Topography-Based and Selection-Based Verbal Behavior: A Further Comparison

Riad Wraikat
Mutah University, Jordan

AND

Carl T. Sundberg and Jack Michael
Western Michigan University

Michael (1985) identified two types of verbal behavior, topography-based (e.g., speaking or using sign language) and selection-based (e.g., using a symbol board). Sundberg and Sundberg (1990) and Wraikat (1990) compared these systems in terms of the ease of learning object naming (tact) and giving the correct sign or pointing to the correct symbol on hearing the object name (intraverbal). Sundberg and Sundberg (1990) also compared them for the spontaneous development of a new relation, identifying the object when hearing its name (stimulus class formation or equivalence). The results of both studies favored the topography-based system, but in each case some subjects were not verbally skillful enough to learn either system and some learned both too easily to permit a useful comparison. The current study replicated the two previous ones by teaching the same two verbal relations and testing for the emergence of new relations, but adjusted the task to the subject's level of functioning during the experiment. This was accomplished by varying the number of object relations being learned, and by interspersing already learned tasks with the training of new tasks. As with the earlier studies, topography-based verbal behavior was easier to learn, and led to more new stimulus-class relations than selection-based verbal behavior. These data confirm the relevant theoretical analysis, and have practical implications for a change in current language training practices.

Pointing at symbols or pictures is often favored over signing as a substitute for vocal verbal behavior in low functioning or otherwise nonvocal developmentally disabled individuals, because it doesn't require the client to learn any new topographies, and because the stimulus provided to the viewer is more easily interpretable than the manual sign. It certainly seems intuitively easier to learn to point at pictures than to learn hand positions and movements, even if the positions and movements resemble in some way the objects, actions, relations, etc. that are part of the verbal functional relation. Michael (1985), however, suggests several reasons why the pointing form of verbal behavior might actually be more difficult to acquire, especially as vocabulary size and complexity increases.

He makes a general distinction between two kinds of verbal behavior, which he calls *topography-based* and *stimulus-selection based* (or just *selection-based*). In topography-based verbal behavior the unit consists of "an increased strength of a distinguishable topography given some specific controlling variable" (p. 1). For example, in the case of the tact, the vocal response *refrigerator* in the presence of a refrigerator or *telephone* in the presence of a telephone are examples of topography-based verbal behavior. Saying *refrigerator* differs from saying *telephone* in terms of the movements of the relevant vocal musculature, that is in terms of response topography. Signing (as in the sign language of the deaf) is similar in that the different signs consist of different response topographies

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(hand and arm movements). Writing is also a topography-based form of language.

In selection-based verbal behavior the operant unit consists of an "increased control of a pointing response by a particular stimulus (such as a verbal symbol) as a result of the presence of a different stimulus (or the strength of a particular establishing operation)" (p. 1). To continue with the previous example, in a selection-based system of verbal behavior, one tacts a telephone and a refrigerator by pointing to a corresponding symbol (e.g., on a communication board) in the presence of the appropriate object; but the pointing topography is approximately the same irrespective of which symbol is pointed at. Thus, the different tacts in a selection-based system are not distinctive with regard to the topographies of the responses involved, because essentially the same form of response is common to all tact relations in the repertoire. This is not the case with topography-based verbal behavior where the topography of the response is a distinguishing part of the verbal relation.

Several factors might be expected to favor topography-based verbal behavior as a substitute for vocal behavior. For one, selection-based behavior consists of a conditional discrimination, one involving two discriminative stimuli, whereas topography-based verbal behavior involves only one (Michael, 1985). In a selection-based tact, for example, the nonverbal discriminative stimulus consisting of a cup alters the controlling strength of a verbal discriminative stimulus, the symbol or picture representing the cup, over a non-distinctive pointing or indicating response. In the topography-based system consisting of speaking or signing, the cup as a visual stimulus directly controls the vocal response *cup*, or making the sign for a cup.

