent a lot of time staring at each demonstrated stimulus relation and achieved a very high overall score (95% correct). This instruction was not given Group D subjects and, like the other students, they maintained a fairly rapid pace of responding. The Group D scores dropped to 88% correct.
A four-way analysis of the variance (ANOVA) for the scores of Groups A, B, C and D showed that their differences were not statistically significant, an important result for our analysis because it allows us to pool the data produced by these four slightly different procedures (Table 15 and p. 49).

**Expected Effects**

There were five effects that we expected to see in these data: (1) the advantage of auditory samples over visual samples (because the auditory samples were part of familiar words, while the visual samples were not); (2) the advantage of learning names for symbols before matching them to patterns -- that is, the order effect: doing the Intraverbal task BC or BD before the Tact AC or AD (because the auditory task gave them names to use while working on the visual task); (3) the advantage of generalizing from TB to SB instead of the reverse (because recognition tasks are often done better than recall tasks, e.g., Brown, 1976; Hanson & Hirst, 1989); (4) the interference of Phase II instruction on retention of the Phase I performance (because of the common observation that forgetting is a function of the intervening behavior rather than the passage of time); and (5) the decrease in scores as the procedures were progressively made more difficult for Groups A, B, C and D (because each procedural change involved less instruction). All these effects were seen, although only (1) was statistically significant (p. 59).

**Error Analysis**

There were 1,391 errors during this experiment. Analyzing the possible sources of control of an error is extraordinarily time consuming. This sort of analysis is rarely mentioned in dissertations on TB and SB instruction or in published papers.
on equivalence relations. A full error analysis goes beyond the scope of this report but summary statements on a few key issues will be given.

**Writing Errors**

These errors were either in details of the response topography or in the stimulus control of the response (i.e., a whole wrong symbol was written). The error response was almost always one of the eight symbols being used at the time or a malformed version of one of them. The two sets of symbols were rarely confused until the full test when, for the first time the students were given a mixed set of all the different tasks from both phases of the experiment.

Some written responses were not perfect but were still recognizable and met the criterion that all observers would point to the same correct symbol when asked to match the written response with a copy of the symbols used in the experiment. These were called problems of penmanship and did not count as errors.

A particularly important type of nonstandard written response was the reversal or rotation of the symbol which will be treated next.

**Reversals**

Thirteen of the 16 subjects reversed or rotated some letters; six examples are included in Appendix E (p. 154: windows 2, 7, 10 & 11; p. 155: windows 3 & 11). Most of this involved indirectly established behavior: 81 of the 96 instances were on generalization tests or on the generalization trials in the full tests. The other 15 examples came during the TB preparatory stage; there were no reversals while working on the four training tasks. Two of the 16 subjects did more reversing than the others: 36 of the 96 reversals were by Marco and Miguel, who ranked among those...
who made the most errors during this experiment (Table 1). During the initial interview both of these individuals mentioned having academic problems.

Biases

There was almost no evidence of biases toward certain response windows or sequence of response windows on the SB tasks, or to certain stimuli (pointed to or written) or to a sequence of trials (learning the scoresheet). The only exception was that during initial acquisition three subjects avoided guessing and stuck to one particular error response until it turned out to be correct. Also, one subject (Nono) used a limited set of error responses in the TB full review: 20 of his 24 errors involved only three different written responses. He was the only subject who showed this kind of bias. He was also the subject who made the most errors during this experiment.

The Methodology

The main datum regarding the use of simple methods for this kind of research is that the experiment was successfully completed. During 115 sessions 14,328 trials were presented to 16 subjects. Scoresheets were filled out for each trial and an audio tape recording was made. A permanent record was kept of the written responses.

Four tasks were directly instructed and another six tasks were taught indirectly. By the end of the experiment each student had organized 48 stimuli into 16 three-member classes made up of a quilting pattern, a nonsense syllable and a Japanese Katakana symbol. Many other stimulus-response relations were established that we did not test as demonstrated by the 11 tasks during the final interviews.

These sessions took between 30 and 50 minutes, usually two or three times a week. At the rate of $5 per session, it cost $725 to pay the students and observer.

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The experimenter kept a list of every mistake he made. In presenting these 14,328 trials E made 58 errors. Most of them could not be expected to affect the student (for instance, 22 trials were given in the wrong order and on 17 other occasions the wrong SA, cue or CO sheet was presented momentarily and immediately withdrawn). Only 5 errors were seriously misleading and required representing a trial with an explanation that the previous trial should be ignored; in 4 of these cases the subsequent performances were perfect. In one instance, however, the experimenter may have contributed to subsequent errors. When Gerardito was writing the eight symbols during his TB preparatory stage, E accepted the wrong symbol on seven trials. Gerardito wrote the 6th symbol listed in the answer sheet on page 124 instead of the 6th on page 126 (they look like || and \|). E did not notice the mistake until the first time the error was made on a training trial when he explained the situation to the S. Later, on the full test, Gerardito missed four out of 18 trials involving these stimuli. On two equivalence trials he pointed to the visual pattern associated with the wrong one of the two symbols E had confused during the preparatory stage.

Reliability

As seen in Table 16, a trained observer recorded 30 of the 115 sessions (26%) and 3,483 of the 14,328 trials (24%). We agreed on over 99% of the trials. We disagreed 26 times. It could be established that the observer was correct on 9 of these trials and the experimenter was correct on 15 of them. On two trials it could not be determined who made the mistake. There were also two recorded instances in which both observer and experimenter were wrong.
The observer was also constantly vigilant for inadvertent cues that might be confounding the experiment. None were noted.

The observer took on several other important roles not in her original job description. She interrupted the session when E made an error that would have misled the student. If it looked as if we were diverging from the scheduled sequence of tasks, this was mentioned. She worked to maintain a pleasant social environment during the sessions and afterwards she helped go over what had happened and what was coming up next.
DISCUSSION

Topography-Based and Selection-Based Verbal Behavior Compared

When there is a significant statistical difference caused by any of our experimental procedures, from then on the subjects who received the different treatments have to be analyzed separately. The phase effect during training means we can compare within columns but not rows in Table 6. The sequence effect means we cannot compare within the Phase II column but we can use Phase I data because sequence was not a factor at the beginning of the experiment. The sensory mode effect is significant during training so we have to separate the auditory and visual data. These restrictions on our analysis limit us to the conclusion that, during Phase I TB training was more effective than SB for visual tasks and nearly so for auditory tasks (p. 60).

The evidence from the training trials, then, supports the advantage of TB over SB verbal behavior found by Sundberg (1990) and Wraikat (1991b). However, there was a difference in the TB and SB procedures that might have been responsible for this observation. The TB preparatory stage involved writing the 8 experimental stimuli in the absence of any cues. The SB preparatory stage involved pointing to the CO stimulus that was identical to the SA stimulus (identity matching). The TB task required control by the full set of 8 stimuli and initially the experimenter thought this kind of set mastery was automatic in the SB case because of the simultaneous presence of the 8 stimuli on each trial. In retrospect it would have been better to teach a SB version of the TB set mastery task. The student could be taught to point to a different one of the 8 stimuli on 8 successive trials (using different CO sheets on each
trial). Alternatively, the student could be shown single stimuli and taught to point to each of the 8 experimental stimuli the first and only the first time they appear. So, it is possible that this difference in the preparatory stages contributed to the sequence effect we observed.

Turning to the results after initial training, we have to allow for the same phase, sequence and sensory mode effects when they are found to be significant. When this is done and the data analyzed we see that none of the observed differences between TB and SB are statistically significant (pp. 62-64), so we are left looking at the directions in which the data point.

We see that more errors were made on SB than TB tasks during training, equivalence, generalization, full review and on 4 of the 5 comparisons made on the full test data (Tables 4, 5, 9, 10, 11, 12 and 13). SB had fewer errors on the review during training (when very few errors were made) and on one of the full test comparisons (when the difference was only one error). These advantages of TB over SB were not significant but they were in the same direction as the significant difference found during training (which may be compounded by a the lack of a set mastery features of the SB preparatory stage).

The same equivalence test was used after TB and SB instruction and this test was SB. It might be assumed that SB testing after TB training would be a harder task than SB testing after SB training (Anna Kay Campbell, personal communication, October 18, 1994). The percentages pointed in the opposite direction, possibly because the initial training was more effective when TB rather than SB (for reasons discussed on pages 76 to 80). It would be possible to do TB as well as SB equivalence tests (for instance, the S could draw the pattern after suitable preparatory training in this task).
Looking at the scores of individual students (rather than grouping the data and applying statistical tests) we see that the TB and SB verbal behavior were handled about equally: with the 16 students each doing 8 tasks the score between the two types of language was TB: 55, SB: 48 (and 25 ties, Table 3). When this was broken down into more and less successful groups of students (above and below the median) the good students did better with SB instruction and the less successful students did better with TB instruction (Table 3). At present we don't know whether this observation is a cause or an effect. TB behavior might be easier for the students having trouble and the better students might make especially good use of the SB procedures (for reasons discussed below), or phase and sequence effects working together might have produced these results (for instance, looking at Table 6, these two effects give high error scores in cell 3, low ones in cell 2 and intermediate ones in cells 1 and 4, producing a SB advantage for those scoring few errors and a TB advantage for those making many errors).

It is interesting that this pattern (in the numbers of students doing better on TB and SB tasks) is found whenever the training tasks are presented (during training, full review and on the full test, Table 3) with the single exception of the review during training when very few errors were made and they were about evenly divided between the language types. The equivalence tests after TB and SB training did not show a difference when the data are separated into high and low performers. The two types of generalization were done equally well by the better students whereas those making more errors had more success in the TB to SB direction than vice versa. TB instruction had an advantage in equivalence and generalization tests when we looked at numbers of errors made, showing us that numbers of students is a less sensitive dependent variable.
There are several problems with this analysis showing that students making few errors did better on the SB tasks and students in trouble benefited from the TB tasks (last two lines of Table 3). Phase and sequence effects working together might produce the same pattern although it is surprising that it persisted into the full test which came after meeting criterion several times during the training and review stages of the experiment. Furthermore, dividing the sample at the median is arbitrary -- the two populations (if they are that) might separate anywhere between the extremes.

We will have to await further experimental studies for clarification of just what various forms of control were intersecting in the behavior of our subjects. In any case, the experiment described here provides valuable suggestions about how to do this research.

It also suggests interpretations of previous work. First, it must be said that the Sundberg (1990) and Wraikat (1991b) studies were extremely useful to me. I cannot overstate how appreciative I am of their contributions. My comments about procedures are meant as suggestions for others who follow us. In this light let us consider several features of the earlier studies that might have made it somewhat more difficult to establish stimulus control in the SB phases rather than the TB phases of their experiments.

In the SB correction procedure the experimenter pointed to the correct comparison (CO) stimulus and then the subject pointed to the same stimulus. This procedure may have prompted imitation of the pointing response rather than discriminative control by the sample and CO stimuli (these subjects readily imitated the motions made by the experimenter). Note that this could have slowed acquisition of the SB tasks but it was not a problem during TB tasks because their correction was based on imitation of the experimenter's sign in any case. In my procedure, an
example of the correct CO stimulus is presented after an error so the subject has to search for the correct stimulus in the CO display.

The Sundberg and Wraikat correction procedures also involved exclusion training. The experimenter would say "No, that was _____; this is _____." Presenting two samples and pointing to two comparison stimuli in rapid sequence might have been more confusing in the SB case than presenting two samples and making two signs in the TB case (the CO's remain in view but the signs disappear). The subjects might even have looked at the second stimulus pointed to while still under the control of the sample mentioned at the beginning of the correction sentence.

Another point is that in these studies there was no preparatory training (echoic, copying a sign or identity matching). The "pretraining phases" were cued trials at the beginning of training and at the start of each session. Demonstrating a SB task may not have been as effective as demonstrating the TB relations, especially given these subjects greater history imitating people as compared to doing discrimination work on a table-top.

Furthermore, from the point of view of these subjects, the CO stimuli in the SB tasks might have been more similar to each other than the signs used in the TB tasks. Sundberg's two-dimensional printed stimuli were a circle, square and triangle and the letters W, X and U. Wraikat's printed stimuli were Greek and Arabic letters. The signs were large motions or positions of one or two arms. In the experiment reported here the CO stimuli were the same as the response-produced stimuli (sets C and D).

Also, the signs they used might have prompted covert naming by the subjects more readily than the printed stimuli. Several of Sundberg's signs involved touching parts of the body for which the subjects already had names (e.g., "pinch nose"). To avoid this confound Wraikat did not use signs in which the arm touched the body, but
covert naming might still have been easier for signs rather than symbols for these subjects.

