The Role of Mediating Verbal Behavior in Selection-based Responding

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Michael (1985) distinguished between two kinds of verbal behavior which he identified as selection-based (SB) and topography-based (TB). Research has shown substantial differences between the two types of verbal behavior for nonverbal participants, but little differences has been found with highly verbal participants. This study arranged for highly verbal participants (college students) to engage in a SB task while "talking aloud," one of Ericsson & Simon's (1993) techniques for conducting protocol analyses. The transcripts of these sessions were analyzed in terms of Skinner's (1957) elementary verbal operants. Very consistent types of statements were found to precede correct selections in the SB task. This finding lends support to the possibility that some SB conditional discriminations, and related emergent equivalence relations, are mediated by TB vocal responding when using highly verbal participants. These data also account for some of the differences observed in the SB and TB research.

Two different types of verbal behavior have been identified by Michael (1985) as selection-based (SB) and topography-based (TB). Selection-based verbal behavior consists in pointing toward, touching, or in some way identifying a verbal stimulus, for example a symbol or picture on a communication board (McDonald & Schultz, 1973), or selecting a picture card from a stack as is used in the Picture-exchange communication system (Bondy & Frost, 1993). The symbol pointed to or selected is the basis for the viewer's appropriate response to the pointer's behavior. This form of communication has been used in research with apes (Savage-Rumbaugh, 1984) and is currently used extensively as a form of augmentative communication for developmentally disabled individuals with very defective vocal behavior (Shafer, 1993). A developmentally disabled child naming something (a tact) or requesting something (a mand) by pointing to the appropriate symbol on her communication board is an example of SB verbal behavior.

In SB verbal behavior, the stimulus and response each involve two components. The stimulus involves (1) a sample stimulus or establishing operation (the mand), that affects the responder in such a way as to (2) increase the evocative control of one of the choice stimuli over the pointing or indicating response. Such a situation is often called a conditional discrimination (Sidman, 1994): the stimulus pointed to is conditional upon what is being named or asked for. The response in SB verbal behavior involves (1) scanning the stimulus array, then (2) emitting the pointing response to the appropriate choice stimulus.

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Topography-based verbal behavior consists of making a response with a unique form or topography, with the resulting response-produced stimulus being the basis for the listener's or the viewer's appropriate response. Common TB response forms are speaking, signing (the language of the deaf community), and writing. With a TB relation, the particular response topography is controlled directly by an antecedent stimulus or an establishing operation and contains a single component response.

Several researchers have compared these two types of verbal behavior with respect to ease of learning (Bristow & Fristoe, 1984; Cresson, 1994; Hodges & Schwethelm, 1984; Stratton, 1992; Sundberg & Sundberg, 1990; Tan, Bredin, Polson, Grabavac, & Parsons, 1995; Wraikat, 1990; Wraikat, Sundberg, & Michael, 1991). Results have shown that TB behavior is generally acquired faster and results in more accurate responding than SB behavior. In addition, when the emergence of equivalence relations were tested, TB training was found to result in better performances than with SB training. These results have been demonstrated with TB responses including writing (Cresson, 1994), and signing (Bristow & Fristoe, 1984; Hodges & Schwethelm, 1984; Sundberg & Sundberg, 1990; Wraikat, 1990; Wraikat et al., 1991). Most of this research investigated only gross differences between the two paradigms, although a number of specific differences exist as noted by Michael (1985).

One variable that was investigated during the initial part of the present study was the role that response-produced kinesthetic stimulation might have in the acquisition of conditional relations. SB responses differ very little from one another in response-produced kinesthetic stimulation because the different indicating responses (pointing, touching, etc.) are nearly identical irrespective of the stimulus indicated. TB responses, however, require a unique topography in order to provide the distinctive stimulation for the listener or viewer—vocal responses must produce distinctive auditory stimuli, and manual signs distinctive visual stimuli to function as effective communication. This necessarily results in unique kinesthetic (as well as auditory or visual) feedback for different TB responses.

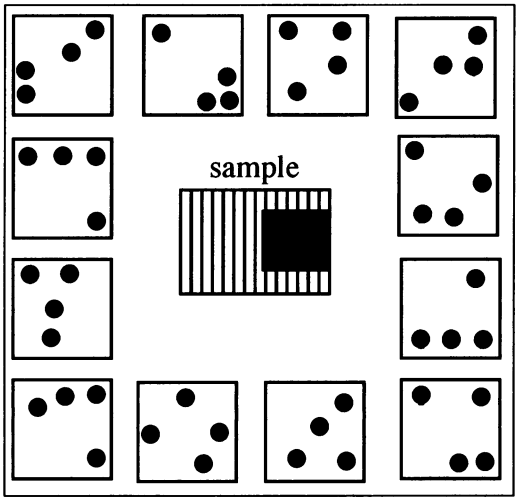


Fig. 1. Illustration of the patterns and screen arrangement used.

The first part of the present study arranged a SB matching-to-sample procedure in which participants learned to select a comparison stimulus (a pattern of four dots in a rectangle) from a set of such stimuli (see Figure 1), with the sample stimuli being auditory nonsense words or visual nonsense patterns. The critical experimental comparison was between a condition in which the selection response consisted in clicking a computer mouse on each of the four dots that made up the pattern of dots, and one in which the selection response consisted in clicking the mouse cursor twice in the upper left and twice in the lower right corner of the pattern, irrespective of the nature of the pattern. The first condition involved a distinctive or unique response pattern for each stimulus selected, and the latter did not – the same response pattern was used in selecting each of the different stimuli. If differential kinesthetic feedback was important, the relations learned with the distinctive selection response (unique kinesthetic stimulation) should be learned quicker and with fewer errors, and should have resulted in stronger stimulus-equivalence relations. This was not the case, however. Per-

formances differed little across conditions. However, all participants reported using vocal-verbal behavior to aid in both tasks. It was concluded that TB verbal behavior was mediating the arranged SB task, overshadowing any differences between experimental conditions. Some additional evidence for verbal mediation of SB responding comes from an analysis of the results of studies examining SB/TB differences. When using participants with poor verbal skills (Hodges & Schwethelm, 1984; Sundberg & Sundberg, 1990; Wraikat, 1990, Wraikat et al., 1991), TB verbal behavior performances were significantly better than SB verbal behavior performances. However, when highly verbal participants were used the differences between SB verbal behavior and TB verbal behavior was small (Bristow & Fristoe, 1984; Cresson, 1994), although still in favor of TB verbal behavior. Other researchers have also suggested such verbal mediation in conditional discriminations and some have researched this issue (Horne & Lowe, 1996; Lowenkron, 1991; Mandell & Sheen, 1994; Stratton, 1992; Wallender, 1993).