Also, in selection-based responding, the person who points at the verbal stimulus must first scan the options, then point to the appropriate one. Normal adults usually develop a good scanning repertoire, but it may take special training to develop effective scanning with those who lack this repertoire (Sundberg & Sundberg, 1990). Mirenda (1985), for example, noted that students with severe handicaps usually have difficulty scanning an array of pictures that are too broad (i.e., more than one picture on a page) and some may exhibit very fleeting visual fixation and/or attention skills. Yet other individuals often have difficulty (require more training time) in picture/background discrimination. Further, if the various visual stimuli are not all presented at the same time, the verbal behaver must *remember* which ones were previously seen, and this constitutes an additional complexity. If the scanning takes a long time (e.g., too many pictures on the communication board, or too many pages to shuffle through), the effectiveness of the original controlling variable may become too weak to evoke the correct response (Sundberg & Sundberg, 1990). Also, if the speaker wishes to convey a message consisting of two or more symbols, and if they are not located close to one another, for example on different pages, the speaker will have to sort through this material just to make one statement.

Some additional practical limitations of selection-based systems have been noted by Sundberg (1987). One is the necessity of depending on auxiliary equipment. It is not always possible to have a picture board or a computer synthesizer by your side. As pointed out by Trefler and Crislip (1985), this type of equipment requires frequent maintenance, is costly, and there are environments in which the client would not have access to such equipment. An important practical feature of speech (Skinner, 1974, p. 100) is that it does not require any form of environmental support, and the same could be said about signing.

The differences described above would be expected to be of minimal significance with very small repertoires, but even here, it is possible that a more complex relationship, such as the spontaneous occurrence of stimulus equivalence relations, would be in some way weaker with a selection-based than with a topography-based repertoire. With this in mind, Sundberg and Sundberg (1990) taught four developmen-

tally disabled adults to name three objects (the tact relation) by pointing to the corresponding symbols (the selection-based procedure), and to name three different objects by making an appropriate sign-language response (the topography-based procedure). They were also taught either to select the appropriate symbol (selection-based) or to make the appropriate sign (topography-based) when the experimenter stated the name of the object (an intraverbal relation). A test of a form of stimulus equivalence, consisting of showing the objects and asking the subjects to identify them as their names were spoken, was also made. The equivalence comparison could not be made with one of the subjects because she could not learn the selection-based tact. Of the other three, one demonstrated the topography-based equivalence repertoire, but not the selection-based. One subject demonstrated neither, but came closest with the topography-based set of objects. The third easily demonstrated both. Three subjects had considerably less difficulty learning the simple tact and intraverbal relations with manual signs as the response form, than by pointing at the symbols. The fourth subject acquired both repertoires quite easily.

The possibility that even very simple selection-based verbal behavior may be more difficult to establish than comparable topography-based behavior is reason enough for a more definitive comparison of the two systems. The proposed role of stimulus class formation in language development and elaboration, and the possible importance of verbal naming, the tact relation, in the establishment of stimulus equivalence (McIntire, Cleary & Thompson, 1987) constitutes another reason for conducting a further comparison of the two language systems.

An effort to systematically replicate the initial findings (ignoring the issue of equivalence) of Sundberg and Sundberg (1990) with five new subjects was made by Wraikat (1990). The study was limited by the fact that the general procedure was too difficult for three of the five subjects, who failed to reach a criterion performance on one or more of the four relationships being taught. With those three subjects, however, it was clear that they had more difficulty learning the selection-based than the topography-based relations. The data for the other two subjects was unclear. The purpose of the present study was again to compare topography-based with selection-based verbal repertoires, both with respect to ease of learning and also in the development of an equivalence relation. The procedures were modified in an effort to improve the initial acquisition of the tact and intraverbal repertoires, and thus obtain more data with respect to the formation of equivalence relations.

