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A Review of Studies Examining the Nature of Selection-based and Topography-based Verbal Behavior

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Selection-based (SB) verbal behavior, in most general terms, consists of selecting stimuli from an array, which presumably has some effect on a listener. Topography-based (TB) verbal behavior consists of responses with unique topographies (e.g. speaking, signing, writing) which is also presumed to have some effect on a listener. This article reviews research examining the nature of these two types of verbal behavior. Overall, TB verbal behavior appears to be more easily acquired and may also function to mediate some SB verbal behavior.

Researchers are in the process of clarifying the differences between selection-based and topography-based verbal behavior, as initially specified by Michael (1985) and expanded on by Cresson (1994) and Stratton (1992). The purpose of this article is to provide an overview of these differences, then summarize the research which has been conducted in this area.

Topography-based (TB) verbal behavior consists of making a response with a unique form or topography (e.g., saying "What time is it?" or manually signing the same). The resulting stimulus from such a behavior presumably affects the listener in an appropriate manner. Common examples of topography-based verbal behavior include speaking, signing (as with the sign language of the deaf), and writing.

Contrast this with selection-based (SB) verbal behavior, which consists of pointing to a stimulus, or series of stimuli, arranged in an array. The listener, watching which stimuli are pointed to, responds in an appropriate manner. For example, when the symbol for "bathroom" is pointed too, the listener may bring the student to the bathroom. In this case the form of the response, pointing, is always approximately the same regardless of the stimulus selected. One example of SB verbal behavior is the use of communication boards, as used with developmentally disabled (DD) population (Shafer, 1993) and in ape language studies (Savage-Rumbaugh, 1984). Another example is the more recently developed Picture-Exchange Communication System (PECS). This method requires students to select symbols or pictures from a stack, then hand them to a listener. While still SB verbal behavior, this method facilitates more interaction between the speaker and listener (primarily used with children with developmental disabilities). This method also allows students to arrange pictures into "sentences" (see Bondy & Frost, 1993 for a more thorough explanation, and the application, of PECS).

It is useful to contrast SB verbal behavior with TB verbal behavior to illustrate the differences pointed out by Michael (1985). Consider a situation in which a teacher is training a student to use a communication board, consisting of a flat surface upon which a number of symbols are displayed. The student may point to a particular symbol on the device and the teacher will pro-

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vide feedback about the correctness of the response. For example, the teacher may present a picture of a dog and the student may then point to the symbol for a dog in the upper-left corner. If the selected stimulus is correct, the teacher will respond in a positive fashion. The teacher may then hold up a picture of a cow. Again, an appropriate consequence follows depending on the student's selection. Note that except for minor positional differences, the topography of the response (pointing) is very similar whether the student is pointing to the symbol for a dog or for a cow.

In the case of a teacher presenting a picture of a cow to a deaf student learning sign language, the response evoked (if accurate) will be the particular sign for cow. The teacher judges the accuracy of the response based on the topography of the response. When the teacher presents a picture of a dog, the sign emitted is different from that of the sign for cow, or in other words, the topography of the signed response "cow" differs significantly from that of the signed "dog" response. This is not the case with SB verbal behavior (i.e., the pointing response is similar for all verbal responses). Other differences between the two types of verbal behavior are presented in Table 1 and are discussed later in this article.

There appear to be at least three general reasons why research into the SB/TB distinction is valuable. First, as some researchers have recently noted, there appears to be an increase in the use of SB techniques (e.g., communication boards, PECS) with developmentally-delayed and disabled populations (Bondy & Frost, 1993; Shafer, 1993; Shane & Bashir, 1980; Sundberg, 1993; Sundberg & Sundberg, 1990). This increase has not been accompanied by much empirical research (Shafer, 1993; Sundberg & Sundberg, 1990), and published studies are often in the form of case studies (Romski, Sevcik & Pate, 1988). It may be the case that the increasing use of SB systems has resulted in a decrease of TB system use, without empirical justification. Understanding the relevant variables in SB/TB verbal behavior would aid teachers in selecting and designing communications systems/programs for people with developmental disabilities (see Shafer, 1993 and Sundberg, 1993 for reviews of this area).

Second, although there has been much research using SB and TB systems with nonhumans, few if any, of these studies have considered the distinction or made any comparison between the two kinds of verbal behavior. The aims of these researchers vary considerably, but each, at some level, recognize the importance of nonhuman research in understanding the nature of language (Epstein, Lanza & Skinner, 1980; Gardner & Gardner, 1969; Pepperberg 1988; Rumbaugh, 1977; Savage-Rumbaugh, 1990; Terrace, 1979). It would be valuable to determine if differences exist between these types of verbal behavior, in order to aid in interpreting the results of such studies.

Third, research on stimulus equivalence, among other research areas, frequently uses SB procedures. Stimulus equivalence is singled out here because it has strong implications for the acquisition of verbal behavior (see Sidman, 1994). Much of this research involves the use of the "matching-to-sample" technique. This technique involves presenting some kind of antecedent stimulus (e.g., a picture of a car, or the auditory stimulus "car") along with several choice stimuli from which the participant is required to select the correct relation (e.g., pick the word "car" in the presence of a picture of a car). It also should be noted that research is conducted in which SB and TB responses are intermixed in a single equivalence experiment. For example, one of the earliest studies (Sidman, 1971) involved training a severely DD participant to match pictures of a cat to the printed word cat (SB response), as well as to say the word "cat" upon seeing a picture of a cat (TB response). In summary, given the differences which appear to exist between these two types of verbal behavior, it would seem important to investigate these differences to aid in designing and interpreting future research.

Table 1

A comparison of selection-based and topography-based verbal behavior.

Item Compared	Selection-based	Topography-based
Stimulus Control	• Conditional discrimination. The pointing response is controlled by a stimulus or establishing operation that alters the evocative strength of a particular choice stimulus (from an array). • In a controlled/experimental setting, all choice stimuli are present allowing the student to react to them.	• A direct relation. The antecedent stimulus condition evokes the response (no second stimulus or stimulus array is involved).
Response	• Nearly indistinguishable from other SB responses. • Requires an additional "scanning" repertoire to come into contact with the choice stimulus effective in evoking the pointing response. • It is likely that the pointing response already exists in the student's repertoire (no new topography needs to be learned).	• Clearly distinguishable from other TB responses. • Requires no "scanning" repertoire. • The topography of the response must be learned before it can be emitted.
Response-produced Kinesthetic Stimulation	• Nearly indistinguishable from other SB response-produced kinesthetic stimuli.	• Clearly distinguishable from other TB response-produced kinesthetic stimuli.
Correspondence Between Response and the Antecedent Stimulation for the Listener	• No point-to-point correspondence between the response and the response-produced stimulus functioning as an antecedent stimulus for the listener's behavior.	• Point-to-point correspondence exists between the response and the response-produced stimulus functioning as an antecedent stimulus for the listener's behavior.
Environmental Arrangement	• Necessitates additional apparatus (the stimulus array). • In most such communicative activity, if it can be assumed that the correct symbol is on the board (as with any training exercise), finding it even if it is not well known is made easier by being able to eliminate the known symbols for other objects or events. • If the number of symbols is large enough to require a considerable search time, there will be a loss of control by the variable that initiated the search, even if the relevant symbol is well-known.	• Generally, no additional apparatus required (writing is an exception). • There is no sense in which the entire relevant repertoire can be examined and incorrect responses eliminated, other than by emitting the responses which are strong, which may not include the relevant one. • If the response is strong, there is no time delay between the presentation of the controlling variable and the response occurrence.
Notes	Derived from Cresson, 1994; Michael, 1985; Stratton, 1992.	