For example, Wallender (1993) compared responding in a SB task using familiar stimuli as samples (English words) and unfamiliar stimuli as samples (Japanese Katakana characters). Participants learned the relations involving familiar sample stimuli twice as fast as those relations involving unfamiliar sample stimuli. Mandell and Sheen (1994) similarly found that pronounceable sample stimuli resulted in better performance on a SB task, in addition to better performance in equivalence testing. In both studies the researchers concluded that the obtained differences were probably due to mediating TB verbal behavior. It is interesting to note that stimulus equivalence research often involves a SB task, and sometimes mixes SB and TB tasks in a single experiment (e.g., see Sidman, 1994). See Potter and Brown (1997) for a more thorough review of these studies.

Lowenkron (1991) has suggested that generalization of SB verbal behavior is dependent on TB responses. In a series of studies (Lowenkron 1984, 1988, 1989) he demonstrated generalized matching-to-sample by incorporating a TB response into a SB task. He proposed that SB verbal behavior may consist of "joint control," that is a response to the sample stimulus is repeated while the participant scans the choice stimuli. When the participant emits the same response to the choice that he is making echoically, the pointing response is evoked.

It is difficult to examine TB responding that "creeps" into a SB task for several reasons. First, if the experiment is arranged on a computer, it is very difficult for a computer program to determine the accuracy of TB response forms (e.g., the problems with handwriting recognition and voice recognition). Thus, researchers using computers often ignore TB verbal behavior. Second, researchers conducting noncomputerized SB experiments often are occupied in observing and arranging the SB task, with little time to record TB response forms. Finally, these TB emissions, at least with highly vocal verbal participants, are often covert in nature.

Some researchers have examined the utility of using "Protocol Analyses" to overcome some of these problems. Protocol analyses examine verbal behavior under various experimental conditions. Ericsson and Simon (1993) have classified such analyses into several categories, and their "Talk Aloud" procedure was used in the present research. Basically, this involves asking the participant to simply speak aloud any covert responses that might occur during a task (concurrent as compared to post-session or post-trial verbalizations). Efforts are made to prevent the occurrence of self-observation responses. For example, instructions often state that participants should talk aloud as they would when working on a difficult problem or working alone, and should not attempt to explain what they are doing (Ericsson & Simon, 1993).

Recently, several behaviorally oriented researchers have either proposed the use of talk-aloud protocol analyses (Hayes, 1986), or have incorporated them in research (Wulfert, Dougher, & Greenway, 1991).

Interestingly, Watson (1920) used talk-aloud procedures in studying problem-solving. The common assumptions underlying this type of research is that covert verbal responses are no different from overt verbal responses, and can be made overt without loss or distortion of the research results. Wulfert, et al. (1991) in a study of stimulus equivalence recorded participants' vocal verbal responses and categorized them as relational responses (a statement of some kind of relation between sample and the correct comparison), common physical features, stimulus compounds, and other. They found that participants who made relational responses generally demonstrated stimulus equivalence and those who did not, also did not show equivalence. Participants were then trained, either to name stimulus compounds or to name relations between stimuli. In general, those in the "relations" group demonstrated stimulus equivalence and the other group did not.

While the original focus of this research was on response-produced kinesthetic stimulation (as described above), little difference was found between conditions. This was probably due to participants engaging in mediating TB verbal behavior. Thus, the research described below focuses on the conducted protocol analysis, with the resulting transcripts examined in terms of Skinner's (1957) elementary verbal operants (tact, intraverbal, etc.). This analysis was especially directed at the possibility that SB responding may in some cases be composed of both TB and SB components.

Method

Overview

As noted previously, the study described here was part of a larger one in which little difference between conditions was found (as described in the introduction). The focus of this article is on the last session of the overall experiment, in which a protocol analysis was administered. It should be noted however, that participants had a generous amount of training (four sessions involving a minimum of 192 relations learned) to develop the mediating TB verbal behavior examined here. Thus, the type of TB verbal behavior used in the SB task is examined, but the evolution of that TB verbal behavior is not.

Participants

Two male and two female students attending California State University, Stanislaus, and ranging in age from 21 to 28 years served as participants. They were unfamiliar with the selection-based and topography-based research area. Only one protocol analysis session was conducted, and participants were asked at the start of the session if they felt fit to participate (e.g., "Did you get enough sleep?") to determine if the session should be conducted.

Setting

The experimental sessions was conducted in a quiet office in the Classroom Building of California State University. The room contained a desk, an empty file cabinet, and an empty bookshelf. It had no windows, but was ventilated through an air conditioning vent that also provided some masking noise. During the first part of the session the participant sat in front of a computer situated on the desk, and was alone in the office with the experimenter waiting just outside the door. During the protocol analysis the researcher was present in the back of the room, but not in the participant's field of vision.