METHOD

Both of the preceding efforts to compare the two paradigms with respect to ease of acquisition and the development of stimulus equivalence obtained useful comparative data from only a few of the subjects tested. Unfortunately, it is not easy to accurately predict how subjects classified as profoundly to mildly retarded will function on the verbal training tasks. Both of the previous relevant studies used a standard procedure with all subjects and attempted to select subjects who would be appropriate for that procedure, then used the procedure without modification. In some cases the subjects' verbal repertoires were so deficient that they failed to learn the procedures well enough to provide comparative data (a sort of *floor effect*); and in some cases their verbal skills were so effective (in spite of appearing less so on assessment instruments or in everyday activities) that both paradigms were acquired too rapidly to permit useful comparisons (a *ceiling effect*).

The present study attempted to improve on the previous methodologies in two ways. First, two versions of the testing procedure were developed, one using two objects for each relation and one using three, and subjects were assigned to a procedure on the basis of all prior information relevant to their general verbal effectiveness. Secondly, both the two-object and the three-object procedures were elaborated by

including the interspersal of already learned relations with the training of new relations. This meant that if the subject's verbal skill had been overestimated, and s/he was not reaching criterion with one or more relations, interspersal data which could contribute to the comparison were still being collected on all relations, and the increased exposure to the various relations might facilitate the equivalence comparison. On the other hand, if the subject's verbal skills had been underestimated, and s/he was acquiring both kinds of relation too quickly to permit much of a comparison, interspersal data were still being collected throughout the experiment, and could be the basis for further comparisons. In other words, even though the subject might have acquired both kinds of relation rapidly it was still possible that throughout the remainder of the experiment, performance differences would show up with the already-learned relations as they were being tested during the learning of new relations.

During the experiment an adjustment of the interspersal procedure, called *retention training*, was used with two of the subjects for which the regular interspersal was at first believed to be too difficult. This adjustment, like the regular interspersal, also resulted in the collection of more data for comparison purposes than the training procedures of the two preceding studies, and is described in detail below.

In summary, the main research questions for this study are: (1) With which paradigm (topography-based or selection-based) will tact and intraverbal relations be easier to learn (number of trials to mastery criterion), (2) With which paradigm will tact and intraverbal relations be learned more accurately (percentage of correct responses), and (3) Will there be any differences between the two paradigms in the spontaneous development of a form of stimulus equivalence relation, the mand-compliance (receptive language) task?

Subjects

Seven developmentally disabled adults served as subjects in the experiment. All seven attended the day-treatment Center for Developmentally Disabled Adults (CDDA), Douglass Site, Kalamazoo, Michigan. There were three males and four females, ranging in age from 26 to 50 years (see Table 1). Inclusion criteria were: (a) a moderate to severe language deficit (as documented in the subject's files), (b) the exhibition of manual dexterity allowing for the formation of manual signs, (c) the ability to imitate, (d) the ability to follow instructions (as determined by prestudy probes), (e) no special dietary requirements that might prevent the client from going out weekly to a local restaurant.

Consent was obtained from guardians, Western Michigan University Human Subjects Institutional Review Board

Table 1

Subject characteristics.

Pseudonym	Age	Primary Diagnosis	Secondary Diagnosis
Amelia	40	cerebral palsy (CP)	mild mental retardation
Jesse	26	moderate mental retardation	spastic quadriplegia & CP
Kathleen	33	severe mental retardation	microcephalic
Karen	29	moderate mental retardation	epilepsy
Troy	33	moderate mental retardation	epilepsy
Jessica	50	profound mental retardation	none
Jordan	46	profound mental retardation	none

(HSIRB), Center for Developmentally Disabled Adults (CDDA), and Human Services Department (HSD) prior to each subject's participation. The subjects' characteristics are presented in Table 1.

Setting

The study was conducted in a room (14 m by 12 m) at Douglass Community Center, Kalamazoo, MI. The room was empty except for two chairs and a card table. A third chair was brought in on days when reliability data were taken.