So, the procedures used earlier may have been slightly biased in the TB direction. The current subjects may also have been handicapped because of a difference in the TB and SB preparatory stages (pp. 71 & 81). In spite of this, the most successful training in the experiment reported here was the Phase II SB instruction (cell 2 in Table 6). This could have been due to the combination of phase and sequence effects, but it could also be that there are circumstances under which SB training has the advantage.

What features of TB and SB verbal behavior might explain their differences? Each of the two types of language has features that make it both easier and harder than the other type. We don't know which features were at work during this experiment but some discussion of the possibilities is appropriate at this time. Note that we are considering features of the behavior itself rather than its convenience to the teacher or student, which is the topic of two recent reviews (Shafer, 1993; Sundberg, 1993; see p. 14).

Advantages of TB Language

When a cue is copied during the initial demonstration stage of training, the various component features of the cue control the response. This is also true when the cue is copied during correction after an error. On the SB trials only part of the cue and correct CO have to control the pointing, enough to contrast with the control in the presence of the error stimuli.
Additionally, there is a temporal difference: it takes longer to copy a stimulus than to point to one. This additional time might be important in itself or it could allow the action of other factors on this list.

As the writing response proceeds it produces a characteristic product which itself may control responding. In the SB case there isn't a stimulus change of this kind.

It may be that the difference in TB and SB behavior is simply the difference between control by one stimulus and two. Conditional control may be inherently more difficult even though the response controlled is different in each TB relation but the response is the same in all the SB relations.

Memory is aided by giving the objects to be remembered a characteristic place (this is a standard trick of memory experts). Writing may be like having a special place on the paper for an object (the line).

Emitting a characteristic motor response in the presence of a stimulus helps us respond appropriately to that stimulus at a later time. A striking example is Frank Laubach's literacy technique that has been used to teach over 300 languages around the world (Laubach, 1960). Each letter is incorporated into the drawing of a common object whose name starts with that letter (a "B" might be drawn on a sketch of a bee). When in the presence of the "B" alone the student presumably thinks of the bee whose sketch resembled the letter and names it covertly (these are the characteristic responses), then takes the initial sound of the name and says that as the sound of the letter. Another example of a TB response aiding memory is called the modality effect: a list read vocally is remembered better than one read silently. (Crowder, 1986) You can try this with the numbers listed in the scoresheet in Appendix D: read ten numbers silently or aloud, count to five and see how many of the numbers you can say, beginning with the last one and proceeding backwards. I wouldn't be surprised if this
effect increases with age, as those of us know who keep saying the telephone number as we walk from the phone book to the telephone.

TB behavior results in kinesthetic and proprioceptive response-produced stimuli that are then available for pairing with the consequent stimuli. SB response products are similar from trial to trial.

Any of the above may be effective by mediating the delay between response and consequence.

Disadvantages of TB Language

Does TB language run into limits when large numbers of stimuli are involved, or when very long periods intervene between training and testing?

Those who advocate the use of SB techniques with disabled people argue that intuitively it must be more difficult to recall a characteristic form than to recognize one (Brown, 1976; Hanson & Hirst, 1989). Also, it is reasoned that when stimulus control is weak it is presumably a help to have overt stimuli there in front of you.

Advantages of SB Language

A SB trial provides overt stimuli, the CO sheets, not present during the TB trial. It should be easier to compare two stimuli, clear up confusions, to exclude some stimuli and only work with the others, calculate the significance of an incorrect guess, and to practice correct responses to all the stimuli during any one trial. This may be mainly useful to the students with histories that prepare them to set up covert memory schemes and to do so in a minimum of trials.

These advantages of SB are not inherent in the behavior itself but in other behavior of the subject while during the SB performance. Of course, this all can be
done during TB trials but that is without the support of the overt cues present in SB arrangements.

Intuitively, SB has the advantage of recognition over recall and the response is simpler because it is the same on each trial.

**Disadvantages of SB Language**

It is possible that on SB tasks it is easier to make careless errors or ones that come from moving too rapidly -- that is, ones that the subject corrects moments later. During the experiment reported here the error card was used much more often on SB rather than TB tasks (although data on this was not calculated). It may be that SB errors are more likely when control is weak, such as when the subject is disabled, unmotivated, under aversive control, stressed, tired, distracted or nervous.

On a SB correction trial it is possible to pick the CO stimulus that shares features with the cue and rapidly move on to the next trial which then interferes with the previous trial because all the CO stimuli are the same (although in different positions). In the TB case there is a period of time during which a distinctive stimulus emerges (that produced by the response). Looking at a sequence of trials from one presentation of a sample to the next presentation of the same sample, the intervening trials are more similar to each other and to the first instance in the SB case than the TB case -- and there is more possibility of interference by similar behavior during the interval between training and testing.

The presence of error stimuli during a trial may make their control on a later trial more likely than in the case where only stimuli produced by the student are present (in addition to the sample that is present in both types of trials). As the student responds correctly he or she may look at the error stimulus and covertly
respond to it at almost the same time or even after the response but before reinforcement. This would be like the presence of error choices on a multiple choice exam serving as an occasion for the student to learn the wrong responses.

One student, Eugenia, reported after the experiment that the SB tasks were hard because she second guessed herself, becoming undecided, whereas in TB trials she simply responded. It may be that in the SB case overt error stimuli compete more closely with the correct stimuli than in the TB case where only the sample is overt.

The relative strengths of control by correct and incorrect stimuli may be nearly the same at the moment of response -- after all, they are all present in front of the student, the error stimuli have just been controlling the searching behavior and they are in positions that they share on different trials. It is reasonable that a student might be able to successfully complete a SB trial under weaker control than the typical TB trial. Often during the early stages of acquisition the student's finger will move back and forth between two stimuli or even hovers over the line between the two.

These, then, are some of the possible sources of differences between TB and SB language. The type of instruction to choose in a teaching situation will be considered in the section on the applied significance of this work (p. 97). Which of these variables are at work needs to be studied and suggestions will be made in that regard (p. 101). First, let's consider what else we saw during the experiment described here.

Effects That Were Observed

Six effects were observed. These were called the phase, preparatory, sequence, sensory mode, order and stimulus subset effects. In this section these
effects will be defined and their causes discussed. A later section of this report will deal with designing experiments that avoid these confounding effects (p. 101).

Phase Effect

Each subject received two sets of tasks, TB or SB. A phase effect was seen when there was a significant difference in the total errors during the two phases (combining the TB and SB scores for all the subjects). In our experiment, the first phase was always the most difficult (p. 58).

Why might the students make more errors at the beginning of the experiment? Many of them said they were nervous. Certainly they were unfamiliar with the procedures. This does not explain how nervousness or unfamiliarity impacts the performance. During Phase I there were 230 SB errors compared to 70 TB errors. It could be that SB behavior is more affected by nervousness and unfamiliarity (as suggested on pp. 79 & 81), but it could also be that the preparatory or sequence effects account for this difference between the SB and TB error totals.

Preparatory Effect

Any difference during the TB and SB preparatory stages might affect the data. The purpose of the preparatory stage was to familiarize the subject with the stimuli, responses and procedures of the experiment. This was done by having the students write the full set of 8 symbols, rapidly and repeatedly in different orders (this was done in 7 stages as described on p. 35). In the SB case preparation was accomplished by identity matching (pointing to a CO stimulus that is identical to a SA). It was assumed that mastery of the set was implied by the simultaneous presence of all 8 stimuli in front of the subject on each trial. This might not be true. The student who
received TB training to produce the 8 stimuli (without any cues) might have had an advantage when doing the SB tasks in the next phase as compared to those students who received the SB training first. Notice that this would not explain why SB error scores were lower than TB in Phase II. In any case, there is no independent measure of the preparatory effect -- it might be called the preparatory hypothesis. Further experimental work will have to be done to determine if this is an important experimental variable.

**Sequence Effect**

This is shown by an advantage of TB followed by SB compared to SB followed by TB. A sequence effect cannot be seen in the first phase because by definition it is the product of one stage of instruction on the next. Six of the top eight students were given the TB-SB sequence and six of the bottom eight students were given the SB-TB sequence (p. 58). Of course, this could have been produced by the combination of phase and preparatory effects with the differential sensitivity to these effects of TB and SB behavior.

Please notice that these effects are not exclusive categories: a sequence effect could be produced by a phase effect plus a TB performance that is better than SB (or vice versa). A sequence effect could also derive from the combination of phase and preparatory effects. To produce the pattern we observed in the four cells in Table 6, we would need an additional source of control such as a tendency for errors to lead to more errors (as is often seen in programmed instruction, e.g., Cresson, 1979). This could explain why there were more errors on TB tasks that followed the Phase I SB tasks and why the fewest errors were made on Phase II SB tasks.
There are other sources of competing control. There was probably some tendency for the second phase to be more difficult because the total number of stimuli was larger (counting both phases together) and because there would be some confusion between stimuli used in the two phases. Two students mentioned this problem during the final interview. This was made worse by the fact that I had put potentially confusing stimuli in separate subsets so the introduction of the second subset could have entailed several confusions. One student associated flowers with two of the patterns in the first phase and then did it again in the second phase and became confused on the full test when three stimuli associated with flowers were present on the same trial.

Several variables may be at work at the same time. The current data does not allow us to distinguish between these causes of the observed effects.

**Sensory Mode Effect**

This is seen when the tasks with auditory samples are done more successfully than those with visual samples, as shown during training and the full test (p. 59). Similar results have been reported by Gina Green (1990) who found with mentally retarded adults that three-member equivalence classes including one auditory and two visual stimuli developed more rapidly than classes that were purely visual.

There are several possible reasons for this effect: (a) these students had much more history with the nonsense syllables (which were all components of common English words) than quilt patterns; (b) the patterns might have been more easily confused with each other than the sounds; (c) the physiologies of some people may be more suited to auditory rather than visual discriminations; and (d) auditory stimuli may evoke covert naming of the stimuli which could be advantageous.
Order Effect

This involves differences due to the order in which the two training tasks are taught. The data support a slight but not statistically significant advantage of receiving the auditory task before the visual, especially in the first phase and on the TB tasks (p. 58, Table 7). This is not surprising because it means the symbols and patterns in the second task can both be named with vocal versions of the auditory sounds associated with symbols in the first task.

Stimulus Subset Effect

The students did about equally well with the two different subsets of each stimulus (p. 59). This is a very time consuming sort of analysis, involving comparing the two subset's composite scores derived by adding up the errors made by all the students who received a particular stimulus or response in a particular context in the tasks.

The only exception was the two sets of sounds, but that was probably confounded by the fact that one subset was used by the best students and the other by a more representative sample. Also, this result was only found in the first phase of the experiment. If one set of the syllables really was easier to work with than the other, then it should have affected the performance of the rest of the subjects who got these syllables during the second phase.

Other Observations

Equivalence Tests

The subjects demonstrated the formation of 8 stimulus equivalence classes
and 8 functional classes (the equivalence tests after SB and TB training, respectively). Each of the 16 classes had three members, a pattern, a nonsense syllable and a Japanese Katakana symbol. Thirty-two relations were taught directly and, as demonstrated by the equivalence tests, 16 others were formed indirectly.

Also, during the final interview 64 other functional relations were demonstrated when the students wrote the appropriate letters and vocalized the sounds in the presence of the visual patterns and the symbols used in TB and SB training. Teaching 32 relations resulted in 80 additional performances (although no one subject did all these tasks). The relevance of this to education is discussed on p. 97, below.

Reflexivity was demonstrated during the errorless preparatory stages and symmetry appeared accidentally when the experimenter presented symbols as SA's with patterns as CO's on two trials (which were done correctly). A form of symmetry involving functional rather than equivalence classes was shown when students responded to a visual symbol by correctly vocalizing the sounds or writing the letters that represent the sounds that served as samples when these symbols were written or pointed to during training. The students also wrote, pointed to or said the appropriate sounds when shown patterns, tasks that were symmetrical with a task that was itself indirectly established, i.e., the task used in our equivalence tests (pointing to a pattern in the presence of a sound).

An important question is which of the characteristics of training show up in the equivalence performance. The advantage of TB in training was evident in this test (although this was not statistically significant). There were no significant phase, sequence or order effects in this data. The sensory mode effect was not relevant since all the tests used auditory SA's and visual CO's. Interestingly, rank established during training did not show up in the ranking during this test, although there does seem to be a positive correlation with rank in some of the later stages in the experiment (p. 65).
Some of the students responded on equivalence trials as quickly as they did on the trials at the end of training. Others worked slowly, apparently doing a lot of thinking before responding. Apparently the equivalence relations were sometimes established during training and sometimes worked out at the time of testing.

The performance after TB training was slightly better than that after SB training (87% correct vs. 78% -- not a statistically significant difference). There were not many errors, the differences are not statistically significant and there was a lot of variability in the data (with results ranging from 100% to 38%). This does not help us much in comparing functional equivalence and stimulus equivalence.