Differences Between Selection-based and Topography-based Verbal Behavior

Table 1 (derived from Cresson, 1994; Michael, 1985; and Stratton, 1992) compares the differences between SB and TB tasks in five general categories: (1) the stimuli controlling the SB or TB response (stimulus control), (2) the response itself, (3) the nature of the response product (response-produced kinesthetic stimulation), (4) correspondence between the response and the response product which controls the listener's response and, (5) the general environmental arrangement required for each of the task types.

The following paragraphs briefly summarize some of the more critical parts of Table 1. As noted in the part of Table 1 addressing stimulus control, an SB task is controlled by a relation between two stimuli, namely the sample stimulus (or an establishing operation, although this is generally not referred to as a stimulus) and a choice stimulus. The sample stimulus affects the participant in such a manner as to increase the evocative strength of one of the choice stimuli. This choice stimulus evokes the pointing response from the participant. Such a situation is often called a conditional discrimination, that is, it involves an extra degree of stimulus control. Contrast this type of stimulus control with that of a TB task, in which no choice array is present. In this case, the response is often evoked directly by the antecedent stimulus.

Several differences also exist between the types of responses characteristic of SB and TB verbal behavior. All final SB responses are similar (e.g., pointing to a choice stimulus), while TB responses are all necessarily different as the form of the response (vs. what is pointed to for SB verbal behavior) is what has the desired effect on the listener (Michael, 1993). Prior to the final SB response, a scanning response must occur; that is, the speaker must come into contact with the appropriate comparison stimulus before that stimulus can evoke the pointing response. This is not the case with a TB response. When acquiring new relations in an SB framework, no new response needs to be added to the existing repertoire (i.e., the pointing and scanning repertoires having already been established). In a TB framework, however, acquiring a new relation generally involves adding a new response to the speaker's existing repertoire such as learning a new sign or vocalization (Stratton, 1992). However, in both TB and SB types, the response must be brought under appropriate stimulus control. Most of studies described below (and in Table 2) describe research that has focused on examining gross differences between SB and TB relations in terms of stimulus control and response type.

There are clear differences between SB and TB verbal behavior in regard to response-produced kinesthetic stimulation (versus the more ambiguous differences in visual and auditory feedback related to each response form). The pointing response is nearly identical in all cases of SB verbal behavior, producing little differences in response-produced kinesthetic stimulation. However, with TB verbal behavior, the kinesthetic stimulation is directly related to the differences among responses, which must be distinct enough to produce the desired effect in the listener (thus, also resulting in distinct response-produced kinesthetic stimulation).

Finally, certain logistical elements differ between the two types of verbal behavior, which have some interesting practical implications as noted in Table 1 and are described later in this review (Cresson, 1994; Michael, 1993). For example, SB verbal behavior has been called an "aided" (Romski, et al., 1988; Sigafoos & Iacono, 1993) communication system, in that it necessitates the use of additional apparatus such as a communication board or a computer. Other factors include the size of the stimulus array and the necessity to be close to a listener.

OVERVIEW OF RELATIONS TRAINED AND TESTED

A number of studies have directly investigated the nature of these two types of verbal behavior. Many of these studies are summarized below with additional information provided in Table 2. Nearly all the studies conducted to date have focused on the acquisition of tact and intraverbal relations[1]. In addition, most of the studies have incorporated some component of stimulus equivalence: reflexivity, symmetry, or transitivity. A brief overview is provided of each of these types of relations prior to examining the results of SB and TB studies.

The tact relation as defined by Skinner (1957) is "a verbal operant in which a response of given form is evoked (or at least strengthened) by a particular object or event or property of an event. We account for the strength by showing that in the presence of the object or event a response of that form is characteristically reinforced in a given verbal community" (p. 82). Thus, in the tact relation, the controlling variable is nonverbal – it is not the product of another's verbal behavior and the response is typically reinforced by other members of the verbal community. An example of this would be a child saying "red" in the presence of a red apple. Note that the aspect of the environment controlling the response is the "red" property of the apple, which of course might be shared by other items (e.g., a barn, a sunset). Skinner classified this particular type of tact as abstract. An example in which an auditory stimulus controls the tact response would be someone saying "airplane" in the presence of the sound of an airplane overhead. Notice that the definition does not specify that a particular type of reinforcer is required for this relation: it is not an important distinction (Peterson, 1978). Some researchers have stressed that generalized conditioned reinforcers probably play a rather large role in the acquisition of tact responses as well as the intraverbal (Michael, 1993; Skinner, 1957; Sundberg, 1990; Sundberg, Michael, Partington & Sundberg, 1996).

The intraverbal relation (Skinner, 1957) is a verbal response controlled by a verbal stimulus, but little similarity exists between the controlling verbal stimulus and the product of the evoked verbal response. For example, saying "The Herald" after hearing someone say "newspaper" would be considered an intraverbal relation. The intraverbal relation is also not limited to any sense modality. For example, signing "cat" after reading the lips of someone saying "dog" would also be considered an intraverbal response. As with other relations controlled by verbal antecedents, the intraverbal tends to be consequated with generalized conditioned reinforcers (as noted above). Differences found between the acquisition of tact and intraverbal relations will be discussed later in this article.

As previously noted, a number of SB/TB studies have incorporated some form of stimulus equivalence. Stimulus equivalence training generally consists of participants learning a series of relations. For example, after hearing the nonsense word "Ork," the participant is required to select a picture of some object (e.g., a lump of coal). Next, the participant is required to select the correct nonsense symbol (e.g., "¬") from an array when presented with the lump of coal. Once these relations are trained, then equivalence testing can be conducted. The first test, called reflexivity, consists of presenting a particular stimulus both as the sample and the correct comparison in an array of stimuli, to test if the participant has this untrained relation in his or her repertoire. Next, one could test to see if reversing the sample and choice stimuli results in accurate responding; for example present "¬" and require the participant to select the lump of coal from an array of stimuli (a symmetrical relation). The last relation, called transitivity, would consist of presenting a nonsense word (e.g., "Ork") and having the symbol "¬" as the correct comparison stimulus in an array. In symbolic terms, these relations can be summed as: A—>B and B—>C (training), then test A—>A (and all other reflexive relations), B—>A, C—>B (symmetrical

[1] It should be noted that some of the intraverbal relations reported in these studies used a nonsense word (thus nonverbal) for the antecedent stimulus. According to Skinner's classification, this would make those relations tacts, not intraverbals. The term intraverbal is used in this article to maintain consistency with previous reports.

relations) and A—>C (transitive relation). When all three emergent relations, transitivity, reflexivity, and symmetry have been demonstrated, then stimulus equivalence is said to exist for the set of stimuli used (Sidman & Tailby, 1982). While most researchers have focused on demonstrating reflexivity, symmetry and transitivity, others have explored various combinations and arrangements of these relations. For example, Sidman and Tailby (1982) examined the emergence of both a symmetrical and transitive relation. To do this they trained the relations B—>A, C—>A, then tested B—>C and C—>B. These researchers showed that equivalence could be demonstrated between two sample stimuli which had been paired only with a common choice stimulus. For the purpose of this article, this type of emergent relation will be called "equivalence" (Lazar, Davis-Lang & Sanchez, 1984) and was tested by Cresson (1994), Sundberg and Sundberg, (1990), Wraikat, Sundberg, and Michael (1991), and Potter, Huber and Michael (1997).