Experimental sessions occurred Monday through Friday from 9:00 to 11:00 a.m., usually consisted of 48 trials and lasted from 15 to 20 minutes per subject. Occasional schedule changes occurred due to participants' sickness or other conditions.

Apparatus/Materials

All subjects were taught the following verbal relations between: (a) nonsense objects and symbols, the selection-based tact; (b) nonsense spoken names and symbols, the selection-based intraverbal; (c) nonsense objects and manual signs, the topography-based tact; and (d) nonsense spoken names and manual signs, the topography-based intraverbal. The objects, symbols, and manual signs were chosen so as to control for the differential ease of acquisition due to iconicity and other factors. Common objects, names, signs, etc. were not used because it was thought important to guard against the influence of previous experience with any of the signs, symbols, names, or objects. One-syllable words that were judged easily distinguishable from one another were selected.

The following procedures were used in selecting symbols, signs, and names. A list of symbols, names, and signs was provided to four experts (people who have a B.A. in psychology or related fields and a minimum of two years of experience with developmentally disabled adults). They were asked individually to rate these symbols, names, and signs on a scale of 1 to 10 in terms of difficulty level for developmentally disabled adults. From the ratings, a list of signs, symbols and names which obtained low difficulty ratings was developed (the signs and the names were demonstrated by the experimenter). Combinations of least difficult signs, names and symbols were also provided to these experts to account for difficulty when the items were combined together in sets. The sets used in this study were the ones that were agreed upon as least difficult by these judges.

The objects were made of various materials, were of various shapes, and had no obvious function. For example, the metal object was symmetrical and approximately 12 cm long. It had a hole in the middle with two sliding joints connected by screws. In each end of the object there were hooks on opposite sides. The polystyrene object was a white cylinder approximately 12 cm long. The bottom portion of the object was about .5 cm in diameter and the top portion was approximately 2.5 cm in diameter. Each object was assigned a nonsense name to be spoken by the experimenter, an arbitrary symbol drawn in black ink on a 10 cm by 10 cm piece of white poster board for the selection-based paradigm, and a manual sign for the topography-based paradigm. The symbols resemble the Greek letters omega, sigma, phi, psi and the Arabic letters "B" and "D." The names, objects, symbols and signs for each set of relationships are described in Table 2. The signs did not involve touching a part of the body so as to avoid the possibility of suggesting to the subject that s/he is naming a body part with a nonsense name. All signs involved only one arm and either one was acceptable. Each set was assigned an unknown name to be spoken by the experimenter; "puck" for example was the name that went with the polystyrene object, the phi symbol (when the selection-based paradigm was used), and an open hand sign (when the topography-based paradigm was used) and so on.

For three of the subjects, a total of four objects were used. For example, with Jessica, the verbal sets "nack" and "teef" were used in the selection-based paradigm,

Table 2

Set contents.

Name	Object	Symbol	Sign
puck	polystyrene	phi	displaying an open hand
nack	plastic	Arabic D	waving a hand over the head back and forth
teef	sponge	psi	holding up a fist
dil	metal	Arabic B	making a circle in the air
koob	wood	omega	moving arm several times in a horizontal plane
doof	cloth	sigma	pointing down with an open hand

and "dil" and "koob" in the topography-based paradigm. This order was reversed for Amelia and Kathleen. For the remaining subjects a total of six objects were used. The verbal sets "puck," "nack" and "teef" in the selection-based paradigm and "dil," "koob" and "doof" with the topography-based paradigm were used with Karen and Troy. This order was reversed with Jesse and Jordan.

The name of each object was written on a prepared randomization sheet which determined which set was to be used for each trial. The number of times each object appeared on the sheet was predetermined; however, the order of each object was random.