Improvement during testing was not seen except when students were working out problems on the full test (something they tried to do even though no consequences were delivered during the test).

**Generalization Tests**

It was slightly easier to point to a stimulus that had been written during training than to write what had been pointed to. This difference was not significant but that is probably because of a ceiling effect -- only 91 errors were made by these 16 subjects in the 32 generalization tests.

Also, there were more reversals or rotations of the indirectly established performance than that directly trained (when errors were corrected). The same phenomenon was noted when generalization tests were given during the full test and the final interview (p. 67). This should be studied.

Other kinds of generalization were demonstrated when, during the final interview, the experimental stimuli or written responses were sorted into two sets according to the type of training with which they were associated (TB or SB), and also
when the students wrote phonic equivalents of the sounds used in TB and SB training (p. 57 and Table 14).

The difficulty of writing a stimulus that has been pointed to during training and the frequency of reversals of these indirectly trained writing responses shows us that learning to point to a stimulus and learning to write it are not the same thing. Other evidence that may indicate the same basic difference is that TB tasks were learned with fewer errors than SB tasks, and that this advantage appeared in the review during training, the equivalence and generalization tests, the full reviews and the full tests (pp. 60-64).

This would seem to indicate that TB writing is not simply copying what the student covertly points to (since the necessity of writing down something a person thinks can not be a source of error for these subjects). These results do not support the cognitivist argument that TB and SB tasks are different external manifestations of the same covert processes. Writing and pointing are different.

**Expected Observations**

The results given here were as expected with regard to phase, sensory mode and order effects, generalization by pointing and writing and the effect of gradually making the procedures more difficult. These results were not statistically significant (p. 66).

We will discuss two other expected observations that were noted in the pilot study briefly described on p. 89, below.

Thus, the methods described in this report produced scores that tended in the expected direction in all the five situations where we could predict the outcome on the basis of widely known behavioral phenomena. This suggests that the statistically
insignificant results we have been describing may well be accurate representations of the relations we have studied.

Ceiling Effects

When comparing TB and SB verbal behavior the experimenter must make the instruction effective and yet generate errors. The work described here started out as a virtually errorless learning program and was made successively more difficult until errors appeared. Two questions are raised by ceiling effects (that is, when the subjects cannot be compared because they are all performing at such a high level): (1) what use can be made of the small differences noticed during ceiling performances, and (2) what can we do to avoid ceiling effects.

On page 49 we described the adjustment in procedures that were necessary to increase the number of errors for Groups A, B, C and D. These involved the number of trials with a cue present during training, the correction procedure and the number of full reviews before the full test. The percent correct dropped as the adjustments were made (p. 65, Table 15). The performance of the single student in Group C suggests that, in experiments such as this, details of instructions can markedly influence results (p. 65). Pilgrim & Johnston have published a useful discussion of this issue (1988).

Procedural details were a powerful variable controlling the performances in this experiment.

Retention

These subjects did well after delays when no experimental work was done during the intervening time. The subjects met criterion with an average of only 1.4 errors on the reviews given during training (Table 8). Their scores dropped when
other training intervened between the two sessions. The full review of Phase I (whether TB or SB) was done with an average of 8.1 errors compared to 4.4 errors for Phase II (p. 57, Table 11). This supports the notion that we forget because of interference of other behavior during the interval rather than because of the sheer passage of time.

A demonstration of this point came when Marco had to leave town after his full review and be retested after his return (p. 64). Apparently the initial drop in Phase I scores was due to the interference of Phase II training rather than the mere passage of time.

Pilot Studies

Before the work described in this report, two pilot studies were done. The methods were the same as those you have been reading about with the exceptions noted in Figure 8. Initially we thought it would be difficult for the students to keep 48 arbitrary stimuli organized in 16 three-member classes so, in order to give the best instruction in both the TB and SB phases, we included a lot of demonstration, practice and review. For instance, Pilot Study #1, with only 4 stimuli in each set instead of 8, was used to introduce the students to the experiment to avoid a phase effect. Training included an extra stage in which the cues were shown for only about a second at the beginning of each trial. After an error the correction procedure was followed by a repetition of the trial that had been missed. The criterion for mastery was 24 trials instead of 16. The full reviews were repeated several times and review was given at the beginning of each session during the first administration of the full test.

The result was a virtually errorless learning program. None of the results obtained was statistically significant. These students averaged one error during
Figure 8. Differences in the Procedures Between the Main Experiment, Pilot Studies and Follow-Up Study.
training on the four basic tasks, while those in the main experiment averaged 24 errors. Preparing the students by giving Pilot Study #1 first seemed to help. The six subjects made 18 errors during training in the preliminary experiment and then only 6 errors in acquiring the four tasks in the second study even though it involved twice as many stimuli. On their first full test in Pilot Study #2 these subjects averaged 3 errors (in 144 trials) compared to 23 for the students in the main experiment.

When the full test was re-presented without the benefit of any review or retraining these hard-working students made an average of 4 errors after a delay of one week and 7 errors after a further delay of one month. This is not a record. Long-term stability of equivalence relations in the absence of training or practice was demonstrated over two- and three-year intervals with a mildly retarded adult subject (Saunders, Saunders, & Spradlin, 1990).

Although there were very few errors on these full tests, they tended in the same direction as the errors on the full test in the main experiment. Equivalence class formation was better after TB than SB training (99% to 95%), generalization was easier from TB to SB than the opposite (99% to 94%), and auditory samples were handled more successfully than visual (99% to 95%). The only disagreement with the work described earlier in this paper was that SB training tasks produced fewer errors than TB training tasks (100% to 96%) and this was probably because 8 stimulus CO sheets were used instead of 16 stimulus sheets (on SB tasks there were 8 available choices but on TB tasks the student could write any of 16 symbols).

There was one point at which these clever people made a lot of errors: when the tasks from the first pilot study were re-tested they averaged only 62% correct. The delay was only a few weeks but Pilot Project #2 had intervened and powerfully disrupted the earlier performance. The scores were so highly variable that no useful conclusions about retention could be drawn from this data.
These pilot studies support several of the conclusions already drawn from the main experiment:

1. Procedural variables are very strong in these experiments; the teacher's methods can be a powerful determinant of student errors.

2. A preparatory experiment can lower the number of training errors in the experiment that follows.

3. With these methods statistically insignificant effects often point in the expected directions.

4. Interference rather than time is the critical variable on memory tasks.

**Follow-Up Study**

After the main experiment was completed, the two students who had made the most errors were run through Phases I and II again with the Sanskrit letters from Pilot Study #1. There were only 4 (instead of 8) patterns, sounds and symbols introduced during each phase. This follow-up was done to see if students who had trouble in the main experiment would still have trouble or whether the advantage of experience and a simpler task would result in fewer errors. It was also done to end the work with these students on a successful note so as to minimize any damage done by having given them a task designed to be difficult and on which they produced many errors.

Marco and Miguel (who both had histories of academic difficulties) did much better under the slightly different conditions of the follow-up study. Marco made no errors and Miguel made only three. By contrast in Pilot Study #1 (with many more training trials and repetition as well as correction after errors) 3 of the 5 students made no errors and the other 2 made 3 errors each. It was the experimental conditions that
made the pilot subjects look like geniuses and the two worst students in the main experiment look like failures.

Reliability of the Observations

When using simple apparatus there are many opportunities to provide inadvertent cues as to which response will be correct or whether a response on a test is correct. The observer watched the student and recorded the performance and she watched the experimenter to see if there were any inadvertent cues.

We disagreed on less than 1% of the trials (Table 16). The experimenter and observer were about equally at fault. This was determined by checking the audio tape or the written response sheet or, if these didn't help, by looking at details of the trial on which there was disagreement. It was usually the case that if one of us made the error the other person must have scored it correctly (in order to produce the record as it exists) but if the other person made the error then a total of three errors were made by the two people scoring the trial. The result was that in 24 of the 26 disagreements we could determine who was correct and who made the error.

The observer in this experiment did more than check score keeping and inadvertent cueing. Kendra Pearsall made many suggestions about running the sessions and she provided a skeptical sounding board for the discussion of issues as they arose. Her cheerful presence was a help to both the students and the experimenter. In sum, an observer can be an important addition to an experiment.

So, these then were our conclusions based directly on the data. Let us now move to a discussion of three more general issues. What general conclusions can be drawn about the experimental analysis of writing behavior, the applied significance of all this and further studies that could be done?
The Writing Response

Writing is unique among TB behavior in that a permanent record of the response is produced (see Appendix E for examples). Analysis is easier than in the cases of speech or manual signs. Thinking is made somewhat overt by keeping track of the corrections made in the course of the response. Simple apparatus is particularly helpful in this research because it is hard to program a computer to record a written response (the same argument applies to research with speech or signs).

Is Writing Independent of Speech?

There has been considerable debate in the fields of linguistics as to whether writing and speech are simply two manifestations of one underlying process or if they are separately conditionable. An excellent review of this question was done by Roy A. Moxley (1990) who concluded that the data support a multidirectional relationship between the two TB behaviors: separate speaking and writing vocabularies are common, deaf-mutes often can write but not speak, and writing may have characteristics not found in the vocal repertoire (such as self-editing). He finds support for this position in the behavioral literature, as in B. F. Skinner's comment that, "speaking and writing are obviously different kinds of behavior, which utilize different parts of the body in different ways....The two forms of behavior must be separately conditioned." (Skinner, 1957, p. 191, quoted in Moxley, 1990, p. 136)

In the experiment reported here vocal responses were not required. They may have been emitted covertly. Our data show that an overt spoken response is not necessary for the establishment of a written response, although covert versions of speech may have been involved. During the final interview spoken responses were correctly emitted although they had not been directly trained -- in some cases they
were even established by written instruction. Also, naming was important enough to result in an order effect during training (learning an auditory and therefore a subvocal name for a symbol did not help acquisition of a subsequent discrimination involving that stimulus). All this suggests the independence of the written and spoken behavior, although a better demonstration would be if the written instruction failed to establish naming or if the work was done with subjects who could not speak.

On the Covert Level, Is Writing Really SB Behavior?

If TB and SB tasks were really the same on the covert level, then how would we explain the various differences between TB and SB found in this study? If writing was a matter of covertly pointing to and then copying a stimulus, we would expect the written and SB performances to be similar (since these students could copy symbols readily and accurately).

The Kinds of Errors

The were four kinds of writing errors; the subjects produced: (1) a stimulus not used in the experiment, (2) the wrong one of the experimental stimuli, (3) a malformed version of the correct stimulus, or (4) a rotated or reversed version of the correct stimulus.

When an error was made quite often the students suspected it was wrong. Sometimes they immediately thought of the correct response, hitting the error card before the experimenter had responded. On other occasions the students struggled over a response making changes or starting over. Sometimes when one feature was wrong they would change a correct feature (correctly tacting the response-product as an error but not tacting the feature responsible).
Reversals

Occasionally students wrote the correct symbol but it was rotated or reversed. These met our criteria for correct responses. The number of examples was reduced by the experimenter’s corrections (after a task was completed penmanship problems were addressed so they would not be a source of errors later on). Also, when SB tasks were mixed in with TB ones the students sometimes corrected their own mistakes (although this didn’t always happen). Even the best students sometimes reversed or rotated letters: 13 of the 16 did it (p. 67). It was especially common on generalization tests: indirectly taught behavior did not resist reversal and rotation as well as directly taught behavior.

SB verbal behavior may be more sensitive to reversals than TB behavior. Sidman & Kirk (1974) found that letter reversals were more common during SB matching to sample than TB naming or writing, and improvement during testing occurred with the TB but not the SB procedures.

Interestingly, there were no reversal or rotation errors with the Sanskrit letters used in Pilot Study #1 and the Follow-Up Study. These letters each have a horizontal stroke at the top and a vertical stroke down the right side. When letters are combined into words the top bars connect so letters are divided by short vertical lines hanging down from a horizontal line across the top of the word. Connecting these top lines within words means that words are visually distinct units when a sentence is written and it is easy to keep the writing in a straight line. This alphabet is one of the oldest of which we have record and it is still used in India. Can it be that there is less dyslexia among readers and writers of Sanskrit rather than English?!
Methods for Studying Writing

This experiment demonstrated a sure way of instructing writing behavior and recording the responses. The cover sheet assured us that previous work did not serve as a cue. The various stages of instruction allowed errorless acquisition of both the preparatory copying task and TB responses controlled by auditory or visual stimuli. The procedures could be titrated to produce the desired level of errors. A few conventions made it possible to record the sequence of responses when the subject made changes during composition (i.e., crossing out earlier attempts, placing them in sequence on the paper and using a different color pen for later corrections). A permanent product was available for analysis. The associated stimuli, auditory or visual, were recorded on audio tape and on scoresheets. All in all, this was a very satisfactory way to study writing.