The relevance of these emergent relations to verbal behavior has been noted by many researchers (Barnes, 1994; Fields, Verhave, & Fath, 1984; Hall & Chase, 1991; Sidman, 1986; Wulfert & Hayes, 1988) although some have raised questions as to the applicability of stimulus equivalence to TB verbal behavior (Hall & Chase, 1991; Tan, Bredin, Polson, Grabavac, & Parsons, 1995). Sidman (1994) generally believes that the capacity to demonstrate stimulus equivalence is an innate feature of humans, one essential to the development of verbal behavior. Hayes and Hayes (1989) also believe stimulus equivalence to be essential to verbal behavior, although they believe the development of this capability to be a function of a specific learning history. Others have claimed that stimulus equivalence is a function of verbal behavior; that is, without verbal behavior, stimulus equivalence would not emerge (Dugdale & Lowe, 1990; Mandell & Sheen, 1994). To date, only one study has demonstrated the development of stimulus equivalence as defined by Sidman and Tailby (1982) in nonhumans (Schusterman & Kastak, 1993), although many others have tried and failed. Horne and Lowe (1996) argue that distinctive aspects of the procedure used by Schusterman and Kastak may have allowed TB response forms to facilitate the performance of the single sea lion which was used in this study. To date no researcher has replicated these finding, which has been taken as evidence that language is a prerequisite for demonstrations of stimulus equivalence (Horne & Lowe, 1996). Although, as Hayes and Hayes (1989) have noted, this failure to demonstrate stimulus equivalence could also be due to a lack of a particular training history.

SUMMARIES OF SELECTED SB/TB STUDIES

Below, ten studies that have examined the nature of SB and TB verbal behavior (most have examined difference in acquisition and accuracy) are summarized. After summarizing these studies, the implications and ramifications of these studies will be examined. Table 2 provides additional information on each of these studies.

Bristow and Fristoe, 1984

Twenty nonhandicapped children (average age 8.2 years old) participated in this study. These researchers first trained all the participants to select a particular picture when presented with one of 12 auditory nonsense words. Half of the participants then had six of the pictures presented as sample stimuli and were required to emit appropriate manual signs to each (TB condition). Later, these same participants learned to select symbols from an array when presented with the remaining six pictures (SB condition). The remaining participants received similar training except that the pictures used in each condition were counter-balanced. Correct responses were simply acknowledged by the researcher, while incorrect responses were followed by the researcher noting that it was incorrect and modeling the correct response. A 30 s limited hold was in effect that when timed out, was treated as

Table 2

Partial summary of research in SB/TB verbal behavior.

	Participants	Correction Training	Antecedent Stimuli	Comparison Stimuli	TB Response Form
Bristow & Fristoe, 1984	20 children (non DD) av. age 8.2 years old.	Incorrect- said incorrect or similar. Participant required to imitate correct response.	TB: pictures SB: pictures & nonsense words.	Symbols or pictures (12 or 6 used - ordering not reported)	Manual signs
Hodges & Schwethelm, 1984	52 retarded children Av. age 12.2 years	Fading and prompting were used, but no correction training was cited (e.g., remedial).	TB & SB: objects (e.g., candy, ball).	Symbols ordering not reported (4 used)	Manual signs
Sundberg & Sundberg, 1990	4 adults with DD	Non answer = demonstration with verbal prompt. Incorrect = told incorrect, then model with verbal prompt, correct.	TB & SB: nonsense objects & nonsense words (auditory).	Symbols Pseudo random order each trial (3 used)	Manual signs
Wraikat, 1990	5 adults with DD	Non answer = demonstration with verbal prompt. Incorrect = told incorrect, then model with verbal prompt, correct.	TB & SB: nonsense objects & nonsense words (auditory).	Symbols Pseudo random order each trial (3 used)	Manual signs
Wraikat, Sundberg & Michael, 1991	7 adults with DD	Non answer = demonstration with verbal prompt. Incorrect = told incorrect, then model with verbal prompt, correct.	TB & SB: nonsense objects & nonsense words (auditory).	Symbols - 2 for 3 part. 3 for other 4 part. Pseudo-random order each trial	Manual signs
Stratton, 1992	28 college students	Non answer = correct answer and asked participant to do response. Incorrect = same as non answer. In both cases words "try again" typed.	TB & SB: written English word.	Symbols (Kanji chars.) random order each block (5 or 20 used)	Vocal (Japanese 2 syll. word).
Wallender, 1993	20 college students	Non answer = present correct answer and ask participant to do response. Incorrect = same as non answer. In both cases tone heard & "incorrect" shown.	SB only: written English or Japanese words.	Symbols (Kanji chars.) random order each block (20 used)	None
Cresson, 1994	16 college students	Incorrect = correction: repeat trial with correct answer displayed (for both paradigms).	TB & SB: visual pattern & auditory non. word.	Symbols (Katakana) pseudo-random (8 used)	Write Katakana symbol
Tan et al., 1995	8 college students	Incorrect answer resulted in a low tone. Not reported if participant was required to redo relation.	TB & SB: typed French or English word.	French or English word (ordering not reported) (4 used)	Typing
Potter, Huber & Michael, 1997	6 college students	Non answer = "incorrect, try again." Answer flashed and participant emitted correct response. Incorrect = same as non answer.	SB & SB/TB: "flaglike" patterns & auditory non. word.	Dot patterns (10 to 14 used)	Mouse click on each of 4 dots in a choice.

an incorrect response. Participants were also counterbalanced in the order of training for SB and TB systems.

Finally, each participants was administered a transitivity test in which a nonsense word was presented and the participant was required to either emit the sign paired with the same picture that the sample stimulus had been paired with (after TB training), or to select a similarly paired symbol from an array (after SB training). Participants were also tested a day after the initial training to examine long-term retention.

Results indicated that acquisition was slightly faster (no statistical significance) for the TB training. TB training also resulted in higher overall accuracy (also not statistically significant) in both training and for transitivity tests.