Reinforcement Selection

The reinforcers utilized in this study were similar to those commonly used at CDDA (Douglass site) and included social reinforcement, achievement certification, stickers, cards and individualized reinforcers such as a sports magazine. Money or edibles were not used as reinforcers in this study. However, weekly noncontingent outings to a local restaurant were provided to help insure that subjects remained interested in the study. The principal investigator accompanied the subjects to the restaurant.

Measurement

Responses were recorded as correct or incorrect on a specially prepared data sheet by marking a plus (+) or a minus (-) in one of the squares for the 48 trials for one of the two or three sets corresponding with each object, name, symbol or sign. For example, if a subject was first being trained in the selection-based tact relation, the three sets were "puck," "nack," and "teef." If the subject failed to select the phi symbol when shown the polystyrene object, the response was recorded as a minus sign in the cell appropriate for that trial under the set named "polystyrene." The first symbol/sign emitted by the subject, depending on the paradigm in use, was the one recorded on the data sheet. Mastery criterion was defined as 11 out of 12 successive correct responses for the test trials in the case of two objects, and 7 out of 8 in the case of three objects. Interspersed verbal relations were recorded as correct or incorrect but were not included in determining the mastery criterion. When the retention-training procedure, described below, was used, the training was continued until the subject reached criterion or until the cut-off or stopping point was reached. This meant that retention-training sometimes ended in a session before 48 trials had been com-

pleted, and sometimes more than one session was required.

Dependent Variables

For each subject, two verbal relations for each paradigm were directly taught and tested: (1) the tact (pointing to a symbol or making a sign, depending on the paradigm in use, when shown an object), and (2) the intraverbal (pointing to a symbol or making a sign, when an object name was spoken by the experimenter). The two paradigms were compared with respect to the number of trials to the mastery criterion, and with respect to the overall percent correct. This latter value was calculated by dividing total correct trials during test trials by total trials and multiplying by 100. Average trials to criterion for all subjects in each verbal relation was calculated by dividing the total number of trials to criterion for each subject by the number of subjects. The same procedure was followed with the average percent correct.

After tacts and intraverbals were either mastered or the cut-off or stopping point (an arbitrary 144 trials for five of the subjects and 72 for Kathleen and Jesse with the intraverbals only) was reached, two unreinforced mand-compliance (receptive language) trials were conducted. For example, after the subject went through training with all verbal relations, s/he was then shown all of the objects and told "Show me teef." If s/he pointed at the appropriate object within the next twenty seconds, the mand-compliance response for that object for that trial was scored as correct. S/he was then told "Show me nack," and so on for all of the objects. The objects were then displayed a second time (arranged in a different order), and the subject was again told "Show me teef," and so on. If an object was correctly identified on both trials, that mand-compliance relation was scored as correct. If an error occurred on one or both of the trials with that object, that relation was scored as incorrect.

For a response to be scored as correct it must be a close enough approximation to the desired response to be easily distinguished by the experimenter from the other responses in the subject's repertoire.

Experimental Design

The experiment involved a within-subject comparison where each subject was trained on four verbal relations, two topography based and two selection based, and then given a brief test for the existence of the mand-compliance or receptive language repertoire. Three subjects were trained in the order topography-based tact, selection-based tact, selection-based intraverbal, and topography-based intraverbal. The other four were trained in the order selection-based tact, topography-based tact, topography based intraverbal, selection based intraverbal. This arrangement was used to balance the topography- and selection-based training so that neither had both of its verbal relations taught first nor both taught last.

Response Definitions

Topography-based tact. When presented with a certain object and asked "What's this?" the subject makes the correct sign within 20 seconds of the presentation of the object. For example, when presented with the sponge object and asked "What's this?" the subject makes the hold-up-a-fist sign within 20 seconds.

Topography-based intraverbal. When the experimenter speaks the name of an object the subject makes the corresponding sign within 20 seconds of its presentation. For example, when the experimenter says "What's teef?" the subject holds up his fist within 20 seconds.