Apparatus and Materials

All experimental conditions were presented and arranged by a Macintosh Quadra 610 personal computer, programmed by the experimenters using HyperCard 2.2 (Apple Computer, 1989). Participants were taught relations between sample stimuli consisting of visual patterns (described as "flag-like" from this point on) and comparison stimuli consisting of squares of dot patterns (the tact relation). See Figure 1 for an illustration of the patterns and screen arrangement used. In previous sessions nonsense words were also used as sample stimuli, but these were not

used in the last session described here. The flag-like patterns were constructed with the aim of decreasing the likelihood of vocal-verbal tacts to such stimuli. These stimuli had four components: background pattern (with three variations, horizontal, vertical or diagonal lines); shape of inset item (two variations, rectangle or semicircle); location of inset item (two variations, left or right side); and the shading within the inset item (four variations, white, light gray, dark gray, and black). All 48 possible patterns (3 x 2 x 2 x 4) were created, with the result that different sample stimuli had many features in common, and were thus less discriminable. The dot patterns used were created using a HyperCard program that produced patterns (mathematically calculated) and eliminated similar patterns. Recall that the dot patterns were used to help answer the initial research question of whether or not response-produced kinesthetic stimulation would affect acquisition. Finally, all dot patterns and flag-like patterns were reviewed by the experimenter and two assistants to ensure that no pattern was easily namable nor closely resembled any other dot pattern. The created patterns were randomly paired, then randomly assigned to one of the four sets of relations trained (12 relations in each set).

Response Definitions

Participants were required to select the appropriate choice stimulus from an array of 12 stimuli by clicking on them with a computer mouse. While it is true that two different response requirements were used, little difference was found between the two and they will not be described here. Instead the protocol analysis will be focused on.

Protocol Analyses

During the protocol analysis the participants were asked to talk aloud while being re-exposed to relations they were exposed to earlier in the session (the last two sets trained). These vocalizations were recorded, transcribed, and encoded. The experimenter and one assistant established criteria, prior to encoding, for classifying these vocalizations into the elementary verbal operants as listed below. Once the transcripts were completed the participants were recalled to clarify unclear parts of the tape recordings and to indicate, if possible, what aspect of the situation controlled the emitted response. The frequency of various types of statements was then calculated.

Responses were classified as tacts (T) under the control of either a sample or choice stimulus if the participant indicated which stimulus was "referred to" and it was clearly controlled by some aspect of the sample or choice stimulus. Responses were labeled as repeated intraverbals (RI) if they appeared to be tacts from a previous trial (e.g., when the choice stimulus was made apparent to the participant—in tutorial or remedial trials), repeated in the trial to be encoded. Repeated tacts or intraverbals were defined as sharing common words within a statement and controlled by the same stimulus as in the original statements. This was confirmed by having each participant review the transcript of his/her protocol session and indicate what aspect of the situation controlled the response.

Vocalizations were operationalized and encoded as follows:

1. "T": Tact of the sample or choice stimulus (when apparent, e.g., tutorial and remedial trials).
2. "-": No tact or intraverbal.
3. "RT": Repeated tact to sample stimulus from previous tutorial or remedial trial within the same relation.
4. "RI": Repeated intraverbal. A repeat of a tact to a choice stimulus from a previous tutorial or remedial trial within the same relation (called an intraverbal here as the current choice stimulus was not apparent to the participant and control of the response is most likely the preceding verbal behavior, i.e., the tact to the sample stimulus).
5. "NI": New intraverbal. Not a previous tact for this relation.
6. "RET": Repeated "Exam" Tact ("Exam" is used as a synonym for "Test," the

proper term, which would be confused with the T used for "Tact"). Tact to sample stimulus in the trial that was encoded, which was repeated from an earlier test trial, correct or incorrect (within the same relation), but was never emitted during a tutorial or remedial trial for this relation.

7. "REI": Repeated "Exam" intraverbal. Intraverbal emitted in encoded trial, which occurred as an intraverbal in an earlier test trial, correct or incorrect (within same relation), but never occurred during a tutorial or remedial trial for this relation.

To illustrate how this coding was done, part of a transcript from participant C was encoded and is presented in Figure 2. The encodings appear below each vocalization (e.g., T/T and RT/RI), with further elaboration directly below the encoding. The "/" indicates responses to the sample stimuli (left side) and choice stimuli (right side) – or as an intraverbal in test conditions, when the choice is not indicated. Figure 2 also shows what the participant saw when he/she aided in clarifying the transcripts.

Dependent Variables

A tally of the total number of correct and incorrect selections was recorded. While latencies and durations of responses were also recorded, they will not be reported here (no difference between conditions was found). A response was recorded as correct or incorrect immediately after it was selected. Mouse movements were also recorded to determine if topographical responses were occurring to choice stimuli via this modality. These movements were classified as topographical to the choice stimulus if the mouse pattern was seen to connect at least three dots of the choice stimulus together or a stereotypical movement appeared to occur. During the protocol analysis all vocalizations were recorded and encoded as noted above.

Incentives

As an effort to foster speed and accuracy, participants were paid: (a) $.02 for each correct choice, excluding tutorial and remedial choices; (b) $.10 for each minute under 90 that the session was completed; and (c) $5 for completing the session. They earned in a range of $8 to $14 per session, and were paid immediately following each session.

Procedure

During the same session as the protocol analysis was conducted, participants were exposed to four sets of stimulus relations. Each set consisted of 12 unique flag-lake patterns which had been paired with the same number of unique dot patterns. For all sets, one tutorial trial and five test blocks (a single presentation of each relation) were arranged. During the protocol analysis (which occurred approximately 15 minutes after the above described conditions) the last two sets of relations were represented to the participant in reverse order (to analyze the most recent first). During the protocol analysis, participants received one tutorial trial and 2 test trials during which time they were prompted to "Talk aloud" and all vocalizations were recorded.