Hodges and Schwethelm, 1984

Using 52 profoundly retarded nonverbal children (average age 12.2 years old) these researchers examined the difference between acquiring signs (TB) or matching-to-sample (SB). In both cases participants were shown common objects (e.g., candy, ball) as sample stimuli. In the TB paradigm, an object was held up while the researcher modeled, then prompted (molded the child's hands) the participants to emit the correct sign. In SB training the researcher also modeled the correct response by tapping the sample object with the correct symbol (used as choice stimuli). Correct responses were followed by various foods, objects and praise. Fading and prompting were used in training relations, but no remedial procedures were specified after an incorrect response occurred. Mastery was defined as 80% correct responding with 8-10 signs, or 80% on 9 SB relations.

Results indicated that participants learned more signs, and also learned those signs faster than they learned the SB task. However, as noted later in this review, the researchers actually trained mand relations in the TB condition (vs. tact relations in the SB condition) which may account for the obtained results.

Sundberg and Sundberg, 1990

Using four adults with mild to moderate mental retardation, these researchers examined the differences in acquisition and accuracy between TB and SB verbal behavior. In the SB paradigm participants were trained to match nonsense objects (e.g., an oblong piece of wood) or nonsense words (e.g., "Zug") to various symbols arranged in an array of three. In the TB paradigm, the same type of sample stimuli were used, but participants were required to emit a manual sign. In both cases, pretraining consisted of presenting each relation five times while the experimenter modeled the correct choice.

During the acquisition phase, correct responses were followed by pennies and praise, while incorrect responses were acknowledged as incorrect and the correct response modeled. A 10 s limited hold was in effect, that when timed out resulted in the same conditions as an incorrect response. The acquisition phase continued until a participant obtained 9 out of 10 correct responses for a particular training set (mastery). At the start of each session, participants received remedial training consisting of two demonstrations (as in pretraining) of each previously trained relation, but only within the paradigm being trained in that particular phase of the experiment.

Following mastery, an equivalence test was administered. Participants were asked to select "Zug" (or some other nonsense name was provided) from an array of three nonsense objects. Thus, only the sample stimuli used in training were being use in the equivalence test. The correct choice in each trial was to match the name and object which had been paired with the same symbol (after SB training) or sign (after TB training) in the preceding training sessions.

Results indicated faster acquisition for all TB trained relations, as well as for equivalence tests following TB training. In addition, TB training resulted in higher accuracy (the number of relations correct) across all conditions. The researchers also reported that several participants occasionally emitted mediating TB responses prior to responding in an equivalence trial (primarily after TB training sessions).

Wraikat, 1990

Using five adults with mild/moderate developmental-disabilities, Wraikat presented participants with either an object (e.g., an "I" shaped plastic object) or a nonsense syllable (e.g., "ki"). Participants were then required to either learn to select (SB) an appropriate symbol from an array of three or to emit the appropriate sign (TB). Correct responses were followed with praises/stickers. Incorrect responses resulted in the experimenter noting that the response was incorrect, then re-presenting the sample stimulus and modeling the correct response (the participant was not required to emit the correct response in a remedial trial). A 20 s limited hold was in effect, after which time the same conditions were followed as when an incorrect response was emitted. Maintenance training was provided for each relation (5 trials each) at the start of a new session. Participants continued training until mastery was achieved, defined as 9 out of 10 correct responses.

Results indicated that overall participants acquired TB relations faster (in terms of trials to mastery). In addition, performance tended to be more accurate in the TB condition. Interestingly, Wraikat reported that participants appeared more attentive and positive when performing in the TB condition. Furthermore, some participants were observed to emit vocalizations prior to emitting signs.

Wraikat, Sundberg and Michael, 1991

Seven participants, diagnosed as developmentally disabled and exhibiting moderate to severe learning disabilities, were used in this study. Similar to the Sundberg and Sundberg (1990) and Wraikat (1990) studies, these researchers presented either nonsense objects or nonsense (auditory) words to a participant as samples, then asked the participant to select an appropriate symbol from an array of either two or three (SB), or to emit a manual sign (TB). In addition, these researchers added an equivalence test in which the objects used in training were placed on a table and the participants was asked "Select the 'Nack' " or some other nonsense word. Thus, the participant was required to select the object that had been paired with the same symbol that the spoken nonsense word had been paired with in SB training, and to select the object that had been paired with the same sign in TB training as was paired with the nonsense word. These researchers also incorporated the use of interspersal training in their study. After the first relations were trained, each subsequent session mixed new relations along with review trials of previously trained relations (half of the trials in each session were dedicated to this interspersed training). Thus, in each subsequent session, 24 trials were always dedicated to new relations, while 24 trials were split equally among all relations previously trained.

Correct responses were followed by praise and stickers, while incorrect responses resulted in an acknowledgment that the response was incorrect, then the correct response was modeled by the researcher as the trial was repeated. A 20 s limited hold was in effect and when timed out, resulted in the same conditions as an incorrect response. Participants continued until mastery was reached, defined as 11 out of 12 consecutive trials correct when using two objects and 7 out of 8 correct consecutive trials when using three objects (interspersed training was not counted as being part of mastery).

Results indicated faster acquisition and more accurate responding when the participant was asked to manually sign (TB) versus select a symbol from an array. Accuracy was also better in the equivalence test after TB training. Wraikat et al. noted that participants again appeared more alert and engaged in the TB conditions (as Wraikat reported in 1990).

Stratton, 1992

Using 28 college students, Stratton examined stimulus set size (5 vs. 20) and language paradigm (SB or TB). In the SB paradigm, participants were asked to select a written Japanese Kanji character after being presented with an English word (e.g., "clam"). They did this by clicking a mouse over the appropriate Kanji character presented in an array of either five or twenty (all stimuli were presented on a computer). In the TB paradigm, participants were also shown an English word on the computer screen, but in this case were required to say the matching Japanese word. In both paradigms participants received one trial of pretraining indicating the correct matches.

Correct responses were followed by "Good" written on the computer screen in both cases (the experimenter evaluated whether the TB response was correct and entered it into the computer). Incorrect responses were followed by the written statement "Try again" at which point participants were shown the correct choice and required to emit the correct response before continuing. A 20 s limited hold was in place, which when timed out, resulted in the same conditions as an incorrect response. Participants continued until mastery occurred which was defined as three consecutive blocks (one trial for each relation trained) with no errors. Participants were also tested for emergence of symmetrical relations. Symmetry tests were not conducted on a computer. For the SB conditions, participants were required to select (circle on a paper) the correct English word from an array, after being shown a written Kanji character. In the TB condition, participants selected the correct English word after the experimenter said the matching Japanese word. Participants only received one condition, thus there were seven participants in each of the four groups: SB with five relations; SB with twenty relations; TB with five relations and TB with twenty relations.

Results indicated little difference between the SB and TB conditions when the five stimulus set was used all participants easily mastered the relations. When 20 relations were trained, performances were much better in the SB conditions vs. the TB condition (on average, SB performances reached mastery six blocks earlier then TB performances). This was the only study demonstrating better performance in the SB task. All participants performed well in symmetry tests, regardless of which paradigm they were trained under. Stratton reported that participants were likely engaging in TB responding in the SB task (covert vocalizations).

Wallender, 1993

Using 20 highly verbal college students, Wallender examined the effect of familiarity (very familiar and unfamiliar) with the sample stimulus on matching-to-sample performance. His research extended that of Stratton (1992) in examining some of the parameters which might affect SB performances. All experimental conditions were presented, and responses recorded, using a Macintosh personal computer.