Selection-based tact. When presented with a certain object and asked "What's this?" the subject points to the correct symbol (out of an array of two or three) within 20 seconds of its presentation. For example, when presented with the polystyrene object and asked "What's this?" the subject points to the phi symbol within 20 seconds. The first symbol pointed to is recorded.

Selection-based intraverbal. When the experimenter speaks the name of an object the subject points to the corresponding symbol (out of an array of two or three)

within 20 seconds of its presentation. For example, when the experimenter says "What's puck?" the subject points to the phi symbol within 20 seconds.

Receptive language or mand compliance test for equivalency. When asked to identify an object (out of an array of four or six) the subject correctly points at the object within 20 seconds. For example, when asked "Which one is koob?" the subject points to the wood object within 20 seconds.

Procedure

The general procedure consisted of approximately five demonstrations of newly trained verbal relations with corrections. This includes training to imitate signs, to make the sign when presented with an object or with the vocal name of the object, and to point to one of two or one of three symbols when presented with an object or the vocal name of the object. Sessions were conducted once a day, five days a week, for each subject. Each session lasted approximately 20 minutes, usually consisted of 48 trials, and was run at approximately the same time every day for each subject.

As shown in Table 3 four of the subjects (Jesse, Troy, Karen and Jordan) used three objects in each verbal training set. The remaining subjects (Amelia, Kathleen, and Jessica) used two objects with each verbal relation set. The order and number of objects utilized with each subject are also shown in the table.

Table 3

Number of objects and order of training.

Subject and No. of Objects	Order of Training
Amelia: 2 Objects Only	Phase I, TB-Tact only; Phase II, SB-Tact interspersed with TB-Tact; Phase III, SB-INV interspersed with the tacts; Phase IV, TB-INV interspersed with all; Phase V, Mand compliance.
Jesse, Troy, and Karen, 3 Objects	Phase I, SB-Tact only; Phase II, TB-Tact interspersed with SB-Tact; Phase III, TB-INV interspersed with the tacts; Phase IV, SB-INV interspersed with all; Phase V, Mand compliance.
Kathleen: 2 Objects[1]	Phase I, TB-Tact only; Phase II, SB-Tact only; Phase III, Tacts retention; Phase IV, SB-INV interspersed with the tacts; Phase V, TB-INV interspersed with all.; Phase VI, Mand compliance.
Jessica: 2 Objects[1]	Phase I, SB-Tact only; Phase II, TB-Tact only; Phase III, Tacts retention; Phase IV, TB-INV only; Phase V, SB-INV only; Phase VI, Intraverbal retention; Phase VII, Mand compliance.
Jordan: 3 Objects[2]	Phase I, TB-Tact only; Phase II, SB-Tact interspersed with the TB-tact; Phase III, SB-INV only; Phase IV, TB-INV only; Phase V, Mand compliance.

[1]Due to an inaccuracy in the assessment of this subject's level of function, the procedure was changed somewhat during the process of the experiment by adding a retention-training phase, as described at the end of this section.

[2]Jordan's procedure also varied from what was originally planned but the variation did not involve retention training and will be described below.

For all sessions with interspersal training, half of the trials were assigned to the newly trained verbal relations (test trials). These were alternated with the verbal relations previously known. For example, Amelia's Phase II consisted of 24 selection-based tact trials (test trials) alternated with 24 trials from the already learned topography-based tact; her Phase IV consisted of 24 topography-based intraverbal trials (test trials) and the other 24 trials were divided evenly among the previously trained verbal relations (four trials for each of the two objects with the topography-based tact, selection-based tact and selection-based intraverbal). In the case of three objects, the last session involving interspersal usually consisted of 54 trials instead of 48 trials, with 27 assigned to the new relation being taught (test trials) and three sets of nine trials (three for each object) for each of the three verbal relations that had been previously taught.