A typical trial. First, a "tutorial" trial occurred for each of the 12 relations to be trained. In these trials the computer presented one flag-like pattern (the sample stimulus), then highlighted the correct dot pattern among the 12 dot patterns in the choice array. Once all relations had been presented in this manner, test trials began. In a test trial the computer presented the sample stimulus, but without highlighting the correct choice stimulus. In tutorial and test trials, the participant was required to select the correct comparison stimulus after which the computer said "Correct" if the correct stimulus was selected. The participant had 15 s in which to respond. If 15 s elapsed without a response, the computer said "Incorrect, try again." and immediately presented a remedial trial that consisted of re-presenting the sample flag-like pattern, and highlighting the correct dot pattern. Once the participant selected the highlighted comparison stimulus, the next relation in the block was presented. A mouse click within one of the dot patterns prior to the 15 s time-out period extended

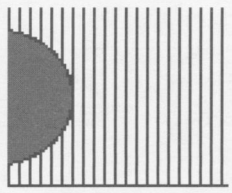
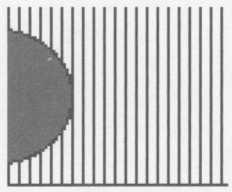
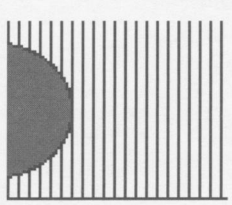
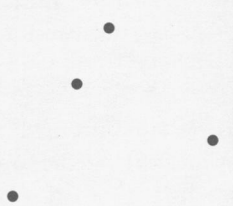
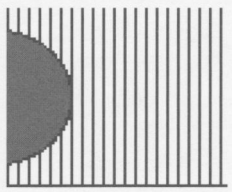
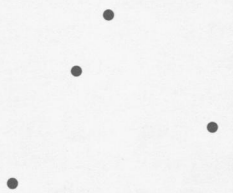
TUTORIAL TRIAL "*Dark gray semicircle* would go with the... *mountain shape*" T/T T (dark gray semicircle - Tact) /T (mountain shape - Tact)			C
TEST TRIAL "*Dark semicircle with the vertical lines* ahhh.... " RT/- RT (dark semicircle - repeated tact from tut. trial) /- (.... no comment made)			I
REMEDIAL TRIAL "With the *T like pattern*" -/T - (no comment made) /T (T like pattern - new tact for this relation as on remedial trials the correct choice is shown to the participant)			C
TEST TRIAL "*Vertical lines with the gray semicircle* would be the *mountain-like pattern*" RT/RI RT (Vertical lines with the gray semicircle) /RI (mountain-like pattern). This is classified as an intraverbal as the choice stimulus was not made apparent to the participant			C

Fig. 2. A sample coding of one representative relation. Note: The coding is listed in the left most box under the actual transcribed comments. To the right is the sample stimulus present for each trial followed by the comparison stimulus which the participant selected. The column furthest to the right denotes that the trial was C = Correct, I = Incorrect, or T = Timed out. This is a section of the actual form used when participants aided in clarifying the transcripts and to specify what controlled each part of the response. Note, however, that all relations were presented in random order thus, these trials appeared in this order, but were separated by many other relations. This transcript is part of participant C's data.

the time-out period by 5 s to reduce the number of time-outs occurring during the process of responding to a comparison stimulus. A response to an incorrect comparison stimulus had the same effect as a time-out: the computer presented the auditory "Incorrect" and then provided remediation training as described above.

Each correct response resulted in a brief intertrial interval (less than 1 s) in which all stimuli were removed from the screen and re-presented in a scrambled order. The rectangular shape the dot patterns made on the screen was retained: only the positions of each dot pattern within the rectangle changed (see Figure 1). Scrambling the stimulus positions was done to prevent positional cues from aiding discriminations, and occurred after a correct response and at the start of each new block. Finally,

at the start of each block of trials, the order of the stimuli used as samples was randomized, thus providing for a unique presentation order for those stimuli for each block the participant completed.

Results

Overall, very consistent types of statements were found to precede the selection of correct choice stimuli in both test and tutorial trials. In addition, relatively consistent types of statements preceded incorrect selections. These findings indicate that highly verbal participants are likely to be engaging in TB responding during SB tasks. For the sake of brevity, group data is presented first then individual participant data is covered in summary form.

Protocol Analyses

Group data. Figure 3 shows the aggregate data for all four participants in the protocol analysis. In the tutorial condition, they all made tacts to the sample and choice stimuli (both stimuli were apparent to the participant). In a few instances, some participants emitted a tact response only to the sample or the choice stimulus, as noted in the "T/-" and "-/T" bars of the upper left hand graph of Figure 3. Note that participant P was responsible for nearly all of the incidents in which tact responses were not emitted either to the sample or the choice stimuli ("-/-" bar). M was the only other participant to emit such a response, and did so only one time. It is clear from the graph, however, that in nearly all cases, a tact response was emitted to both stimuli in the tutorial condition – in fact, for 83% of all tutorial trials, a tact response was made to both the sample and choice.

The second graph in Figure 3 shows the frequency of correct choices which occurred after each type of verbal statement. Prior to selecting a correct choice, participants usually emitted the same tact as emitted to the sample stimulus in prior tutorial and remedial trials, and an intraverbal which was almost always the same as the tact emitted to the choice stimulus in previous tutorial and remedial trials (see the "RT/RI" category). As noted earlier, these are labeled as intraverbal responses as the appropriate choice stimulus was not apparent and the response was most likely controlled by the ongoing verbal behavior of the participant (i.e., the tact of the sample stimulus). Of all statements preceding correct trials, 77% fell into THE "RT/RI" category. No other type of verbal statement, by itself, preceded more than 4% of the total correct responses.

The third graph in Figure 3 shows the frequency of incorrect choices which occurred after each type of verbal statement. The highest number of incorrects occurred after participants emitted the same tact response to the sample stimulus as in the tutorial or remedial conditions, but then either a different intraverbal response than previously emitted ("RT/NI" verbal statement) or no intraverbal response at all ("RT/-" verbal statement). These two types of statements preceded 48% of the incorrects which occurred. The type of statement which preceded the second highest number of errors was when the participant emitted a new tact to the sample stimulus and a new intraverbal (that is, neither had been emitted in that relation's previous tutorial or remedial trials). This type of statement ("NT/NI") preceded 14% of the total incorrects. In all, these three types of statements comprised 62% of the total statements preceding incorrect selections. No other type of verbal statement preceded more than 9% of the total incorrect selections.

During the remedial condition, the participants generally did not make a response controlled by the sample stimulus, and either did not emit a tact response to the choice (the "-/-" verbal statement type), emitted the same response as in a previous tutorial or remedial trial for that relation ("-/RT"), or emitted a new tact to the choice stimulus ("-/NT"). These three types of statements preceded 71% of all remedial selections.