Using 20 pairs of stimuli, Wallender asked different groups of participants (10 per group) to select the appropriate Japanese Kanji characters when presented with either an English animal name (familiar group) or a Japanese Katakana character (unfamiliar group). All comparison stimuli were simultaneously presented in an array (randomly positioned for each block) while only one sample stimulus was presented at a time. The SB response was using a computer mouse to select the correct comparison stimulus. A response was considered incorrect if the wrong comparison was selected, or if a 20 s limited hold timed out. Incorrect responses resulted in the written feedback "Incorrect" (and a distinct tone) at which time the correct choice was revealed and the participant was required to click on the correct choice. Correct answers were followed by the written feedback "Good" and a distinct tone. Dependent variables consisted of the number of blocks (each of the 20 relations presented once) prior to two consecutive blocks in which no errors occurred (mastery). In addition, reaction times were recorded - that is the time from the onset of the sample stimulus to the occurrence of the selection response.

Results indicated that when English words (familiar) were used as sample stimuli, half as many blocks were needed prior to mastery, versus using Japanese Katakana symbols as samples. No difference in reaction times were found between the two conditions. Wallender noted that familiar stimuli "made the SB task easier for the verbal adults because of other responses such stimuli might evoke in these subjects" (p. 15).

Cresson, 1994

Cresson arranged for 16 college students to learn relationships between arbitrary pairs of stimuli. Either nonsense sounds or visual patterns were used as sample stimuli, while Japanese Katakana characters were used as choices. In one condition (TB) the participants were asked to write the Katakana character which matched either the nonsense sound or the visual pattern. In the second condition (SB) participants were asked to select the correct Katakana character from an array, in the presence of either the auditory nonsense syllable or the visual pattern. Participants were randomly assigned to the order of presentation (TB or SB first). The participants learned 8 relations at a time.

The dependent variable consisted of tracking the number of errors (incorrect selections or incorrect written response products) for each condition. Pretraining consisted of familiarizing the participants with the choice stimuli (e.g., writing the characters or selecting them) and initially showing the participants the correct matches. Correct responses were followed by praise ("Correct") and $5 was given at the end of each session. Incorrect responses resulted in the participant being shown the correct selection/written response product and asked to emit the correct response. The same choice stimuli were used for the auditory sample stimuli as for the visual patterns. This arrangement allowed Cresson to conduct an equivalence test. In this test, participants heard the nonsense sounds and were required to select the correct choice from an array of the previously used visual patterns. The correct choice was the visual pattern which had been paired with the same Katakana character as the nonsense sound had been paired. No time limit (limited hold) was imposed on participants. Two trials of each previously trained relation was provided when training within the TB or SB paradigm extended to more than one session (these reviews occurred at the start of the next session).

Results indicated better TB performance across all conditions, including equivalence testing. In addition, participants acquired the auditory discriminations faster.

Tan, Bredin, Polson, Grabavac and Parsons, 1995

Using eight college students, these researchers arranged for a computerized task in which the participants saw French words as sample stimuli and either selected English words from an array (SB) or typed English words (TB[2]). Different tones along with the written words "Right" or "Wrong" provided feedback after each response indicating whether the response was correct or not. Interspersed in this training were two types of symmetry relation testing. In both cases the sample stimuli were the previous choice stimuli (namely English words displayed on the computer screen). Participants were then required to either select comparison French words from an array (SB symmetry test) or to type in the appropriate French word (TB symmetry test). For each training condition (SB and TB), half of the trained relations were tested for symmetry using the TB response form and half were tested using the SB response form.

Results indicated all training conditions were learned equally well. Near perfect performance was demonstrated when the response form was SB in symmetry tests,

[2] Tan et al. used typing words as the TB response form. It should be noted however, that even if the participants were touch typists, typing is not a pure TB response. Typing relies on a mechanism (keyboard) and involves composing words from letters. Thus, such an arrangement is likely to involve SB components (i.e., seeing the stimulus array).

whether training was SB or TB. Poorer performance was demonstrated when symmetry testing involved TB responses. The authors noted: "For the behavior analyst this should come as no surprise: seeing the stimulus word, whether during selection-training or topography-training, no matter how often, does not guarantee that one will later be able to produce it, especially if the word is unfamiliar" (p. 2).

Potter, Huber and Michael, 1997

Using six college students, Potter et al. arranged for a computerized matching-to-sample task. Participants were either presented with a nonsense sound or a visual "flag-like" pattern. In both cases the participants were asked to learn the relation between each of the 12 or 14 sample stimuli and a set of 12 or 14 dot-like patterns (a square consisting of four dots in it) arranged in an array on the screen.

In one condition (point-to-point or PTP), participants were asked to select comparison stimuli by clicking on each of the dots in the selected comparison. This arranged for a SB task with an added TB component, namely unique response-produced kinesthetic stimulation. This was the case as each dot pattern was significantly different from all others. In the second condition (non point-to-point or NPTP), the participants were required to select the appropriate comparison stimulus by clicking twice in the upper-left corner and twice in the lower-right corner of the square. Thus, the same number of clicks were required across conditions but only the PTP condition had unique response-produced kinesthetic stimulation. Both visual and auditory sample stimuli (as describe above) were used in the PTP and NPTP conditions, with the same comparison stimuli used with the visual and auditory sample stimuli. This arrangement allowed for equivalence testing; namely presenting a nonsense word and requesting the participant to select the matching visual pattern. The correct choice was always the visual pattern which had been paired with the same dot pattern as the nonsense word had been paired. During training, but not during equivalence testing, a correct response was followed by the auditory "correct" via the computer, while incorrect responses resulted in the auditory "Incorrect." A remedial trial followed incorrect selections, and consisted of the participant being shown the correct choice and asked to complete that response. A 20 s limited hold was in effect – which when timed out resulted in the same conditions following an incorrect response.

Results showed no consistent difference between the PTP and NPTP conditions in acquisition (number of trials/blocks to acquisition) or in accuracy (the number of correct responses in each conditions). Exit interviews and protocol analyses (concurrent vocalizations) showed consistent vocal-verbal behavior by the participants, indicating that this may have obscured any true PTP and NPTP differences, as well as implicating the use of TB verbal behavior in SB tasks, especially with highly vocal-verbal participants.

TOPOGRAPHY-BASED AND SELECTION-BASED STUDIES

This section will examine some of the findings and ramifications of the above summarized studies (with additional information provided in Table 2).

Acquisition

For the nine studies that investigated ease of acquisition across language type (Wallender, 1993, investigated SB parameters only), there was an advantage for TB verbal behavior demonstrated in six studies.

The typical arrangement for each of these six studies was to either present a nonsense sound (the intraverbal condition) or present some object (tact condition), then ask participants to either select the correct symbol from an array (SB), or to emit the correct manual sign, vocalization, or written response (TB). While each researcher equated all stimuli used (similar in both SB and TB conditions), it is nearly impossible to equate response types across conditions, for the reasons noted in Table 1. Across these six studies, SB response types were similar (pointing), but choice stimuli array sizes varied, a point discussed below. Again, across these six studies, TB response forms were primarily manual signs (Bristow & Fristoe, 1984; Hodges & Schwethelm, 1984; Sundberg & Sundberg, 1990; Wraikat, 1990, Wraikat et al., 1991) with one study incorporating a writing response (Cresson, 1994).