Now we will turn to the implications of this research in applied areas, particularly in the classroom.

Applied Significance

Relevance to Education

Teachers want to know whether to rely on TB or SB instruction (Shafer, 1993; Sundberg, 1993). Here are some cautionary points to consider as we begin to answer this question:

1. Different variables may be affecting the two kinds of behavior we seek to compare. For example, SB performance may be determined by the student's collateral behavior during the trial (searching behavior, covert behavior) while the TB scores
may be slightly higher because of the increased control by all the features of the stimulus in question.

2. We may be measuring the resultant produced by the operation of many variables at once.

3. Many circumstances may affect the comparison, such as the number of items being taught, whether we are looking at acquisition or retention after a very long delay or a lot of interference, or how nervous or careless the student is (if SB scores are more affected than TB scores).

4. The student's individual history may be critical (this covers many areas such as physical differences, mastery of prerequisites, motivation, and emotional reactions to the instruction).

5. Procedural details may be radically affecting the outcome; we might be comparing well-taught TB tasks with SB tasks that are difficult by their very design. With good instruction either TB or SB tasks can be learned errorlessly.

6. Even if one method works better than the other in acquisition, will it also be better when generalization is tested or on retention tests? Many situations might affect the comparison.

7. Number of errors is only one measure of the desirability of using a particular method. For example, several of the students in Pilot Study #2 reported that TB training seemed much easier than the SB version to them but this did not keep them from being almost perfect in both types of training.

8. Just because a student has more trouble with one method does not necessarily mean that the other method should be used. The problem is often the very thing we most need to work on. Check the prerequisites.

9. We must not mix together questions about fundamental differences and questions about convenience. TB language is easier because you don't have to carry
around a symbol board and SB language does not require special training of the audience, but boards can be small, specialized or computerized and audiences can be trained.

So, the teacher's choice of method depends on many factors besides any fundamental differences inherent in TB and SB verbal behavior. The student is a locus where many competing influences come together. The behavior we see has many sources and the same performance may represent very different behavior environment relations. In the end, rather than ask whether TB or SB instruction is better, we should ask which method works in the individual situation represented by each student. The present study does not help the teacher with this task except to suggest that it is important and to show that there are simple ways to do the large variety of tasks that need to be considered as the teacher searches for effective variables.

Relevance to Animal Behavior in General

This would be a most interesting and useful extension of the analysis given in this report, but it fails because of a lack of data. It would go to the heart of what distinguishes our species from others, and the role of learning in the ontogeny and phylogeny of behavior. Behaviorists have not effectively addressed these questions with nonhuman subjects, and biologists have not related their observations to our conceptual categories.

This topic needs the attention of both fields. Appendix G gives a few general comments for the student of animal behavior.
The Usefulness of These Methods

The methods described in this report may be useful in four areas: research, diagnosis, teaching and professional training.

Many kinds of research could be done with methods like those described here. They are particularly appropriate for tasks that are difficult to computerize, but, more generally, simple methods allow more people to engage in research.

We need comprehensive diagnosis of academic problems whether with normal children with academic problems, developmentally disabled people or brain injured people. The tools for this must be ones we can take to the client, ones that anyone can afford and ones that allow the systematic survey of all the language tasks. A great variety of procedures must be available to allow fine tuning to the needs of the individual student. Finally the methods must be sensitive to slight differences in the repertoires being assayed.

Teaching often involves an interaction between teacher and student on a tabletop. The present study simply systematized what would be an ordinary teaching environment. It allows the teacher to zero in on specific skills and to present them in a variety of ways. When problems are encountered it gives the teacher many options.

Some academic deficits might improve with practice in the mastery of simple academic tasks. Thus, these methods are available as a treatment vehicle. This was suggested by Marco who reported that his memory and concentration were improving during the experiment.

Lastly, this is a context in which it is easy to train teachers and researchers. Introductory behavior analysis laboratories need methods that are available to any participant and that can be applied to a wide variety of learning issues.
Many studies could be done with these methods, but let us return to the topic with which we started. What studies will help us compare TB and SB verbal behavior?

Suggested Studies

**Improvements in the Methods Used Here**

A group design with one treatment for each subject would be an advantage for research comparing TB and SB language. This would do away with the phase, sequence and stimulus subset effects that confounded the analysis of this experiment; these are all caused by giving both TB and SB instruction to the same student. The sensory mode and order effects result from each subject being taught two tasks; as long as an equivalence test is part of the experiment these effects have to be handled with a balanced design in which all possible combinations were given to the students. Training all four tasks at once would eliminate phase, sequence and order effects. The preparatory effect could be dealt with by including a SB preparatory task that involved control by the full set of stimuli (e.g., pointing to a different one of the set on each successive trial, as described on pp. 71-72).

It would be important to use many subjects to increase the likelihood of getting statistically significant results. The problem here was a large range in the error scores as well as so many confounds that the remaining groups had few subjects. Many subjects would allow us to compare their ranking throughout the experiment -- that is, to see if differences in training persisted through to the end of the study. Also, this would allow comparisons at the two ends of the spectrum to see if the results varied between the students doing very well and those making many errors.
Repeated acquisition: retrain the same subjects with different pairs of stimuli and responses (one way would be just to use a different answer sheet each time). This procedure would solve the phase, sequence and stimulus subset problems and help us control for sensory mode and order effects. This could be continued until a reliable pattern of results was produced. A lot of data could be obtained from a few subjects. Even though such recombinations are not a part of normal language instruction, a method for repeated acquisition might reveal useful distinctions between TB and SB verbal behavior.

Some thought should be given to the best ways to generate errors while trying to avoid any procedures that would differentially affect one type of verbal behavior more than the other. I varied the number of stages during training, the number of training trials, the error correction procedure and the amount of review before tests. Increasing the delay between training and testing didn't help unless an interfering task is included during the interval. Making the stimuli more similar to each other would help as would working with more stimuli in each set or introducing all the tasks at the same time.

Simple apparatus worked well in this study but, unfortunately, this study needs many subjects because one treatment per subject is recommended and because statistical significance is a priority. A classroom full of computer terminals would allow one experimenter to work with many subjects simultaneously. Also, I managed to deliver 25,552 trials in 195 sessions with very few mistakes but other experimenters might not succeed in this (these totals include the pilot and follow-up studies as well as the main experiment). Measuring response latencies and timing the tasks would help answer some questions such as whether the equivalence tasks were learned during the initial training or when the test was presented. Data analysis can be done more easily. Computers with touch sensitive screens are commercially available and
Dube and McIlvane (1989) have provided us with a detailed guide for attaching one to a microcomputer. Amy McCarty has suggested that Braille and Morse code are forms of writing particularly suited to computer instruction (personal communication, September 29, 1994).

Of course there are many advantages of simple apparatus: (a) people can do behavioral research without budgetary support or when they are isolated in cognitive departments or other underdeveloped places in the world; (b) it is easier to design modify; (c) it is hard to make a computer respond to written or spoken behavior by the student; (d) complicated equipment isn't automatically productive -- there are other ways to increase experiments such as using student labor or direct instruction classroom techniques; (e) simple apparatus evokes positive reactions from people who see it ("Hey, I could do that with my kids!"); and (f) simple methods are well suited to student laboratories and can even be applied to language studies with species other than humans (e.g., Michael, Whitley, Hesse, & Cresson, 1983).

I recommend college students as subjects: these people worked hard for me, came to my office on time or called if they couldn't come and were pleasant people to know. They were happy to work for $5 an hour which was more than they could get for minimum wage jobs.

The primary measure of the dependent variable was number of errors. With a mastery criterion of 16 or more trials, the measures that include the number of trials (trials to criterion or percent correct) can be distorted by when the errors came during the series. For example, with a criterion of 16 in a row correct, three errors can produce a score of anywhere between 84% and 95%.

Be careful about the instructions: they should be clear and minimal and standardized. One sentence can radically affect the performance (p. 65).
It would be good to have a criterion for dropping already mastered stimuli from the training set because I spent a lot of time going through useless trials to get to those we needed to work on (as in Stevens, Blackhurst, & Slayton, 1991).

To summarize, I recommend the following methods for research in TB and SB verbal behavior: (a) give each subject one phase only and use a group design (to avoid phase, sequence and stimulus subset effects); (b) try repeated training with different combinations of the experimental stimuli (to deal with phase and sequence effects, to increase the amount of data from each student and to see if the results change with continued exposure to the contingencies); (c) use a large number of subjects (to make the statistical tests more powerful and to allow comparisons between the high and low performers); (d) computers are needed (to help with the large number of subjects, to allow measurement of response latencies on equivalence tests, and to aid in the analysis of the results); (e) the SB preparatory stage should require mastery of the full set of experimental stimuli as was done in the TB case in the present study; (f) as much as possible make the covert behavior overt; and (g) use college students (because many subjects will be needed, they are easy to work with and they have extensive histories of both TB and SB verbal behavior).

**Topics for Research**

Improvements in the current study have already been suggested. Here are some other topics that sound interesting:

Equivalence: do TB and SB instruction serve equally well to establish equivalence? when is it learned and is this reflected in differences in response latencies during testing? what other versions of equivalence need to be included in
these studies? are reversals more likely among stimulus and response relations established indirectly?

Reversal and rotation of written responses: what variables make them more likely? are they more common when the task is indirectly established (by equivalence or generalization)? does allowing reversals during training make them more likely later during testing? does adding a top and side bar help (as in the Sanskrit letters)? what is the dyslexia rate among those who read and write with the Sanskrit alphabet? can we decrease reversals with a simple instruction or by making errors more costly?

Research by mail: students could be tested at home if printed versions of sounds were used. Some measure of their honesty and reliability would have to be obtained.

Use of the same people as subjects in successive studies: student experimenters could take over subjects who have completed one study and continue with another study; these could build on each other or be generally unrelated. A demonstration could involve training a set of students to train subjects and then rotate the subjects from student to student trying to build up useful repertoires. Stables of subjects maintained in a psychology department is one solution to the problem of getting more studies done.

Interference during retention tests: what variables affect the degree to which intervening behavior causes problems on memory tests?

Inconsistent relations: how would TB and SB verbal behavior compare when the student has to learn relations that are true only part of the time (as happens so often in our social environments)? To take an extreme case, Pilgrim & Galizio (1990) showed that reversing the contingencies in a training task reversed the results on symmetric but not transitive equivalence tests. Any demonstration of incongruence among the defining tests of equivalence is an important finding.
Covert behavior: before the study begins the students could be taught to say everything they are thinking. Interviews immediately after a task would help, too.

Covert behavior could also be studied by teaching contradictory relations and then seeing which controls on an equivalence test. One way to do this would be to establish SB relations between an object and two visual stimuli, a printed word and picture; then, after teaching different naming responses to the word and picture the student would be asked to name the object. Alternatively, the object could be paired with an auditory word and a printed word that is the occasion for a different naming response and then, later, the student would be asked to name the object. Would the student respond to the object by, in effect, reading the visual word or echoing the auditory word?

The NO response version: it would be interesting to see if people could master these tasks entirely covertly, simply looking at the stimuli for an amount of time similar to that of other subjects who actually respond.

High and low functioning students: does the comparison of TB and SB behavior vary at the different ends of the spectrum of performance? Students could be recruited who are on academic probation or have dyslexia.

Methods are needed for the behavioral analysis of aphasia and other disorders of the brain (Sidman, 1971a). There has been recent interest in tests that are predictive of Alzheimer's (Masur, Sliwinski, Lipton, Blau, & Crystal, 1994). I have already suggested one test for aging (pp. 77-78, above).

Special student histories: art and science students could be contrasted or drawing teachers and bridge players, and so on.

SB tasks that are in a gray area between TB and SB: for example, SB writing (anagram construction), tactile discriminations (in which the subjects select objects but they do so by making characteristic motions in the presence of these objects), SB
responding with a positional requirement (the CO stimuli occupy specific positions, or instead of pointing to the stimulus a characteristic spot on a response sheet is touched), and SB responding with a schedule during the pointing that is characteristic of the SA and correct CO.