In addition to the previously discussed measures, the protocol transcripts were analyzed for several other types of verbal statements not shown in Figure 3. These included tacts of relationships between the

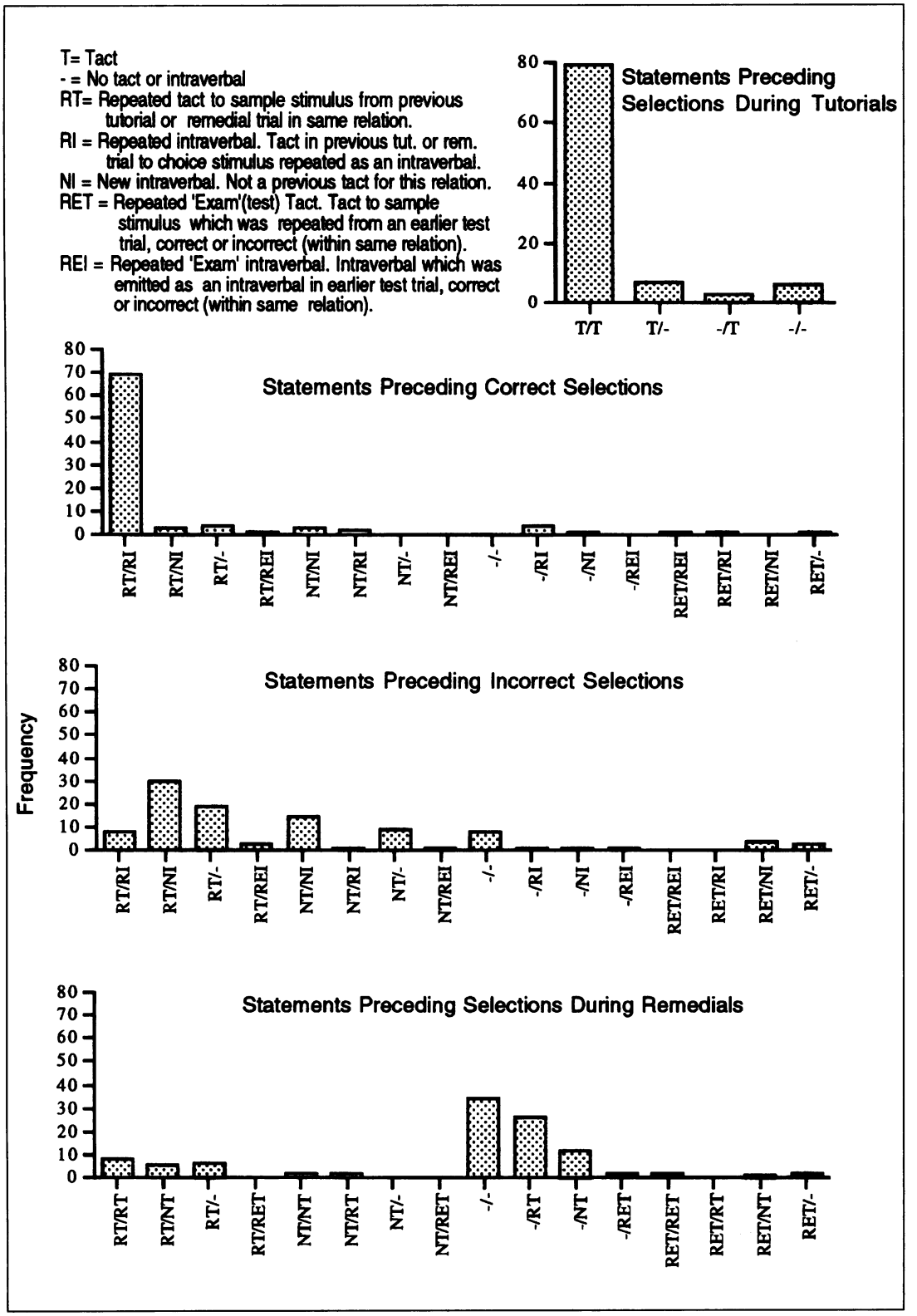


Fig. 3. Protocol data for all participants (group data). Note: The key in the upper left-hand corner explains the abbreviations used. All frequencies indicate the number of specified statements (e.g., "RT/RI") that preceded correct or incorrect selections. All selections in tutorial and remedial trials were correct (as the correct choice was revealed to the participant).

sample and choice. For example, part of participant B's transcript read:

1. Descending black planet ricocheting (tutorial).
2. Moving gray planet, ahhh ricocheting (correct choice).
3. Descending black planet, ok ricochet, ricochet, ricochet, ricochet... hmmm... that worked, a good guess (correct choice).

This verbal statement was considered a tact of a relationship between the sample stimulus and the choice stimulus. Compare this to the following part of B's transcript which was not counted as including a relationship tact:

1. Gray chip little peak (tutorial).
2. Gray chip little peak (correct choice).
3. Gray chips small peak (correct choice).

B's statements reflected relationships 38 times in test conditions. Of these 38 times, only 5 preceded incorrect responses. Also worth noting is that B's statements tended to be shorter than the statements of the other participants, which also might have contributed to B's high success rate (B had 42 corrects out of a possible 48, more than double the number of correct responses of any other participant).

As can be seen in the first example from B's transcript, participants occasionally repeated a phrase (echoic responses) while searching for the "matching" choice. This technique constitutes an efficient method for increasing the effectiveness of a scanning repertoire. Michael (1985) notes "... if the scanning takes much time, the effectiveness of the nonverbal stimulus will be lost by the time the appropriate verbal stimulus is encountered" (p. 4). The number of incidents of this type of repetition was counted for each participant. Interestingly, B had the highest number of such incidents, with a total of 10, and all were intraverbals which had been previous tact responses, in the tutorial and remedial conditions, to the choice stimuli. M's transcripts revealed three such repeats and P's showed two. Participant C did not overtly repeat phrases.