The types of participants used in these studies also varied, but the majority of them used participants with poor verbal abilities, primarily adults and children with developmental disabilities (Hodges & Schwethelm, 1984; Sundberg & Sundberg, 1990; Wraikat, 1990, Wraikat et al., 1991). These studies demonstrated the greatest advantage for TB verbal behavior. Bristow and Fristoe (1984) and Cresson (1994) using normal children and adults respectively, also demonstrated a TB advantage, but both reported the differences to be relatively small. Considering that SB systems are seldom used with highly verbal humans, it would appear odd to use such participants in SB/TB studies. Cresson (1994) provided his rationale:

> 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 (p. 20).

In addition, as pointed out earlier in this review, SB and TB tasks are often intermixed in stimulus equivalence studies (as well as other types of research), thus making research in this area useful for designing better studies. It would appear however, that TB advantages are more significant for less verbal participants. Why this might be the case is discussed later in this review.

Perhaps more interesting to analyze are the three studies that did not demonstrate a TB advantage. Potter et al. (1997) showed little difference between a SB task requiring a stereotypical response (pure SB) and a SB task requiring a unique topography (SB with a TB component). These researchers conducted an additional examination (protocol analysis) which revealed that participants appeared to be engaging in vocal-verbal (TB) behavior under both conditions. Tan et. al, (1995) found no difference in acquisition between the two language types, but this may have been due to the small number of relations trained in each condition (four). These results were the same as those obtained by Stratton (1992). In one part of the Stratton (1992) experiment, only five relations were trained in the SB and TB conditions. This arrangement resulted in little difference between SB and TB performance. Stratton attributed these results to a ceiling effect. However, when Stratton increased the number of relations to be learned in both the TB and SB conditions to twenty, the SB relations were acquired on the average of six blocks (i.e., a single presentation of all 20 relations) faster than the TB relations. This is the only study reviewed which demonstrated an advantage for the SB paradigm.

Stratton's study was also the first study to test SB/TB differences with normal adults - most other researchers focused on children or adults with DD. Other researchers using normally functioning humans included Bristow and Fristoe (1984) and Cresson (1994), using children and college undergraduates, respectively. Both of these researchers found only small differences between the SB and TB paradigms which favored the TB paradigm (Cresson did not record the number of blocks to acquisition; however, to the extent to which accuracy is related to acquisition, this holds true). As mentioned earlier, using normal adults, Potter et al. (1997) also showed little difference between a pure SB response and a SB response with an added TB component. Preliminary results indicate that clearer differences emerge between the two paradigms when participants with poor initial verbal skills are tested, and only slight differences appear when participants with well-developed verbal skills are tested. However, more investigation is needed to clarify this issue.

One possible reason for the preceding observations may be that the highly verbal participants are engaging in vocal-verbal behavior that functions to mediate SB responses. Several researchers have attempted to explain the emergence of stimulus equivalence, and acquisition of conditional relations, in this manner (Dugdale & Lowe 1990; Horne & Lowe 1996; Lowenkron, 1991, 1996). If one were to adopt the hypothesis that SB verbal behavior may be composed of TB components (Dugdale & Lowe, 1990; Lowenkron, 1991), one would expect to see the results described above. Given no verbal skills with which to use in learning SB relations, it would be necessary for a participant to learn a conditional discrimination to select correctly, which has been demonstrated in nonhuman research, but often takes a considerable amount of time (Cumming & Berryman, 1961; Shafer, 1993). An alternative to this is that a participant might learn a topographical response and then have it function as an aide in responding correctly in the SB condition. This of course would require an extra learning step, one not programmed by the researcher, and would also be likely to require an extended training period. However, with highly verbal participants, the training period could conceivably be relatively short due to the extensive verbal repertoires of such participants.

This hypothesis is partially supported by a follow-up study to Stratton (1992) conducted by Wallender (1993). Wallender suggested that Stratton's results were due to the fact that English (very familiar) words were used as sample stimuli (Stratton used the English names of various animals). According to Wallender, this familiarity probably allowed participants to readily emit verbal responses to the sample stimuli and also to the choice stimuli, introducing a TB response as a mediator in the SB task (i.e., identifying common features, emitting the TB response while scanning, etc.). As described previously, Wallender had two groups of participants engage in a SB task similar to that used by Stratton. With one group, however, unfamiliar Japanese characters served as samples and for the other group English animal names served as sample stimuli. In both groups, unfamiliar Japanese characters functioned as choice stimuli. Thus the "familiar" group saw English animal names then selected the appropriate Japanese character and the "unfamiliar" group saw Japanese characters then selected the appropriate (but dissimilar) Japanese character. A clear difference was demonstrated between the two groups; the group receiving the English words as samples learned the relations nearly twice as fast as the other group (Wallender, 1993). Other researchers have examined this same phenomenon, drawing similar conclusions. Mandell and Sheen (1994) examined the effects of pronounceable (e.g., "FLODG") and nonpronounceable (e.g., "NSJBM" or "+]*^!") sample stimuli on the acquisition of conditional discriminations (SB tasks) and on the formation of equivalence classes. In both cases, acquisition was better with more pronounceable sample stimuli, leading the researchers to note that stimulus equivalence (and conditional discriminations) are likely to be mediated by verbal behavior. Some evidence exists for the role of mediating TB responses in the development of stimulus equivalence and conditional discriminations (Dugdale & Lowe, 1990; Lowenkron & Colvin, 1995; Potter et al., 1997; Wulfert, Dougher & Greenway, 1991) but most of this research is necessarily correlational. More investigation is needed to clarify this issue.

Of course, if one were to adopt the hypothesis that TB verbal behavior mediates SB verbal responding, one is still left with the task of explaining Stratton's (1992) results in which SB performance was better then TB performance. Stratton noted:

> The topography-based task is essentially learning 20 new foreign words for 20 English words. There are clearly two aspects to this task: learning to say the foreign words as units, and learning to say the correct one when the English word is shown....whereas no new topographies are required in the selection-based task (pp. 23-24).

Stratton also noted that the SB task offers the highly verbal participant the opportunity to engage in verbal behavior which may eliminate some of the choice stimuli (e.g., "it's not the one with the grid pattern") as comparisons on any given trial.

Others have reported some evidence for this (Cresson, 1994; McIlvane et al., 1987; Potter et al., 1997; Wallender, 1993). McIlvane et al. (1987) showed that responding (using normal adults) in a matching-to-sample task could be controlled by the relation between the sample stimulus and the incorrect choice stimulus. These same researchers found similar results when three and four comparisons were used, versus only two. McIlvane et al. note that previous research with children indicates that exclusion responses "...have been reported to emerge in the second year, coinciding with initial acquisition of verbal behavior" (p. 206).