A Message for the Student of Behavior and Environment

These, then, are some of the many ways to study TB and SB verbal behavior. We need students in the laboratory and the students need our support. Go and play with behavior (B) and environment (E), with the ongoing stream of BEing as revealed by experiment. At the beginning of the scientific revolution Andreas Vesalius told his students, "I do not want to give an opinion, please do feel...with your own hands and trust them." (Boorstin, 1983, p. 357) One of the earliest scientific societies took the motto, "Nullius in Verba" which they translated as "Take nobody's word for it; see for yourself." (Boorstin, 1983, p. 394) As the wise man said, "Know what is in thy sight, and what is hidden from thee will be revealed to thee." (Jesus, quoted by Thomas Didymos, in Guillaumont, Puech, Quispel, Till, & Abd al Masih, 1959, p. 5).
Appendix A

Human Subjects Institutional Review Board Materials
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Date: December 9, 1993

To: Osborn Cresson

From: M. Michele Burnette, Chair

Re: HSIRB Project Number 93-10-14

This letter will serve as confirmation that your research project entitled "The writing response in studies of selection-based and topography-based language" has been approved under the full category of review by the Human Subjects Institutional Review Board. The conditions and duration of this approval are specified in the Policies of Western Michigan University. You may now begin to implement the research as described in the application.

You must seek reapproval for any changes in this design. You must also seek reapproval if the project extends beyond the termination date.

The Board wishes you success in the pursuit of your research goals.

Approval Termination: December 9, 1994

xc: Michael, Psychology
I have been invited to participate in a research project entitled "The Writing Response in Studies of Selection-Based and Topography-Based Language." I understand that this research is intended to compare two different types of language. In one the person using the language simply points to a word or phrase; in the other the person makes a characteristic motion (as in writing or speaking). The purpose of this research is to see which system of language is easier to learn and easier to use in novel situations. I further understand that this project is Osborn Cresson's dissertation project.

My consent to participate in this project indicates that I will be asked to attend between one and 15 sessions with Mr. Cresson; each session will last about 60 minutes. These sessions will take place in a classroom in Wood Hall at Western Michigan University. The only people present will be Mr. Cresson, myself and, on occasion, an observer whom he has trained to sit quietly and record events with pen and paper.

The sessions will involve our sitting at a table, Mr. Cresson presenting visual stimuli on cards or auditory stimuli spoken by him and my responding by pointing to a visual stimulus or writing with pen and paper. These experimental sessions will be followed by a final interview session in which Mr. Cresson asks questions about what I was thinking about as I did the experimental tasks and explains the reasoning behind the experiment. Also, he will answer any questions I have about the experiment at that time. At the end of each session I will be paid $5.00.

As in all research, there may be unforeseen risks to the participant. If an accidental injury occurs, appropriate emergency measures will be taken; however, no compensation or treatment will be made available to me except as otherwise specified in this consent form. I understand that one potential risk of my participation in this project is that I may experience some stress when presented with the choice of how to respond. It is expected to be no worse than that I experience when taking an exam. If I want to stop working during a session, I will simply have to say that I don't want to continue. I will be able to withdraw at any time during the experiment by simply telling Mr. Cresson in person or telephoning to him at home (343-8652).

One way in which I may benefit from this activity is having the chance to experience and talk about how psychologists study language behavior. I also understand that others who study language may benefit from the knowledge gained from this research.

I understand that all the information collected from me is confidential. This means that my name will not appear on any papers on which this information is recorded. The forms will all be coded, and a separate master list with the names of participants and the corresponding codes will be kept by Mr. Cresson in a locked file cabinet in Wood Hall to which only he and his advisor, Dr. Jack Michael, have access. Once the data are collected and analyzed, the master list will be destroyed. In order to protect my confidentiality when the results of this research are presented publicly (in written form or in oral presentations), my data will be identified only by the code assigned to me.

I understand that I may refuse to participate or quit at any time during the study without prejudice or penalty. If I have any questions or concerns about this study, I may contact either Osborn Cresson (343-8652) or Jack Michael (387-4840). I may also contact the Chair of Human Subjects Institutional Review Board (387-8293) or the Vice President for Research (387-8298) with any concerns that I have. My signature below indicates that I understand the purpose and requirements of the study and that I agree to participate.

(Signature)  
(Date)
I have been invited to observe the experimental sessions of a research project entitled "The Writing Response in Studies of Selection-Based and Topography-Based Language." This is Osborn Cresson's dissertation project.

As I observe these sessions I may possibly learn the names of the experimental subjects. I agree to keep these names confidential. Specifically, I will not tell anyone or let anyone learn the names that correspond to the codes that appear on the data. When talking or writing about this experiment I will not reveal the identities of the people participating.

(Signature)                                    (Date)
ATTENTION ALL STUDENTS:

OPPORTUNITY TO PARTICIPATE IN RESEARCH ON THE NATURE OF LANGUAGE

OS CRESSON is looking for subjects in a study of two different kinds of language, called topography-based and stimulus selection-based languages.

THE RESEARCH will be done between January and April of 1994.

SESSIONS will last about 1 or 1-1/2 hours; there will be between 5 and 15 of them.

SCHEDULING will be flexible so as to be convenient for the student.

YOUR PAY will be $5.00 for every session.

THE EXPERIMENT will be explained in detail after the last session.

IF INTERESTED please call 343-8652, or fill in the bottom of this sheet and send it through Campus Mail to:

OS CRESSON
PSYCHOLOGY DEPARTMENT
WESTERN MICHIGAN UNIVERSITY

YES, I AM INTERESTED IN PARTICIPATING IN THE STUDY OF TWO TYPES OF LANGUAGE.

MY NAME IS: ____________________________

MY TELEPHONE NUMBER IS: 343-8652
GLOSSARY

ANSWER SHEET: the page listing stimulus relations taught to a particular student; it contains three columns, each with 8 patterns, sounds or symbols.

AUDITORY STIMULUS: a nonsense syllable; see SOUND, below.

CODIC: a verbal operant in which the stimulus is verbal and the response product shows point-to-point correspondence but no formal similarity.

COMPARISON STIMULUS (CO): the stimuli on the table in front of the student in a SB task.

COMPARISON SHEET (CO SHEET): the piece of paper with 4, 8 or 16 patterns or symbols.

COPYING A TEXT: a verbal operant in which the verbal stimulus is visual and the written response product is similar in form.

CORRECTION: after an error the E presents the cue and the S responds again, correctly this time.

CORRECTION-REPEAT: after correction the E re-presents the trial that was missed (no cue is used).

COVER: the manila folder used to keep the S from seeing the R's already written on the R sheet.

CRITERION: the number of trials (12, 16 or 24) that must be completed without error before moving on to the next scheduled task.

CUE: a stimulus presented by the E that indicates which R is correct, this can be presented intentionally (during training) or unintentionally (a mistake by the E); unintentional cues can come before the R (antecedent cues) or afterwards (consequent cues).

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DUPLIC: a verbal relation in which the stimulus is verbal and the response product is similar in form to the stimulus (e.g. echoic relations and copying a text).

ECHOIC: a verbal operant in which the verbal stimulus is auditory and the verbal response product is vocal and similar to the stimulus in form.

EQUIVALENCE TEST: a SB task in which the SA's were auditory SA's used in training and COs were visual SA's used during training (no differential consequences were given during tests).

FINAL INTERVIEW: the last session during which a variety of tests are given, and questions are asked by both the E and the S.

FULL REVIEW: after training and equivalence and generalization tests, the two TB training tasks (or the two SB training tasks) are presented again until the S meets a criterion of 24 in a row correct.

FULL TEST: after the TB and SB full reviews, the S is given 144 trials of 10 tasks (4 training, 2 equivalence and 2 generalization tasks).

GENERALIZATION TEST: after an equivalence test the S is given the opposite version of the two training tasks (SB if the training was TB and v.v.).

INITIAL INTERVIEW: before training begins the S reads and signs the consent form, fills in the student information sheet and the E reads an introductory statement that explains what will happen during the experiment.

INTERTRIAL INTERVAL: the time between the end of one trial and the beginning of the next trial.

INTRAVERBAL: a verbal operant in which both the stimulus and response are verbal.

MAND: a verbal operant in which the response is reinforced by a characteristic consequence that is effective ("established") at the moment of response.

MANDED STIMULUS SELECTION: SB behavior in which the sample is a verbal stimulus and the comparison stimuli are nonverbal objects.
ORDER: which of the two training tasks comes first and which second (the auditory tasks before the visual one or v.v.).

PATTERN: a picture of part of a quilt.

PHASE: the first or second training and testing sessions (TB or SB), or the sessions in which full review, full test and final interview are presented.

PREPARATORY TASK: tasks that familiarized the student with the stimuli and responses of the experiment involving identity matching (tasks A or D), the echoic task (B), the copying-a-text task (C).

REFLEXIVITY: indirectly trained matching behavior with novel stimuli that is possible after matching has been established with a few training stimuli (i.e., if $A=A$ and $B=B$, then $C=C$); one of the three tests of equivalence (with symmetry and transitivity).

RESPONSE DEFINITION: the S behavior which has been accepted as constituting a response; in SB tasks it is when the S's finger touches the CO sheet, in TB tasks it is when the S has moved the cover to the next window on the R sheet.

RESPONSE SHEET: the sheet of paper marked with 12 boxes on which the S writes.

REVIEW DURING TRAINING: the re-presentation of a training task to start the session after that in which it was first presented.

SAMPLE STIMULUS (SA): an auditory or visual stimulus to which the student responds in SB or TB tasks.

SENSORY MODE: the type of sensory stimulus presented to the S (auditory or visual).

SCORESHEET: the sheet of paper on which the E or O records the S's response, it lists the stimuli to be presented during each trial.

SELECTION-BASED (SB): the kind of language that involves pointing to one stimulus in the presence of another one.
SEQUENCE: whether TB training precedes SB or v.v..
SERIES: several trials given in succession.
SESSION: the meeting of E, S, and O during which stimuli are presented and responses made; it lasts about one hour.
SET: the collection of stimuli of a particular kind (patterns, sounds or symbols).
STUDENT PLAN: the list of tasks for each student and the order in which they were presented.
SOUND: an auditory nonsense syllable spoken by E (represented by a consonant-vowel-consonant trigram).
SUBSET: each set of stimuli was divided in matched subsets of 4 or 8 stimuli each; one was used for TB and one for SB tasks.
SYMBOL: a Sanskrit or Japanese Katakana letter.
SYMMETRY: indirectly trained matching behavior that involves matching the training stimuli but with the SA’s serving as CO’s and vice versa (i.e., B=A if A=B); one of the three tests of equivalence (with reflexivity and transitivity).
TACT: verbal behavior under the control of a nonverbal stimulus.
TASK: the combination of stimulus presented to the student and response required, designated by two letters indicating the stimulus and response sets involved, subscripts indicating which of the two subsets were used, and a hyphen followed by SB or TB.
TOPOGRAPHY-BASED (TB): the kind of language in which the shape of the response varies depending on the stimulus present.
TRAINING TASK: the two tasks taught during the first two phases of the experiment; consequences were presented after each trial during training.
TRANSITIVITY: indirectly trained matching behavior that is possible when both the sample and comparison stimuli have been trained separately in matching-to-
sample relations with a common third stimulus (i.e., $A=C$ if $A=B$ and $C=B$); one of the three tests of equivalence (with reflexivity and symmetry).

TRIAL: one interaction between $E$ and $S$; it usually lasts only a few seconds.

VISUAL STIMULUS: a pattern or symbol printed on paper and presented to the $S$.

WINDOW: one of the 9 or 16 response locations on the array of CO stimuli presented to the $S$, numbered from left to right starting at the top (from the point of view of the $S$).