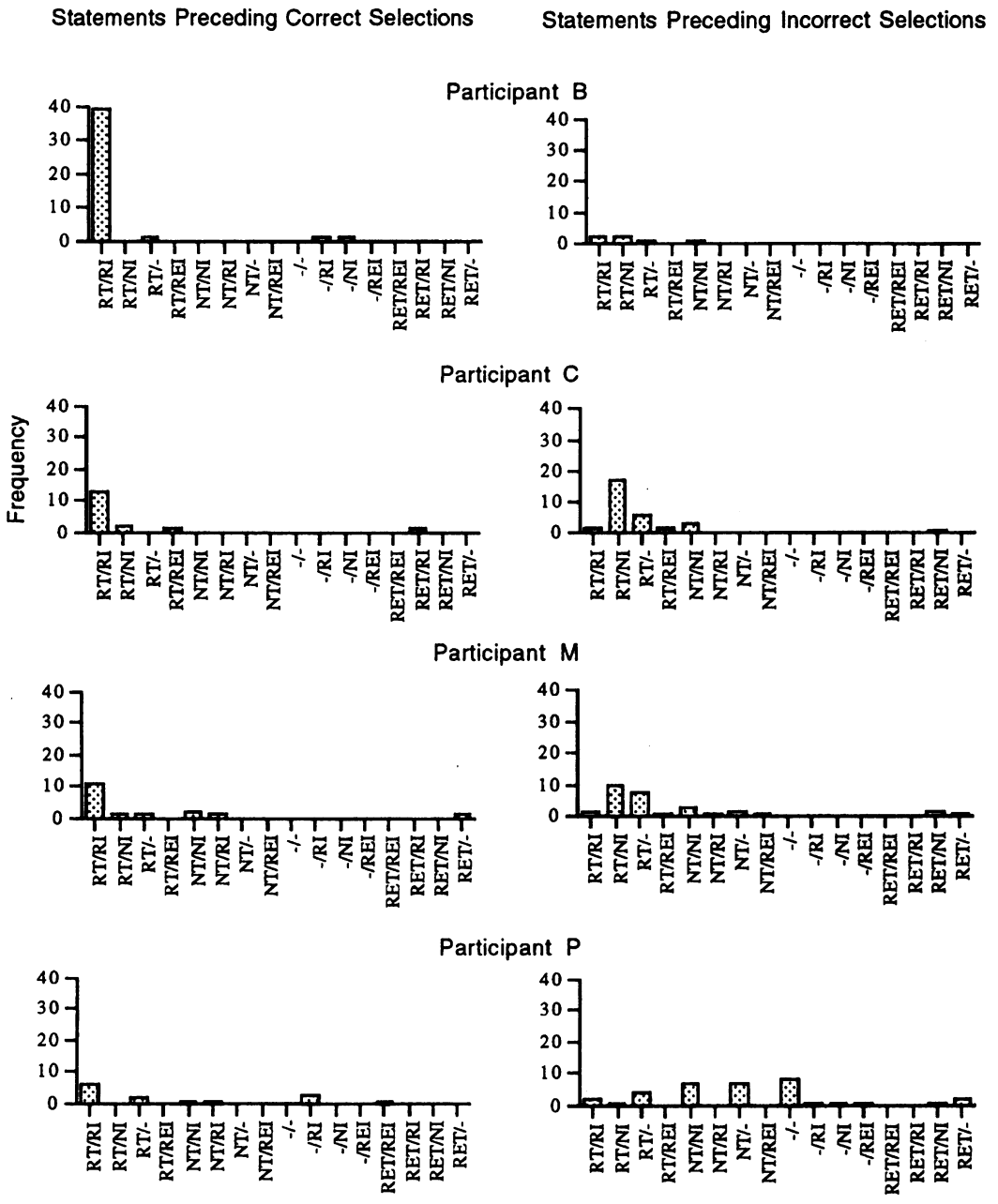
Individual Data. Figure 4 illustrates protocol analysis performances for all four participants. Participant B performed the best of all participants as shown in the first panel of Figure 4. Prior to correct selections, B emitted a statement of the "RT/RI" type 93% of the time. Prior to incorrect selections B tended to tact the sample stimulus as in previous tutorial and remedial trials, but them emitted a new intraverbal or none at all (the "RT/NI" and "RT/-" categories). The right side of the first panel of Figure 4 illustrates this (the "Incorrects Selections" column). Participant B (as well as participant M) appeared to occasionally streamline his vocalizations, perhaps an example of what Skinner (1957) noted: "Operant behavior tends to be executed in the easiest possible way" (p. 141). The following is an example of three exposures to the same relation for B. The condition in effect, or the outcome of each trial is noted in the parentheses following each statement.

1. Let's see a white computer chip in a small basket (tutorial).
2. White computer chip in the basket (correct choice).
3. Okay white chip in a basket (correct choice).

It is interesting to note that participant B seldom emitted a tact to the actual characteristics of the sample and comparison stimuli (e.g., he would say "computer chip" and "basket" versus "dark diagonal" and "horizontal dots"). The other three participants had a much higher frequency of more conventional tacts.

The remaining participants performed similarly to B, but were less accurate. Figure 4 summarizes their data for statements preceding correct and incorrect responses. The "RT/RI" statement type preceded the largest number of correct responses for all participants, accounting for 76%, 69% and 43% of all statements preceding correct responses for participants C, M and P respectively (see the left half of panels 2, 3 and 4 of Figure 4 respectively).

Relatively consistent statements also occurred prior to the selection of incorrect choice stimuli for these three participants (see the right half of Figure 4). The majority



T= Tact; - = No tact or intraverbal; RT= Repeated tact to sample stimulus from previous tutorial or remedial trial in same relation; RI = Repeated intraverbal. Tact in previous tut. or rem. trial to choice stimulus repeated as an intraverbal; NI = New intraverbal. Not a previous tact for this relation; RET = Repeated 'Exam'(test) Tact. Tact to sample stimulus which was repeated from an earlier test trial, correct or incorrect (within same relation); REI = Repeated 'Exam' intraverbal. Intraverbal which was emitted as an intraverbal in earlier test trial, correct or incorrect (within same relation).