It is important to examine the results of Stratton's study in light of the different procedures adopted in each study. Three seem particularly relevant: the number of relations trained (which is usually the number of choice stimuli used for these studies); the nature of the TB response (e.g., a sign, writing, or vocal response); and finally, the extent to which the TB response was pretrained, thus necessitating acquisition of the response during regular training or not, in addition to coming under the appropriate stimulus control for that response.

Stratton (1992) and Potter et al. (1997) were the only researchers to require more than 12 relations be learned, arranging for 20 relations and 14 relations, respectively. Cresson required 8 relations be learned in any given condition and Bristow and Fristoe (1984) required 12 SB relations be learned, but only a maximum of 6 TB relations. No other researcher required more than four relations be learned in any condition. Stratton was also the only researcher incorporating a vocal-verbal TB response. All others used sign (Bristow & Fristoe, 1984; Hodges & Schwethelm, 1984; Sundberg & Sundberg, 1990; Wraikat, 1990; Wraikat et al., 1991), typing (Tan et. al, 1995), or writing (Cresson, 1994). Wallender (1993) and Potter et al. (1997) did not directly incorporate a pure TB response in their studies. Stratton's verbal response consisted of two-syllable Japanese words. It is possible that some of those words contained phonemes not in the English language as Japanese contains some phonemes which English does not contain. In comparison, the writing, typing, and sign responses required of participants in all other studies had no similar subcomponent of the final response that was unfamiliar to them. For example, all would have had experience with drawing lines, with characters in the English alphabet (used when typing French words in the Tan et al., 1995 study), and it is likely all participants had previously emitted all subparts of the sign responses included in these studies.

Stratton (1992) also only provided minimal pretraining of the TB response, namely one preexposure to the sample stimulus and the correct response, at which point the participant would echo the response. In contrast, Cresson (1994) thoroughly trained the TB writing response used. He required the participants to quickly go through a seven step process, starting from copying the Katakana symbols used, to generating a series of them, in any nonrepeating order. Pretraining for the TB response varied across the remaining studies, but could be classified as being more extensive than in Stratton's study, but less extensive than in Cresson's study (e.g., Sundberg & Sundberg, 1990, demonstrated and required imitation for each relation five times). Bristow and Fristoe (1984) and Hodges and Schwethelm (1984) did not report the extent of pretraining.

In summary, it is unclear whether Stratton's results, as compared to other researcher's results, are due to true differences in SB and TB responding, procedural differences, or to both. However, at the very least, the preceding analysis does illustrate the number of variables which might influence obtained results.

Accuracy

Of the seven studies reporting accuracy data (the number of correct responses in each condition) between SB and TB tasks, six reported more accurate responding in the TB condition (Bristow & Fristoe, 1984; Hodges and Schwethelm, 1984; Sundberg

& Sundberg, 1990; Wraikat, 1990; Wraikat, et al., 1991; Cresson, 1994) and one reported no difference between conditions (Potter et al., 1997). These performances paralleled those cited above; relatively large differences were recorded in studies using participants with poor verbal skills and relatively small differences were demonstrated in studies using participants with well-established verbal skills. Although Hodges and Schwethelm (1984) showed clear differences between TB and SB accuracy (and number of relations acquired), it should be noted that these researchers used nonspecific reinforcers when training the SB task (praise and food) and specific reinforcers for the TB task (e.g., candy when "candy" was said). These researchers actually conducted training which ultimately resulted in mand relations. Skinner (1957) defined the mand as "a verbal operant in which the response is reinforced by a characteristic consequence and is under the functional control of relevant conditions of deprivation or aversive stimulation" (p. 36). For example, participants in Hodges and Schwethelm's study were required to sign "Candy" when the researcher held up a candy bar. If the emitted sign was correct, the candy was given to the child. Prompting (molding the child's hands) and fading of these prompts were also incorporated in this training. Eventually, the child was only asked "What do you want?", at which point if the child emitted an appropriate sign, the requested object was given to the child. Skinner (1957) and Sundberg (1990) suggest that the mand is probably the first type of verbal relation acquired by humans. They also note that it is likely to be an easily acquired response, given the powerful nature of the reinforcers used. It is possible that the results of Hodges and Schwethelm's study were actually due to the type of relation trained and not a true difference between SB and TB verbal behavior. Overall, however, TB performance appeared to be more accurate than SB performance across studies.

Stimulus Equivalence

For those studies that incorporated some aspect of stimulus equivalence (reflexivity, symmetry, transitivity, and equivalence), performances tended to be better after TB training versus after SB training. Again, the magnitude of the differences recorded seem related to the type of participants tested. For the two studies using participants with DD, a relatively large difference was demonstrated between the TB and SB conditions (Sundberg & Sundberg, 1990; Wraikat et al., 1991). With verbal participants, TB performance was only slightly higher for two studies (Bristow & Fristoe; 1992; Cresson, 1994) and showed no difference in two studies (symmetrical relations – Stratton, 1992; equivalence relations – Potter et al., 1997). Tan et. al (1995) showed nearly perfect symmetry performance when the response form was SB and poor symmetry performance when the response form was TB (however see footnote #2 regarding this issue). Tan et al. examined the difference between symmetry performances under four conditions: (1) SB training/SB Testing, (2) SB Training/TB Testing, (3) TB Training/SB Testing and (4) TB Training/TB Testing. These researchers used either French words (unfamiliar) as samples and English words as the choice stimuli (either typed out – TB, or selected – SB). In testing for symmetry, when the response was selection-based, regardless of the training, accuracy was generally high. However, when the response was topography-based in symmetry testing, accuracy was generally low. This was an expected outcome as the authors noted: "...seeing the stimulus word, either during selection-training or topography training, no matter how often, does not guarantee that one will later be able to produce it, especially if the word is unfamiliar" (p. 2).

Tact vs. Intraverbal

In those studies that trained both tact and intraverbal relations in the SB and TB conditions, overall, the tact relation appears to have been acquired more readily than the intraverbal relation. Cresson (1994) demonstrated an exception to this, with the intraverbal relation acquired more readily, and Potter et al. (1997) showed little difference between the two conditions overall. Potter et al. (1997) examined this more closely and showed that intraverbal performances were better in earlier sessions and tact performances better in later sessions. These researchers believed that this showed support for the hypothesis that vocal-verbal mediation plays a role in SB responding, as the same choice stimuli were used in the intraverbal and tact conditions to allow for equivalence testing. The participants were apparently generating and learning vocal-verbal responses in the intraverbal condition and simply re-emitting the same responses in the tact condition.

It is difficult to draw conclusions from these tact and intraverbal results for several reasons. First, different participants were used in those studies (Cresson used normal adults, others used adults and children with DD). Second, within each study, the stimuli used as samples are in different modalities (i.e., hearing a sound for the intraverbal and seeing a graphic for the tact), thus making it difficult to equate the two in terms of complexity. Since the researchers in each study used different choice stimuli, it becomes even more difficult to interpret these data.