Tact and/or interspersal training. Training began with the experimenter holding up an object, making the corresponding sign or pointing at the corresponding symbol, and saying "This" (holding up the object) "is this" (making the sign or pointing to the symbol). The subjects were then asked to imitate the sign or point to the symbol. If the subject made the correct response, verbal praise was given ("Good job, you got it."). If the subject did not respond, the proper response was demonstrated along with the same verbal prompt. If the subject made the wrong response s/he was informed of the error, and this was followed by a demonstration of the correct response along with the same verbal prompt. This procedure was then repeated for the other object(s) until the subject began to imitate some of the responses made by the experimenter. Approximately five demonstrations were given to each newly trained verbal relation and two reminders at the beginning of each session. Data collection began with the experimenter looking up a name on a prearranged randomization sheet and holding up the corresponding object and saying "What is this, _____?"(participant's name). The consequences of a correct response, no response, or an incorrect response were as indicated above. This sequence was usually repeated 48 times (ending the session for that day) until criterion was met or until the cut-off point for terminating training was reached for this verbal relation. When the criterion or the cut-off point was reached, the next phase of training was initiated.

If the tact session involved interspersal or a retention test, the session consisted of 48 trials. Twenty-four tact trials with the new relation (e.g., the topography-based tact) were alternated with 24 trials for the previously learned relation (e.g. the selection-based tact). Correct and incorrect interspersal responses were recorded, but no criterion was required.

Intraverbal and/or interspersal training. Training began with the experimenter saying the name of the object and making the corresponding sign or pointing at the corresponding symbol. The subjects were then asked to imitate the response. If the subject made the appropriate response, verbal praise was given just as in the previous relations. If the subject did not respond, the experimenter would say "____(subject's name), this _____(making the sign or pointing to the symbol) is _____(saying the name)." If the subject responded incorrectly, s/he was informed of the error, followed by a demonstration of the correct response, as for example "No, Jordan. That was nack. This is puck." This procedure was repeated for the other name(s) until the subject began to imitate some of the responses displayed by the experimenter. Approximately five demonstrations were given of each newly trained verbal relation and two reminders at the beginning of each session.

Data collection began with the experimenter looking up a name that related to an object and a sign in the randomization sheet, and asking the subject to make the corresponding sign or select the corresponding symbol (e.g., "Jordan, show me puck.") The response was consequated as described above.

If the intraverbal session involved inter-

spersal, the session consisted of 48 trials. Twenty-four were assigned to the newly trained intraverbal relation, while the remaining trials were divided evenly among all other interspersed verbal relations (e.g. selection-based intraverbal—24; topography-based intraverbal—8, topography-based tact—8; selection-based tact—8).

Topography-based and selection-based test for mand compliance. When mastery criterion was met for most or all verbal relations, testing for the emergence of mand compliance (the untrained relation) was conducted. An unreinforced mand-compliance probe was conducted after a few practice trials on all of the trained verbal relations. For the mand-compliance probes the experimenter simply laid all four or all six objects on the table twice (each time in different order) and asked the subject to point to the one the experimenter mentioned by name. For example, the experimenter pointed to the objects (calling attention to them) and asked "Which one is nack?" Until this test, the subject had only learned to make a sign or select a symbol in the presence of the plastic object and to make the same response when asked to sign or select nack. Identifying the object nack is a new relation and the extent to which this relation emerged was another basis for comparing the two paradigms. If in both trials the subject made the appropriate response the relation was considered to have been demonstrated. If an error appeared in one or both trials the relation was not considered to have been demonstrated.

Retention Training With Two Subjects

Although it was originally planned to use the two-object or three-object procedure either with interspersal or without interspersal depending on the level of function of the subject, a modification was made in the case of two subjects because of problems arising during their performance. In all cases the modification consisted in part in the introduction of a procedure referred to as *retention training*. This occurred after training with two relations by themselves, and consisted in retraining with the two relations intermixed with each other.