Fig. 4. Protocol Data for individual participants. Note: The legend on the bottom explains the abbreviations used. All frequencies indicate the number of specified statements (e.g., "RT/RI") that preceded correct or incorrect selections. All selections in tutorial and remedial trials were correct (as the correct choice was revealed to the participant).

of those statements fell into the "RT/NI," "RT/-" and "RT/REI" categories for participants C and M. These categories accounted for 81% of C's statements preceding incorrect responses, and 68% of M's statements preceding incorrect responses. Thus, these participants tended to emit consistent tacts to the sample stimuli, but those tacts did not control consistent intraverbals (i.e., previous tacts to choice stimuli). Statement's preceding P's incorrect choices were more diversified than those of the other three participants. P tended to have little consistency in emitting tacts to sample stimuli (signified by the relatively high frequency of "NT/" type responses) and little consistency in intraverbals, that is repeated tacts made previously to choice stimuli (signified by the "/NI and "/-" categories). P's performance was the worst of the four participants.

Finally, another strategy used by M and P was to eliminate potential choice stimuli, using vocal-verbal behavior to do so. For example part of M's transcript consisted of "The black sun, can't be cup, done cup. It's gonna be dump truck ...."

Exit Interviews

In answer to questions about strategies or techniques used in various parts of the experiment, all participants indicated that vocal (overt or covert) verbal behavior played a key role in their performance. For example, M wrote "I would try and make a word or phrase to the nonsense symbol that related to the dot pattern. For example "Jumit" (a nonsense syllable used in earlier sessions) turned into "Jump it" and related to  because it looked like something jumping over something" (parenthetical text added). Participant C wrote: "... pick out a particular pattern within the flag-like pattern and make it something familiar to me and then gave that a word and the dot pattern a word and paired the two together."

Mouse Movements

A programming feature allowed for mouse movements to be played back and analyzed in terms of whether or not stereotypical mouse movements (potential TB responses) were occurring. These were recorded only when the mouse was over a dot pattern (the likely places where these patterns would occur). Of the 2,116 incidents of the mouse being within a field, only 34 were considered to be a possible TB response. Of those 34, 15 did not involve situations in which that pattern was selected (clicked on) and were thus less likely to have been a TB response for that stimulus. Interobserver agreement based on a review of half of the total recorded incidents (randomly chosen) by a second observer, was 99%.

Interobserver Agreements

The percent of interobserver agreements was calculated by two different observers for the protocol codings (each scored all protocols). For all participants, the average interobserver-agreement value was 94% for encoding each of the statement types. An interobserver-agreement value was also calculated for each of the individual participant's protocols all of which exceeded 89%, ranging from 89% to 98%. An interobserver-agreement value was also calculated for whether or not each observer indicated that a relationship tact occurred (explained in the group data section) on any given trial. For all participants, the average interobserver-agreement value was 90%, ranging from 81% to 97% for each individual participant.

DISCUSSION

This study originally investigated the impact that response-produced kinesthetic stimulation (a feature of TB verbal behavior) might have on the acquisition of SB verbal behavior. Little difference was found between conditions, as was found in previous studies in which highly verbal participants were used (Bristow & Fristoe, 1984; Cresson, 1994). However, virtually all experimental and pilot participants reported in post-session interviews that they used TB verbal behavior to perform more accurately. In general, these findings are consistent with post-session reports

and anecdotal observations obtained by other researchers (Cresson, 1994; Dugdale & Lowe, 1990; Stratton, 1992; Sundberg & Sundberg, 1990; Wulfert et al., 1991).

A protocol analysis revealed that participants were indeed emitting consistent types of TB verbal behavior prior to selecting correct choice stimuli. In essence, participants emitted tacts to the sample stimulus, which appeared to evoke an intraverbal similar to previous tacts to the appropriate choice stimulus, which was followed by the correct selection response. In some cases participants emitted the intraverbal as an echoic response, lending some support to Lowenkron's (1991) account of SB responding with highly verbal participants. Prior to incorrect responses participants often emitted a consistent tact to the sample stimulus, but the intraverbal response which followed varied. These data help to explain why nonverbal participants have larger differences between SB and TB performances (TB performances being better in both cases) than the differences found with highly verbal participants, and why some verbal participants perform better than others. It would appear that participants with effective verbal repertoires (especially well developed problem-solving abilities, as discussed later in this article) use those skills to mediate such SB tasks as arranged in this study.

Horne and Lowe (1996) have suggested that stimulus equivalence might also be mediated by a similar process, although they suggest that "naming" is a basic unit of verbal behavior. To the extent that stimulus equivalence testing and training uses a SB task, the data from this study is relevant (most equivalence studies do use a SB task). Sidman (1994) notes that participants in certain equivalence studies were given post-session interviews to determine if they had developed names or used the names of objects to aid their performance. Little evidence of "naming" was demonstrated. The same procedure was followed in this study, and as Sidman found, the participants were not able to recall many of the actual nonsense syllables used as samples in this study (used in earlier sessions). When pressed to recall, however, several of the participants were able to recall distorted English names for some of the nonsense word choice stimuli. Several of the participants also expressed some hesitation in revealing those names, as they said they were "goofy" or something of that nature. Something akin to this was seen with two of the participants in the protocol analyses. Both women, they commented afterwards that in the actual session they were much more effective in generating names for the stimuli presented to them. However, the researcher's presence (a male) caused them to edit the names they supplied (several comments on the tape recording support these statements). The other two participants (both male) stated that they did not have any reactivity during the protocol analysis, which is partially supported by the somewhat profane nature of one of the participant's labels—although it is possible that this too is indicative of reactivity. It is possible that postsession analyses are affected by too many extraneous variables to give insight into what actually occurred in the experiment. This is the reason why the concurrent "talk aloud" method (Ericsson & Simon, 1993) was used in this experiment, as in the Wulfert et al. (1991) study. Given the results of the protocol analyses and the supporting evidence from other researchers, it seems likely that TB verbal behavior was mediating the SB responses in this study. It should be noted, however, that no direct causal relationships can be inferred from protocol analyses; only a sufficiency argument can be made.