WRITTEN RESPONSE: the symbol drawn by the $S$ on the response sheet.
Appendix C

Stimulus Materials
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STUDENT PLAN

STUDENT CODE: CH

TASK SEQUENCE AND STIMULUS SUBGROUPS: TBACBC, SBEDAD

2-1-1  1-2-2

TASK TYPE: TB

Preparation: \[ \begin{array}{c}
A_2 \\
B_1 \\
C_1 \\
\end{array} \]

Training: \[ \begin{array}{c}
A_2C_1 \\
B_1C_1 \\
\end{array} \]

Test: \[ \begin{array}{c}
B_2A_2 \\
A_2D_1 \\
\end{array} \]

TASK TYPE: SB

Preparation: \[ \begin{array}{c}
A_1 \\
B_2 \\
C_2 \\
\end{array} \]

Training: \[ \begin{array}{c}
B_2D_2 \\
A_1D_2 \\
\end{array} \]

Test: \[ \begin{array}{c}
B_2A_1 \\
B_2A_1 \\
\end{array} \]

REVIEW:

Preparation: \[ \begin{array}{c}
A_2 \\
D_2 \\
\end{array} \]

First task: \[ \begin{array}{c}
A_1C_1B_1C_1 \\
C_2D_2A_1D_2 \\
\end{array} \]

Second task: \[ \begin{array}{c}
A_2C_1D_1 \\
B_2D_2 \\
\end{array} \]

FULL TEST: (ABCD)

FINAL INTERVIEW: 7
<table>
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<th>TASK</th>
<th>RESULT</th>
<th>COMMENTS</th>
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<tbody>
<tr>
<td>1</td>
<td>A&lt;sub&gt;1&lt;/sub&gt;</td>
<td>14/16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>B&lt;sub&gt;1&lt;/sub&gt;</td>
<td>16/16</td>
<td></td>
</tr>
<tr>
<td></td>
<td>C&lt;sub&gt;1&lt;/sub&gt;</td>
<td>3) 14/16</td>
<td>78/80 = 98%</td>
</tr>
<tr>
<td></td>
<td>A&lt;sub&gt;2&lt;/sub&gt;</td>
<td>14/16</td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>C&lt;sub&gt;1&lt;/sub&gt;</td>
<td>1) 8/8</td>
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<tr>
<td></td>
<td></td>
<td>2) 38/53</td>
<td>72%</td>
</tr>
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<tr>
<td></td>
<td>C&lt;sub&gt;1&lt;/sub&gt;</td>
<td>1) 8/8</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>2) 16/16</td>
<td>100%</td>
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<td>81%</td>
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<td>A&lt;sub&gt;2&lt;/sub&gt;</td>
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<td>D&lt;sub&gt;1&lt;/sub&gt;</td>
<td>23/24</td>
<td>96%</td>
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<td>3</td>
<td>A&lt;sub&gt;1&lt;/sub&gt;</td>
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<td>2) 16/17</td>
<td>94%</td>
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<td>SESSION</td>
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<tr>
<td>4</td>
<td>$E_2, D_2$</td>
<td>$\frac{23}{25} = 96%$</td>
<td></td>
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<tr>
<td></td>
<td>$A_1, D_2$</td>
<td>1) $\frac{8}{8}$, 2) $\frac{25}{29} = 86%$</td>
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<td></td>
<td>$B_2, A_1$</td>
<td>1) $\frac{16}{16} = 100%$</td>
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<td></td>
<td>$E_2, C_1, A_1, C_2$</td>
<td>$\frac{24}{24}$</td>
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<td></td>
<td>$A_1, 2$</td>
<td>$\frac{24}{24}$</td>
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<td></td>
<td>$D_1, 2$</td>
<td>$\frac{24}{24}$</td>
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<tr>
<td>5</td>
<td>$A_1, C_1, C$</td>
<td>$\frac{40}{46} = 87%$</td>
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<td></td>
<td>$B_2, D_2, A_1, D_2$</td>
<td>$\frac{26}{27}$</td>
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<td>6</td>
<td>(ABCD)</td>
<td>1) $\frac{141}{144} = 98%$</td>
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<tr>
<td>7</td>
<td>write C</td>
<td>$\frac{14}{16}$</td>
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<td></td>
<td>write B</td>
<td>$\frac{12}{16}$</td>
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<td>add A</td>
<td>$\frac{12}{16}$</td>
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<td>sub D</td>
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<td></td>
<td>sub B</td>
<td>$\frac{16}{16}$</td>
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7/7/2/64
STUDENT CODE: CH
DATE: 3/26
SESSION #: 4

PEOPLE PRESENT: 
TAPE #: 250

TIME: (start) 10:27 (stop) 11:08
TAPE: (start) 300 (stop) 508

PAID: 3

1) TASK: \( B_2 B_2 \)
RESULT: \( \frac{23}{24} = 96\% \)
METHODS: review

2) TASK: \( A_1 D_2 \)
RESULT: \( \frac{1}{8}/8 \)
METHODS: 

3) TASK: \( C_2 A_1 \)
RESULT: \( \frac{1}{4}/1/4 \)
METHODS: test

4) TASK: \( B_2 C_2 A_1 C_2 \)
RESULT: \( \frac{24}{24} \)
METHODS: test

5) TASK: \( A_1 Z \)
RESULT: \( 24/24 \)
METHODS: 

6) TASK: \( D_1 Z \)
RESULT: \( 24/24 \)
METHODS: 

7) TASK: 
RESULT: 
METHODS: 

8) TASK: 
RESULT: 
METHODS: 

9) TASK: 
RESULT: 
METHODS: 

10) TASK: 
RESULT: 
METHODS: 

NEXT SCHEDULED SESSION: 

PLAN: 

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STUDENT CODE: CH

DATE: 3/26

SESSION #: 4

PEOPLE PRESENT: KN

TIME: (start) 10 37 (stop)

TAPE: (start) 256 (stop)

TAPE #: 256

SESSION #:

TIME: (start) (stop)

TAPE: (start) T APE: (s t a r t) (st o p).

A 1 D2 (3)

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<td>A2</td>
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<td>25.</td>
<td>A2</td>
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<td>A2</td>
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<td>A2</td>
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PERCENT CORRECT DURING T-B AND S-B TRAINING
AND DURING THE DERIVED PERFORMANCES BASED ON THIS TRAINING

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<th>PERCENT CORRECT</th>
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<tbody>
<tr>
<td>Tact Training (Task AC)</td>
<td>2-40 1-18 195 99</td>
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<tr>
<td>Intraverbal Training (Task BC)</td>
<td>2-100 58 100</td>
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<tr>
<td>Manded S Selection Test (Task BA)</td>
<td>8 100 99</td>
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<tr>
<td>S-B Test (Task ABBD)</td>
<td>5 2 90</td>
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<th>SELECTION-BASED TASKS</th>
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<tr>
<td>Tact Training (Task AD)</td>
<td>1-22 2-22 10-35</td>
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<tr>
<td>Intraverbal Training (Task BD)</td>
<td>4 2 100 96</td>
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<td>Manded S Selection Test (Task BA)</td>
<td>7 75 96</td>
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<tr>
<td>T-B Test (Task ACBC)</td>
<td>8 3 93 96</td>
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<th>REVIEW</th>
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<td>9 93 96 100</td>
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<td>S-B Training (Task ABBD)</td>
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<tbody>
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<td>2-22 4-44 4-44 1-44</td>
<td>8 4-44 4-44 1-44</td>
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</tbody>
</table>

STUDENTS: ST GR CH MG

LEGEND:
- Red ink: order of tasks
- Blue ink: percent correct
- 2-40 blue ink: Errors -4 trials to criterion
PREPARING FOR A SESSION

ON THE EXPERIMENTAL DESK:
- Clock
- Tape recorder and two labeled tapes
- Two pens
- Cue control box with SA or cue cards for sets A and C/D, arranged face up on the numbered shelf paper and covered with the answer sheets or other papers laid face down, labels showing where the final test SAs will be found
- CO sheets face down on desk beside the box arranged in the order they will be used (if needed for the first task)
- Answer sheets attached to the clamps taped to the front of the desk
- Window numbering memory aids on front and side of the desk for E and O
- Labels showing where the final test SAs will be found

ON THE CHAIR TO THE LEFT:
- Table-top with labels showing where the final test COs will be found
- Blank scoresheets (on another floor to the left if the table-top is full)
- CO sheets face down under the scoresheets, arranged in the order they will be used

ON THE CHAIR TO THE RIGHT:
- Scoresheets labeled with the CO numbers written in if necessary
- Pen for filling in scoresheets
- List of instructions for each task
- Paper for notes, labeled with student code and session number
- Student plan

ON FLOOR TO THE LEFT:
- File box with SA and CO stimuli, student files, backup supplies of forms, and desktop file

ON TOP OF THE FILE BOX:
- Blank response sheets
- Response sheet cover
- Filled in response sheets (face down)

ON THE OTHER DESK:
- Calendar
- Appointment cards
- Desktop file (before the first or last sessions, otherwise it is in the file box)
- $5 bills in accounting envelope

ON THE DOOR:
- "Do Not Disturb" sign
STUDENT INFORMATION SHEET

NAME:

ADDRESS:

TELEPHONE:

GENDER:

BIRTH DATE:

YEARS OF EDUCATION:

MAJOR:

DO YOU HAVE PROBLEMS WITH READING, WRITING, VISION, OR HEARING?

DO YOU KNOW HOW TO READ JAPANESE, CHINESE, KOREAN OR SANSKRIT?

HAVE YOU PARTICIPATED IN OTHER PSYCHOLOGY EXPERIMENTS?

CONVENIENT TIMES FOR US TO SCHEDULE SESSIONS:
SEQUENCE EFFECT

--- SUBJECT --- --- GROUP ---

1) TB: AC, BC, BA - SB: AD, BD, BA
2) TB: AC, BC, BA - SB: BD, AD, BA
3) TB: BC, AC, BA - SB: AD, BD, BA
4) TB: BC, AC, BA - SB: BD, AD, BA
5) SB: AD, BD, BA - TB: AC, BC, BA
6) SB: AD, BD, BA - TB: BC, AC, BA
7) SB: BD, AD, BA - TB: AC, BC, BA
8) SB: BD, AD, BA - TB: BC, AC, BA

STIMULUS SUBSET EFFECT

--- SUBJECT --- --- GROUP --- --- OPPOSITE

1) A-1, B-1, C-1 8) A-2, B-1, D-2
2) A-1, B-1, D-2 7) A-2, B-1, C-1
3) A-1, B-2, C-1 6) A-2, B-1, D-2
4) A-1, B-2, D-2 5) A-2, B-1, C-1
5) A-2, B-1, C-1 4) A-2, B-1, D-2
6) A-2, B-2, C-1 3) A-2, B-2, D-2
7) A-2, B-2, D-2 2) A-2, B-2, D-2
8) A-2, B-2, D-2 1) A-1, B-1, C-1
STEPS TO TAKE WITH EACH NEW STUDENT

"The university requires that I present this consent form to you before we begin work. Please read it and ask any questions; then, if you wish to participate in this study, please sign it." (FILL IN CONSENT FORM)

"Thank you. Of course, your signature does not obligate you to do anything. You can drop out at any time, although if you do your data will be useless to us. Now, I need some general information such as your address and telephone number." (FILL IN INFORMATION SHEET)

"O.K.. Any questions? Now, I have made up a language for this study. You will be taught some tasks and then given some tests. Sometimes I will tell you whether your responses are correct, but at other times I will not let you know how you are doing until after the experiment is over.

We will not talk while the session is running except for discussing the instructions for each task. Basically, we will work in silence. Between sessions, you are asked not to discuss the experiment with other people. You can tell them if you are enjoying it but please don't talk about anything specific having to do with the experiment until afterwards. Also, please do not study this topic between sessions - no homework!

I should remind you that this experiment may have to be ended at any time for a variety of reasons. I can not guarantee you any specific number of sessions but it usually takes about eight. As to money, I'll pay you $5.00 at the end of each session.

If you get here more than 15 min late I cannot guarantee that we will have a session (it depends on whether another student will be arriving for a session an hour at the start of the next hour.)

We sometimes have visitors. They all sign this statement which says they will protect your confidentiality. (Hand them the visitor's statement.) This is a list of people likely to visit. Are there any people on this list whose presence would disrupt your performance?

Any questions? O.K., let's get started."

AT THE END OF THE SESSION, THANK THE STUDENT AND ARRANGE THE DAY AND TIME OF THE NEXT SESSION. RECORD IT ON THE CALENDAR AND GIVE THE STUDENT AN APPOINTMENT CARD.
GENERAL INSTRUCTIONS GIVEN AFTER GETTING STARTED:

"When your finger touches one of the squares on the sheet we count it as a response so please look carefully at all the options before choosing one."

"If you notice that you have made an error, just hit ERROR on this card and you get to try again. This is protect you from the sort of accidental errors that happen when you are responding rapidly."

"Please fill in the squares in the order a person reads, like this... The cover is moved along so that you cannot see what you have already written. When you get to the end of a line move down and then back across (if you moved back first you would see what you had written on that line.) You can correct your written response until you move the cover. That is the signal that you have finished the response. Then I will tell you if it was right or not, or I will simply start a new trial. You can stop everything by hitting the ERROR card - this allows you to try again, just as long as you hit the card before I tell you whether what you wrote was correct or before I start the next trial. This is so you don't make any unnecessary errors."

"We don't care about penmanship, just as long as anyone looking at what you have written would point to the same symbol from our list - that they all know what you are trying to represent - then we don't care about details of penmanship."

"Do you mind our taking photographs or videotaping while you are working? There are many reasons a person might not want us to do this so it is perfectly all right if you so "No, thank you!" For instance, we don't want to take pictures if it would disrupt your performance in any way. It is just that it will be easier to describe this work to people if we have a few pictures of someone doing it. What do you say?"
INSTRUCTIONS FOR EACH TASK

TOPOGRAPHY-BASED LANGUAGE

PREPARATORY TASK A: "This task simply involves pointing to the stimulus on the outside of this square that resembles the one I place in the center. In all these tasks that involve pointing, the moment your finger touches the paper that will be counted as a response, so look at all the choices and think carefully before you touch one of them. Any questions? ... O.K., let's start."