Additional Results

Some studies incorporated reaction time measures (Potter et al., 1997; Stratton, 1992; Wallender, 1993). Stratton was the only researcher to incorporate a reaction time measure and have participants engage in both a SB and a TB task. As would be expected, reaction times were higher for the SB group in Stratton's study as participants needed to scan the choice stimuli, whereas no such scanning response is required in a TB task. Wallender (1993) and Potter et al. (1997) trained and tested only in the SB paradigm, and both demonstrated little difference between conditions in terms of reaction times.

Finally, many researchers reported anecdotal observations of participants engaged in the SB or TB tasks. For example, Hodges & Schwethelm (1984), Sundberg and Sundberg (1990), Wraikat (1990), and Wraikat et al. (1991) all reported that participants appeared more engaged in the TB vs. the SB task. Participants in the Potter et al. (1997) study reported in exit interviews a preference for the SB task which incorporated a TB component. Other researchers noted that participants appeared to engage in vocal-verbal mediating behavior (Cresson, 1994; Potter et al., 1997; Stratton, 1992; Sundberg & Sundberg, 1990; Wraikat, 1990). While most of these apparently mediating vocal-verbal responses occurred during SB tasks, Wraikat (1990) reported some participants emitted vocal responses prior to performing a sign, and those participants tended to perform better. Wallender (1993) proposed that using more familiar sample stimuli "made it easier for the verbal adults because of other responses such stimuli might evoke in these subjects." (p. 15). As discussed earlier, Wallender was examining whether familiarity with the stimuli used in a conditional discrimination task would aid acquisition, which it did, both in his study as well as in a similar study by Mandell and Sheen (1994).

Potter et al. (1997) attempted to study this apparent vocal-verbal mediation by arranging for participants to engage in a computer-based matching-to-sample task while talking aloud. The "Talk Aloud" procedure is one of several types of protocol analysis techniques offered by Ericsson and Simon (1993). Basically, this procedure requires that the participant vocalize normally covert verbal behavior, which is then tape-recorded. Participants are given some training in this to prevent additional intraverbal behavior from creeping into the vocalizations. For example, participants are discouraged from specifying what they are doing at any moment, or from describing mental imagery. Ericsson and Simon (1993) found little difference between groups solving problems, one using the talk aloud procedure and the other solving problems silently. The objective in such research is to simply clarify the role, if any, that mediating vocal-verbal behavior might have in these tasks, without interfering with the task itself. Potter et al. (1997) transcribed tape recordings of participants' vocal-verbal behavior, then classified the participants' statements according to Skinner's (1957) elementary verbal operants (primarily tacts and intraverbals). The participants aided in clarifying controlling variables by listening to the tapes while being exposed to the situation in effect when the vocalization was made. Very consistent types of responses were shown to precede correct responses for all participants. The authors concluded that it is likely that conditional discrimination tasks, and emergent equivalence relations, are mediated by TB verbal responding, at least with verbal organisms.

CONCLUSIONS

Most of the research reviewed in this article demonstrated better overall results in acquisition and accuracy when TB verbal behavior was trained vs. SB verbal behavior.

However, given the limited number of studies conducted, and the data these studies generated, these conclusions should be considered with caution. Special attention should be given to the type of participants considered. Greater differences in SB and TB performances are obtained when persons with poor verbal skills are used as participants, with TB verbal behavior resulting in better acquisition and accuracy performances. This is an interesting finding as SB systems were developed primarily for persons with low, or nonexistent verbal abilities. These issues, and others, are addressed below.

First, it is not clear that a distinct separation of SB and TB verbal behavior was attained in the studies reviewed. In the studies in which vocal-verbal participants were used, there is a fair amount of evidence indicating that the SB task was mediated via vocal-verbal behavior. This was supported by the fact that SB verbal behavior appears to be more difficult to acquire than TB verbal behavior – for both verbal and nonverbal participants. However, the difference between the two language types is greater when participants with weaker verbal repertoires are used, indicating that TB verbal behavior plays a role in acquiring SB verbal behavior (along with other supporting evidence). Interestingly, taken alone, this observation would argue against the use of SB verbal behavior for the very reasons it was initially used, that is to aid nonverbal clients. However, other factors also need to be considered such as the skills of potential listeners (i.e., do they know sign language), the physical capabilities of the client, and the response forms to be trained (e.g., mands, tacts, etc. – see Shafer, 1993 and Sundberg, 1993 for a thorough discussion of these issues).

It would appear that TB responses are somewhat easier, or preferred over SB responding (as most participants of the studies discussed in this article reported). If SB responding were easier or more effective, it would seem that responding would settle into a pure SB form (the vocal-verbal supplements would drop out), which was not the case in some of these studies reviewed. Perhaps with extensive training this would occur. It is possible that existing TB repertoires "block" the acquisition of pure conditional discriminations (that is "pure" SB responding), but again, intuitively, if SB responding were easier, it would seem likely that mediating TB responses would eventually drop out of a conditional discrimination. While SB responding appears on face value to be easier then TB verbal behavior, it probably is so for the teachers/caretakers only, in that they would not be required to learn a new TB form of communication (versus reading words off a communication board). It is clear that more research is needed in this area.

Second, numerous factors, including participant and methodological considerations must be considered when attempting to determine acquisition rates and accuracy for each type of verbal behavior. The amount of pretraining, the extent of existing repertoires, the number of relations trained, the size of a typical response unit (i.e., sentences vs. single words), all would seem to be relevant determinants of obtained results.

Finally, some other distinctions between SB and TB verbal behavior may contribute to the observed differences in acquisition, accuracy and overall utility. SB verbal behavior, being dependent on hardware, is less likely to function as verbal behavior that the speaker can respond to himself/herself (i.e., talking to oneself). This has multiple implications when one considers that much of verbal behavior may be acquired and strengthened via automatic reinforcement (Sundberg, Michael, Partington & Sundberg, 1996). In addition, SB verbal behavior is likely to restrict observing/interacting with a verbal community that models and directly reinforces appropriate verbal behaviors (Sundberg, 1993).

Future Directions

More research is necessary to clarify the differences between SB and TB verbal behavior. Many of the differences outlined in Table 1 have yet to be investigated. Some research that might be conducted includes: the relevance of scanning repertoires; the effect of time delays imposed between the presentation of some antecedent stimulus and the response emissions; the impact point-to-point correspondence might have on acquisition; the effect of SB/TB training with verbal operants other than the tact or intraverbal (e.g., mand); and differential effects across various populations. With the advent of high-powered microcomputers and supporting software, it is becoming easier to conduct research in this area. For example, a TB response might be emitted via mouse movements (or even finger movements with the appropriate hardware inputs) on a computer resulting in auditory emissions from the computer that serve as antecedent stimuli for the listener. By manipulating the nature of the TB response one could examine the effect the point-to-point correspondence has on acquisition and accuracy. Indeed, this very technique might be useful in providing a TB response form to clients with DD who have vocalization disabilities, but good manual dexterity. This technique would not require staff to learn a new TB response form as the computer could be programmed to emit vocal responses in the listener's native tongue.

A thorough understanding of the factors contributing to the differences between these types of verbal behavior can only improve our understanding of verbal behavior. In addition, it will allow us to design better programs for nonverbal persons, as well as design research that takes these differences into consideration. It is hoped that this review has aided in this task.

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