As Sidman (1994) points out, and as the nonhuman and nonverbal research literature supports, it is clearly possible for conditional discriminations to develop without the capacity for verbal behavior. However, comparing nonverbal human performances to human verbal performances, it appears that differences exist that are more than simple innate discrimination abilities. For example, in Sundberg and Sundberg's (1990) study, four mild to moderately retarded adults required the following number of trials to acquire 90%

accuracy on each individual relation (approximate values): SB tact, 98; SB intraverbal, 65; TB tact, 20; and TB intraverbal, 50. Similar results were obtained by Wraikat (1990) and Wraikat et al. (1991). Compare these data with the results of this study in which participant B reached 90% accuracy in as few as two exposures, using 10 relations (during earlier sessions). Researchers studying nonhuman conditional discrimination performances also report that many trials are needed for acquisition. For example, Cumming and Berryman (1961) examined match-to-sample performance in pigeons, using only two choice stimuli. Acquisition at the 90% accuracy level occurred after a minimum of approximately 350 trials for each relation for one bird, and after a maximum of approximately 560 trials for each relation for two other birds. It would appear that the differences obtained here are a function of the TB verbal repertoires available to certain participants in these studies, and unavailable to others. The results of the protocol analyses from this study are clear, but must be taken as only correlational. That is, it is unclear whether the consistent statements preceding the correct selections influenced those selections or were just accompanying statements. However, these data do support the results of other researchers in this area (Wulfert, et al. 1991).

It seems likely that the number of choice stimuli used (or relations trained) may be relevant to the necessity of using existing verbal repertoires to aid in successful SB responding. In many of the equivalence and nonhuman studies, only two choice stimuli were arranged. This study used 12. It is likely that the more difficult the task, the more likely verbal mediation would occur. Something of the sort has been offered as an explanation for remembering (Donahoe & Palmer, 1994). These researchers drew a distinction between reminding and remembering. Reminding is classified as simple stimulus control, in which a stimulus controls a response (either in a respondent or operant manner). Remembering, however, occurs in a situation in which a response is scheduled to be reinforced, but for various reasons it can not immediately be evoked by the present stimulus conditions. The current stimulus conditions then evoke a series of responses (often verbal) that terminate in the production of the target response. This is one of several behavioral processes that have been labeled "problem solving." It is possible that such a process occurred in this study, given the difficulty of learning the relatively high number of relations used in this study. Stratton's (1992) manipulation showed clear differences when he manipulated the number of relations trained. However, no direct evidence (anecdotal data only was reported) was recorded for verbal mediation of the SB task in that experiment.

Protocol Analysis and Conclusions

Protocol analyses are not currently used much in behavioral research, probably for both historical and practical reasons. Historically, such techniques were used primarily for gathering information on thoughts and to aid in uncovering inferred cognitive processes (Hergenhahn, 1986). Inferences and unsupported observations are not thought to be effective or necessary methods for uncovering functional relationships between environmental events and behavior (Skinner, 1974). However, in its current usage, and as with Wulfert et al. (1991), the protocol analysis was used to make potentially important covert verbal behavior overt . This study extended the work of Wulfert et al. (1991) by encoding the protocol analysis in terms of Skinner 's (1957) elementary verbal operants. The results also supported those of Wulfert et al. (1991) by showing relatively clear results in terms of verbal statements which accompany successful SB responses.

As noted earlier, some behavior analysts have examined the utility of using verbal reports (e.g., Hayes, 1986; Perone, 1988). Shimoff (1984) states (as cited in Perone, 1988) "an experimental analysis of behavior generally seeks causes of behavior in the environment, not in other behavior.

Verbal behavior may serve as an intermediate cause, as when it is part of an extended chain preceding some nonverbal response, but an experimental analysis will trace the chain to its environmental origins" (p. 74). It is believed that this study lives up to the spirit of Shimoff's statement. The protocol analysis is used here only as a tool to clarify relations among stimuli and responses, whether they be response-produced (e.g., verbal behavior) or not.

In this study, the protocol analysis allowed direct observation of strategies used which were correlated with SB performance. The observation of exclusion responding and repeating phrases until the choice stimulus was selected, provide evidence that verbal strategies were used to increase accuracy in the SB task. Some behavior analysts have hypothesized that these strategies do take place (Cresson, 1994; Michael, 1993; Stratton, 1992). Additional research might involve training participants to respond in these manners and to test accuracy and performance prior to and after such training. As a start, some researchers have examined the utility of teaching names to participants for various components of the conditional discrimination task. In general, such training has been shown to facilitate acquisition (Dugdale & Lowe, 1990).

These findings, along with others, indicate that more research and possibly new research techniques are needed to investigate this area. Protocol analyses offer a good starting point, but more rigorous accounts are necessary to provide for causal information. Some researchers have attempted to operationalize verbal reports in a more rigorous manner (Critchfield & Perone, 1990; Lane & Critchfield, 1996) by arranging for structured self-reports to be taken immediately after conditional discrimination and equivalence trials. While these reports only indicate a participant's description of the accuracy of a immediately preceding response, they do so in an easily measured and observed manner, a start in a difficult area to research. Stephens and Hutchison (1992) have taken a different tack, arguing that operant principles, modeled on a computer (adaptive network systems), may provide sufficiency arguments for the development of verbal behavior via operant conditioning. To the extent that this technique parallels organismic learning, it is useful in that all environment/behavior relations (overt or covert) are readily available for observation.

While the results of the study show consistency in the type of verbal emissions prior to correct selections, more research is required to provide a full account of the role that mediating verbal behavior plays, and how it evolves. For example, it is unclear why participants spontaneously tact the sample stimulus, but it is likely to be a function of a long history of such responding, in addition to the particular contingencies arranged in this experiment. Researchers could also investigate how the tact to the comparison stimulus becomes an intraverbal. Investigators examining differences between SB and TB verbal behavior should be wary when using highly verbal participants. It is likely that such participants incorporate existing TB repertoires in the SB task, thus performing qualitatively differently than participants with poorer verbal skills.

It is hoped that the results of this study will contribute to a better understanding of the types of variables operating in such research, and provide initial methodologies for analyzing these variables in light of existing verbal categories (the elementary verbal operants, Skinner, 1957).

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