PREPARATORY TASK B: "That was fine. Now, the next task involves repeating the sounds I say. These are not real words in English but are nonsense syllables. Any questions? ... O.K., here goes."

PREPARATORY TASK C: "Thank you. The next task involves drawing a copy of the Japanese/Sanskrit symbol that I show you. Later I will ask you to write the eight symbols on your own. You will have to move this sheet to cover what you have already written. Let's practice that a minute. ... Ready? O.K."

1) "First, I will show you a symbol; please copy it in the boxes on this sheet of paper."
2) "Now, I will only show you the symbol briefly; please write down the symbol."
3) "Great. Can you draw all the four/eight symbols you have been learning? We don't need the cover for this test."
4) "Now, try to write all the symbols using the cover so you don't see the symbols you have already written."
5) "Fine. Now can you write them in a different order?"
6) "O.K. Now, please write them faster."
7) "Please do it again as rapidly as you can."

TRAINING TASK AC: "On this task I will show you a pattern and you will write the appropriate symbol. Initially I will show you which symbol to write. The eight pairs of patterns and symbols will each be demonstrated one time. Then you will be asked to do it on your own. So, I will now show you a pattern and show you the symbol that goes with it; please write the symbol on the sheet in front of you. Any questions? ... O.K."
"Now let's see if you can do it on your own. I will show you a pattern and you write the appropriate symbol. Any questions? Fine."

TRAINING TASK BC: "On this task I will say a sound and you will write the appropriate symbol. Initially I will show you which symbol to write. The eight pairs of sounds and symbols will each be demonstrated one time. Then you will be asked to do it on your own. So, I will now say a sound and show you the symbol that goes with it; please write the symbol on the sheet in front of you. Any questions? ... O.K..

"Now let's see if you can do it on your own. I will say a sound pattern and you write the appropriate symbol. Any questions? Fine."

REVIEW TASK ACBC: "That's good. Now let's do a mixed set of the last two tasks you have already learned. I will present a figure or say a sound and you will draw the appropriate symbol. Ready? ... Fine."

TEST TASK BA: "O.K.. Now, I will say a sound and you will point to the figure that goes with that sound. Please do not say anything while working on this task. I will NOT tell you how you are doing during this test, but please do everything you can to get it right. Any questions? Fine. Let's go."

TEST TASK ACBC: "That's good. Now let's do a mixed set of two tasks. I will present a figure or say a sound and you will draw the appropriate symbol. Please do not say anything while working on this task. I will NOT tell you how you are doing during this test, but please do everything you can to get it right. Ready? ... Fine."

TEST TASK (ABCD): "Now we will do a mixed set of various tasks. I will present a figure or say a sound and you will write or point to the appropriate symbol or figure. That means, when I put one of these sheets in front of you, point; otherwise, write the answer. Please do not say anything while working on this task. I will NOT tell you how you are doing during this test, but please do everything you can to get it right. Any questions? ... Fine."
INSTRUCTIONS FOR EACH TASK

--- SELECTION-BASED LANGUAGE ---

PREPARATORY TASK A: "This task simply involves pointing to the pattern on the outside of this square that resembles the one I place in the center. In all these tasks that involve pointing, the moment your finger touches the paper that will be counted as a response, so look at all the choices and think carefully before you touch one of them. Any questions? ... O.K., lets start."

PREPARATORY TASK B: "That was fine. Now, the next task involves repeating the sounds I say. These are not real words in English but are nonsense syllables. Any questions? ... O.K., here goes."

PREPARATORY TASK D: "Now please point to the symbol on the outside of this square that resembles the one I place in the center. Any questions? ... O.K., lets start."

TRAINING TASK AD: "On this task I will show you a pattern and you will point to the appropriate symbol. Initially I will show you which symbol to point to. The eight pairs of patterns and symbols will each be demonstrated one time. Then you will be asked to do it on your own. So, I will now show you a pattern and show you the symbol that goes with it; please point to the symbol on the sheet in front of you. Any questions? ... O.K."

"Now let's see if you can do it on your own. I will show you a pattern and you point to the appropriate symbol. Any questions? Fine."

TRAINING TASK BD: "On this task I will say a sound and you will point to the appropriate symbol. Initially I will show you which symbol to point to. The eight pairs of sounds and symbols will each be demonstrated one time. Then you will be asked to do it on your own. So, I will now say a sound and show you the symbol that goes with it; please point to the symbol on the sheet in front of you. Any questions? ... O.K."
"Now let's see if you can do it on your own. I will say a sound pattern and you point to the appropriate symbol. Any questions? Fine."

REVIEW TASK ADBD: "That's good. Now let's do a mixed set of the last two tasks you have already learned. I will present a pattern or say a sound and you will point to the appropriate symbol. Ready? ... Fine."

TEST TASK BA: "O.K. Now, I will say a sound and you will point to the pattern that goes with that sound. Please do not say anything while working on this task. I will NOT tell you how you are doing during this test, but please do everything you can to get it right. Any questions? Fine. Let's go."

TEST TASK ADBD: "That's good. Now let's do a mixed set of two tasks. I will present a pattern or say a sound and you will point to the appropriate symbol. Please do not say anything while working on this task. I will NOT tell you how you are doing during this test, but please do everything you can to get it right. Ready? ... Fine."

TEST TASK (ABCD): "Now we will do a mixed set of various tasks. I will present a pattern or say a sound and you will write or point to the appropriate symbol or pattern. That means, when I put one of these sheets in front of you, point; otherwise, write the answer. Please do not say anything while working on this task. I will NOT tell you how you are doing during this test, but please do everything you can to get it right. Any questions? ... Fine."
QUESTIONS FOR THE FINAL INTERVIEW

1) YOU MAY HAVE NOTICED THAT THE SYMBOLS IN THIS EXPERIMENT WERE ORGANIZED IN TWO SETS; YOU WERE TAUGHT ONE GROUP OF 8 SYMBOLS ONE WAY AND THE OTHER 8 ANOTHER WAY. PLEASE WRITE THE TWO SETS OF SYMBOLS, PUTTING ONE ON THIS SHEET AND THE OTHER ON THIS ONE.

2) PLEASE LIST THE TWO SETS OF SOUNDS USED IN THIS EXPERIMENT, THAT IS, WRITE THE LETTERS THAT REPRESENT THE SOUNDS.

3) PLEASE SORT THESE 16 FIGURES INTO THE TWO SETS INTO WHICH THEY WERE DIVIDED DURING THIS EXPERIMENT.

4) PLEASE SORT THESE 16 SYMBOLS INTO THE TWO SETS INTO WHICH THEY WERE DIVIDED DURING THIS EXPERIMENT.

5) PLEASE SORT THESE 16 NONSENSE SYLLABLES INTO THE TWO SETS INTO WHICH THEY WERE DIVIDED DURING THIS EXPERIMENT.

6) NOW, THESE ARE THE ANSWER SHEETS SHOWING THE FIGURES, SOUNDS AND SYMBOLS IN THE TWO SETS. PLEASE WRITE DOWN HOW YOU REMEMBERED EACH COMBINATION OF THREE STIMULI, THAT IS ANY MEMORY TRICKS THAT YOU USED. TO MAKE IT EASIER, YOU CAN USE "A" FOR THE FIGURES, "B" FOR THE SOUNDS AND "C" FOR THE SYMBOLS. USE AN EQUALS SIGN (=) TO REPRESENT WORDS SUCH AS "LOOKS LIKE" OR "REMINDS ME OF". YOU CAN USE A SHEET OF PAPER FOR EACH SET AND NUMBER YOUR LIST FROM 1 TO 8 IN EACH CASE. DON'T WORRY ABOUT SOUNDING SILLY - PEOPLE OFTEN USE HIGHLY INDIVIDUALISTIC MEMORY AIDS. JUST WRITE DOWN WHAT YOU WERE THINKING ABOUT WHEN YOU WORKED WITH THESE FIGURES, SOUNDS AND SYMBOLS.

7) SOME OF THE TASKS WERE NOT DIRECTLY TAUGHT. WHAT CAN YOU TELL ME ABOUT HOW YOU FIGURED THEM OUT?

8) HOW DO YOU THINK YOU DID ON THE FINAL TEST - WHAT WAS YOUR PERCENT CORRECT?

9) DID YOU DO ANY HOMEWORK BETWEEN SESSIONS? DID YOU PRACTICE OR OTHERWISE THINK ABOUT THE SYMBOLS WE USED?

10) DID I GIVE YOU ANY CUES THAT LET YOU KNOW HOW TO RESPOND? DID I GIVE AWAY THE ANSWERS IN ANY WAY? FOR INSTANCE, ON THE TESTS DID ANYTHING ABOUT THE WAY I ACTED TELL YOU WHETHER YOU HAD GOTTEN A TRIAL RIGHT OR NOT? DID THE POSITION OF THESE SLIPS IN THE BOX AND MY MOTIONS IN RETRIEVING THEM HELP YOU REMEMBER WHAT TO DO?

11) HAVE YOU EVER HEARD DR. JACK MICHAEL LECTURE? ARE YOU FAMILIAR WITH THE TERMS "SELECTION-BASED LANGUAGE" AND "TOPOGRAPHY-BASED"?

12) YOU LEARNED BY WRITING OR BY POINTING; WAS ONE WAY EASIER OR A MORE SUCCESSFUL WAY TO LEARN THAN THE OTHER OR WERE THEY BOTH ABOUT THE SAME?

13) IF YOU HAD IT TO DO OVER AGAIN, WOULD YOU AGREE TO PARTICIPATE IN THIS EXPERIMENT NOW THAT YOU KNOW WHAT IT INVOLVES (ASSUMING YOU HAD THE SAME AMOUNT OF TIME AVAILABLE AND THE SAME NEED FOR MONEY AND SO ON.)
A GENERAL DESCRIPTION
OF THE EXPERIMENT

You will need to master the distinction between selection-based and topography-based language. Selection-based tasks involve pointing to a symbol. The response itself (pointing) is a general one is not characteristic of the stimuli in the presence of which the pointing happens. Examples would include using a "symbol board" or replying to a multiple choice exam question. Topography-based tasks involve a response that is different for every linguistic situation. Signing, speaking and writing would be examples.

Recently five experimental studies have been done by Western Psychology graduate students comparing these two fundamental types of language. In this study I repeatedly teach an arbitrary language to college students to see under what conditions each type of language has advantages and disadvantages, especially with respect to ease of acquisition and generalization to novel combinations of the language symbols. My experiment is a variation of earlier work with writing as the topographically-based response.

This can be diagrammed as two triangles. "A" represents figures (quilting patterns), "B" is a sound (a nonsense syllable), "C" is a symbol written by the student and "D" is one that is pointed to. The solid lines represent tasks that are trained and the dotted lines are tasks that can only be done by inferring relations based on that training (the generalization tests). These tasks that are not directly taught are called equivalence relations.

Attached is a more detailed description of all this. Please read it at your convenience. We will then be able to talk about the issues raised, such as the relevance of this work to education.

\[
\begin{align*}
A & \rightarrow C \\
B & \rightarrow C \\
A & \rightarrow D \\
B & \\
\end{align*}
\]

\textit{Topography-based experiment} \hspace{2cm} \textit{Selection-based experiment}
LIST OF DOCUMENTS

DESKTOP FILE
- STEPS TO TAKE WITH NEW STUDENTS
- CONSENT FORM
- STUDENT INFORMATION SHEET
- GROUP ASSIGNMENT LIST
- STUDENT TELEPHONE NUMBERS LIST
- WHAT IS NEEDED FOR EACH SESSION
- PREPARING FOR A SESSION
- TO DO LIST
- QUESTIONS FOR THE FINAL INTERVIEW

MONEY TO PAY STUDENT (55 BILLS IN ACCOUNTING ENVELOPE)

CALENDAR AND APPOINTMENT CARDS

ANNOUNCEMENTS

INSTRUCTIONS FOR EACH TASK

ANSWER SHEETS

SCORESHEETS

SESSION SUMMARY

STUDENT PLAN

EXPERIMENT SUMMARIES (3)

NOTES AND ERRORS

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- MATERIALS
  - GENERAL DESCRIPTION
  - WHAT OBSERVERS DO
  - STEPS IN TRAINING
  - WHAT TO LOOK FOR
  - REPORTS

STUDENTS' CODES LIST

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### Table 1

#### Task Totals*

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<th>SUBJECT</th>
<th>PREPARATION</th>
<th>TRAINING</th>
<th>REVIEWS DURING TRAINING</th>
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* The numbers represent errors.
Table 2
Comparing Topography-based and Selection-based Verbal Behavior: TB Errors Minus SB Errors (Ranked Scores)*

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* The numbers represent topography-based errors minus selection-based errors (positive = SB advantage; negative = TB advantage). The students were ranked separately on each task.
Table 3
Comparing Topography-based and Selection-based Verbal Behavior: Summary of Ranked Scores*

<table>
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<td>3</td>
<td>2</td>
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<td>4</td>
</tr>
<tr>
<td>FULL TEST: EQUIVALENCE</td>
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<td>FULL TEST: GENERALIZATION</td>
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<td>TOTAL STUDENTS</td>
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<td>17</td>
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| TASKS ON WHICH SUBJECTS HAD BEST PERFORMANCE | 1 | 2 | 5 | 6 | 2 | 0 | 4 | 1 | 3 |

* The numbers represent students who did better on topography-based tasks or selection-based tasks (except the last line that represents number of tasks). The students were ranked on each task and the totals presented for the top and bottom 50 percentile.
Table 4

Sensory Mode and Sequence Effects*

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<td>TB</td>
<td>SB</td>
<td>TB</td>
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<td>TB - SB:</td>
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* The numbers represent errors.
Table 5

Training*

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**COMPARISONS**

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* The numbers represent errors.
### Table 6

Training: Phase and Sequence Effects*

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* The numbers represent error averages.
### Table 7

**Training: Order Effect***

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<td>AC after BC</td>
<td>AD before BD</td>
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#### COMPARISONS

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<td>3) SB only: A-B vs. B-A</td>
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* Numbers represent errors.

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Table 8
Review During Training*

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**COMPARISONS**

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* The numbers represent errors.

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Table 9

Equivalence Tests*  

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* The numbers represent errors.
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* The numbers represent errors.
Table 13

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* The numbers represent errors.
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* The numbers represent errors.
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* The column headings show what the numbers represent.
Table 16

Reliability Data*

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<th>OBSERVED</th>
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<th>PERCENT</th>
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</table>

* The numbers represent trials.
Appendix G

Topography-Based and Selection-Based Verbal Behavior and Its Relation to Animal Behavior in General
TOPOGRAPHY-BASED AND SELECTION-BASED VERBAL BEHAVIOR AND ITS RELATION TO ANIMAL BEHAVIOR IN GENERAL

Behavior analysis both does and does not need biology. B. F. Skinner pointed out, "A behavioral analysis is essentially a statement of the facts to be explained by studying the nervous system. It tells the physiologist what to look for. The converse does not hold. We can predict and control behavior without knowing how our dependent and independent variables are connected. Physiological discoveries cannot disprove an experimental analysis or invalidate its technological advances. This is not to question the importance of physiology in a science of behavior. In a more advanced account of a behaving organism 'historical' variables will be replaced by 'causal.'...Neither the science nor the technology of behavior will then vanish, however. Physiological manipulations will simply be added to the armamentarium of the behavioral scientist." (1969, pp. 282-283)

It would be useful to demonstrate the generality of behavioral principles by applying our analysis of TB and SB behavior in species other than our own. As William S. Verplanck put it, "the same classes of experimental variables should control both learned and unlearned behavior, and in similar ways...I am not saying that ethologist and psychologists should borrow each other's concepts to apply to their own fields, but rather that there is only one field of investigation, and failure to examine all the concepts developed in that field may serve to delay the development of an ordered and comprehensive body of data." (1955)

---

1 The phrase "animal behavior" refers to any behavior of any animal, including both humans and nonhumans whether domesticated or not.
But this was a call that went almost unheeded. Many behaviorists are interested in animal behavior but they just don't have time to work on it. As a doctoral student Howard Farris did a very interesting study showing how buzzers can come to control the sexual behavior of quail (1967), but he never got back to the topic. Instead he has set up a school psychology program, chaired a department and so on. On the other hand, many biologists have heard about behaviorism and rejected it (Todd, 1987). The few behavioral publications in this area are largely unknown. Biology students learn about imprinting but how many know that ducklings will learn to walk away from the shoe box if that is what brings it closer (Peterson, 1960)? Behavioral students know of the work of Edmund Fantino (1985) but how many know of his ringing call for a synthesis of the two fields?

So, discussing the relevance of behavioral work to the wider field of biology must be a difficult task. One problem is that we need, but do not have, examples of what may arguably be naturally occurring examples of the behavioral concepts we have dealt with in this paper, such as conditional discrimination, TB and SB behavior and equivalence classes. Another problem is that the treatment of these concepts in the laboratory with nonhumans has been inconclusive. I found only one animal analog of a comparison of TB and SB behavior: Siegel and Honig's "Pigeon Concept Formation: Successive and Simultaneous Acquisition". (1970) (The two procedures produced similar courses of acquisition when the birds were taught to respond differentially in the presence or absence of human forms projected on a panel above a response key in a standard operant conditioning chamber.) On the issue of equivalence class formation in nonhumans experimental analysts of behavior have struggled mightily for 33 years and decided that it may be possible in primates and some other mammals but birds probably cannot do it (e.g., D'Amato, Salmon, Loukas,
& Tomie, 1985) -- unless our methods are simply preventing it (e.g. Cresson, 1979, and Vaughan 1988, and 1989, but see Hayes, 1989).

If we are to explain behavior in the wild we need to know whether concepts such as those discussed in the study reported here are common to all animals or are characteristic of humans. And we need ways of studying behavior and talking about it that are appropriate to such questions. This will not happen until behaviorists and biologists start working on it together.
Appendix H

Behavioral Literature on the Topic of Writing:
An Annotated Bibliography
BEHAVIORAL LITERATURE ON THE TOPIC OF WRITING:
AN ANNOTATED BIBLIOGRAPHY

CONTENTS:

1) SHAPING THE RESPONSE TOPOGRAPHY
2) WRITING AS THE DEPENDENT VARIABLE: EQUIVALENCE RESEARCH
3) WRITING AS THE DEPENDENT VARIABLE: GENERALIZATION TESTS
4) WRITING AS THE DEPENDENT VARIABLE: OTHER RESEARCH
5) WRITING AS THE INDEPENDENT VARIABLE
6) WRITING AS PART OF THE SETTING
7) WRITING SENTENCES AND PASSAGES
8) WRITING THEORY
9) WRITING APPLICATIONS

1) SHAPING THE RESPONSE TOPOGRAPHY

manuscript letter strokes. *Journal of Applied Behavior Analysis, 9*(2), 231-236.
Describes an objective, simple and reliable method of measuring letter
formation using a set of plastic overlays.

Hopkins, B. L., Schutte, R. C., & Garton, K. L. (1971). The effects of access to a
playroom on the rate and quality of printing and writing of first and second-
Writing responses were shown to be under the control consequences at the
end of the instruction period.

Rapport, M. D., & Bostow, D. E. (1976). The effects of access to special activities on
the performance in four categories of academic tasks with third-grade students. *Journal of Applied Behavior Analysis, 9*(3), 372.
Handwriting and word copying improved when recreational activities were
contingent on completion of 80% of the academic tasks assigned daily. This
was done with third-grade students in an ordinary classroom setting.

feedback and consequences on transitional cursive letter formation. *Journal of
Applied Behavior Analysis, 11*(3), 381-393.

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Used the technique described in Helwig et al (1976) for shaping letter strokes with various types of reinforcement, feedback and practice. All conditions showed improvement and generalization to untrained and unpracticed letter strokes was demonstrated.

2) WRITING AS THE DEPENDENT VARIABLE: EQUIVALENCE RESEARCH


Mentions pilot data on equivalence relations with colors and their auditory and visual names in which response modality was irrelevant (placing letter cards, writing or using a typewriter). However, one subject generalized only from writing to the placement of letters, not in the opposite direction.


Written manding as a test for stimulus equivalence. Generalization was demonstrated from signing to writing and vice versa.

3) WRITING AS THE DEPENDENT VARIABLE: GENERALIZATION TESTS


Correct spelling was trained by silent or vocal reading. This generalized to correct written spelling.


College students, working in a second language, correctly wrote answers to questions on the basis of SB training with a simple 4-key teaching machine.


SB training was the basis for correct written spelling on subsequent tests.


Written spelling of three-letter words improved as a result of training in delayed constructed-response identity matching.

Written spelling of three-letter words improved as a result of training in delayed constructed-response identity matching to complex samples made up of a picture and a word.

**ALSO SEE THESE ARTICLES LISTED ABOVE:**
- Mackay, H. A. (1985)

4) **WRITING AS THE DEPENDENT VARIABLE: OTHER RESEARCH**


Written spelling improved most when the instruction was student-directed and incorporated visual (nonverbal) and auditory (verbal) cues.


Interspersal of familiar items aided acquisition of a written spelling task as compared to either high-density reinforcement or baseline conditions. Retention was poor even after interspersal training and the reinforcement phase was very brief; these problems were addressed in the 1980 study by the same authors.


Written spelling improved more when previously mastered words were interspersed with test words than when reinforcement was increased without interspersal.


Writing was included in a comprehensive set of language tests given to three brain injured patients. The samples were numbers, words and colors in the auditory, visual or tactile sensory modes. It is suggested that convenient methods are needed for the systematic survey of verbal behavior, allowing the teacher to "chart lines along which behavior fractures in aphasia".


Letter reversals were more common during SB matching to sample than TB naming or writing. Improvement during testing occurred with the TB but not the SB procedures.
5) WRITING AS THE INDEPENDENT VARIABLE


Writing was compared to fingerspelling as part of the instruction procedure in an equivalence study. Both procedures worked well to establish directly and indirectly taught tasks; the two deaf adult subjects preferred writing to fingerspelling.


Writing number names was one of the tasks directly taught in an equivalence paradigm. In another experiment, constructed-response spelling was part of both the training and test tasks.

6) WRITING AS PART OF THE SETTING


Writing was going on during the experiment but it was neither the independent nor the dependent variable. The study concerned the modification of face-touching, posture and voice-loudness during mathematics and spelling periods.

7) WRITING SENTENCES AND PASSAGES


A technique is described for administering a written exam without the possibility of visual and vocal cheating. Especially folded forms were interleaved with carbon paper; writing was done with a golf tee so no response product was visible.

Contingent reinforcement was sequentially applied to three objective aspects of composition: total number of words, number of different words and number of new words. The writing output increased greatly for all the students in this fifth-grade remedial classroom.


Writing was part of both the training and testing during this study of transfer to novel questions when three different types of tasks were taught (definition, exemplification and example identification).


Objective measures of creative writing improved with consistent application of instructions, reinforcement and practice.


A study of the effects of an instructional package on the writing of correct sentences. Modeling, reinforcement and remedial feedback were the independent variables.


Writing assignments enhanced student achievement in a college chemistry course, although the design did not show whether the results were do to the effect of writing on later performance, or to the organization of materials during the writing exercise or simply to the increased study time that this involved.


This article presents a "process writing approach" in which spelling emerges as a collateral effect of writing (as contrasted with the "assign-and-test" method which involves the direct instruction of spelling behavior); both research and theory are discussed.


Rate of written composition was found to be sensitive to explicit timing and feedback procedures.
8) WRITING THEORY


Discusses two theories of the relationship between speech and writing: that writing is simply a representation of speech (the unidirectional theory) and that these are separate behaviors and can each affect the other (the multidirectional theory). It is suggested that modern behavior analysis supports the latter position.

9) WRITING APPLICATIONS


Reviews the application of equivalence research to education.


Review the basic concepts and methods of stimulus equivalence research and its application in the establishment of equivalence-based networks of matching-to-sample, writing and naming performances.
Appendix I

Behavioral Literature on Topics Related to Writing:
A Reference List
BEHAVIORAL LITERATURE ON TOPICS RELATED TO WRITING:
A REFERENCE LIST

CONTENTS:

1) TOPOGRAPHY-BASED VS. SELECTION-BASED VERBAL BEHAVIOR
2) CONSTRUCTED-RESPONSE SPELLING (ANAGRAM NAMING)
3) SEQUENCES
4) FUNCTIONAL EQUIVALENCE
5) NAMING
6) SIGNING

1) TOPOGRAPHY-BASED VS. SELECTION-BASED VERBAL BEHAVIOR


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2) CONSTRUCTED-RESPONSE SPELLING (ANAGRAM NAMING)


ALSO SEE THESE ARTICLES LISTED IN THE BIBLIOGRAPHY ON WRITING:

3) SEQUENCES


ALSO SEE THE ARTICLES LISTED UNDER CONSTRUCTED-RESPONSE SPELLING (ANAGRAM NAMING)

4) FUNCTIONAL EQUIVALENCE


5) NAMING


**ALSO SEE THESE ARTICLES LISTED ABOVE:**

6) **SIGNING**


ALSO SEE THESE ARTICLES LISTED IN THE BIBLIOGRAPHY ON WRITING:
BIBLIOGRAPHY