Kathleen. This subject was trained using two objects with topography-based tact only and then with selection-based tact only (with no interspersal because she was assessed as sufficiently low functioning that the interspersal would not be useful). However, her performance on the two tact relations was sufficiently good that it was decided to use the retention-training review procedure as the next phase, and then go to the regular interspersal after the first training on an intraverbal relation.

Jessica. This subject, like Kathleen, was started with no interspersal, the retention-training was added after the tact training, but instead of going to interspersal with the intraverbal training (her performance on the selection-based tact was very poor) she was simply given a retention-training phase after the intraverbal training.

Data Collection and Reliability Checks

Each trial was recorded as correct or incorrect under the corresponding relation. Reliability data on each subject's responses were collected by a trained observer who was a graduate student in psychology at Western Michigan University. The observer used the same type of data sheet as the experimenter and was seated at a nearby desk so that he could see the subject's responses but not the experimenter's data. Reliability was calculated for each observed session utilizing the following formula: [trials scored in agreement divided by (trials scored in agreement + trials scored in disagreement)] × 100. For a trial to be recorded as an agreement the observer and the experimenter must have agreed on a recorded response as correct or incorrect. Reliability data were obtained for two sessions for Amelia (96 trials); two sessions for Jesse (102 trials); three sessions for Kathleen (144 trials); seven sessions for Jessica (336 trials); eight sessions for Troy (402 trials); seven sessions for Karen (354 trials) and six sessions for Jordan (288 trials).

Interobserver agreement per subject ranged between 97 and 100 percent. The

two observers clearly had no difficulty in classifying the various responses.

RESULTS

Overall Results

Trials to criterion. Five of the seven subjects (Jesse, Jessica, Troy, Karen and Jordan) generally showed fewer trials to criterion for every verbal relation when trained with the topography-based system (see Table 4 below). The remaining two subjects demonstrated variations among the different verbal relations. Amelia did equally well with the tact in both paradigms but better on the topography-based intraverbal, and Kathleen did better on the selection-based than the topography-based tact but worse on the selection-based than topography-based intraverbal. Three of the seven subjects (Jessica, Karen and Jordan) did not reach criterion for the selection-based tact and four (Jesse, Kathleen, Jessica and Jordan) for the selection-based intraverbal, but all subjects reached criterion with the topography-based verbal relations. Average values are shown in the last row of Table 4, and it is clear that the averages for the topography-based relations are lower than for the selection-based relations, although the actual quantitative relation is not known because of the use of an arbitrary stopping point, which was reached with several of the selection-based values.

Overall percent correct for each subject. Three of the subjects (Jesse, Jessica and Jordan) had clearly higher accuracy in terms of percent correct for the topography-based relations than for selection-based relations (see Table 5). Amelia performed perfectly with the tact in both paradigms, and with the topography-based intraverbal, but she made some errors with the selection-based intraverbal. Kathleen did slightly better on the selection-based than the topography-based tact, but much worse on the selection-based than the topography-based intraverbal. Troy and Karen both did much better on the topography-based than the selection-based tact; and somewhat better on the selection-based than the topography-based intraverbal. Average values are shown in the last row of Table 5, and as with the average trials-to-criterion, the actual quantitative relation is somewhat unclear because of the use of an arbitrary stopping

Table 4

Trials to criterion for each subject.

Subject	T-B Tact	T-B Inv	S-B Tact	S-B Inv
Amelia	22	22	22	48
Jesse	22	22	48	81*
Kathleen	46	72	22	72*
Jessica	96	70	144*	144*
Troy	45	72	144	135
Karen	22	72	144*	96
Jordan	45	120	144*	144*
Average	43	64	95[3]	103[3]

* did not meet criterion.

[3]Averages are shown, but in those cases where the cut-off point was reached, that is, where training was terminated without the criterion being reached, such averages are relatively meaningless.

Table 5

Percent correct for each subject.

Subject	T-B Tact	T-B Inv	S-B Tact	S-B Inv
Amelia	100	100	100	92
Jesse	100	100	90	81*
Kathleen	92	72	96	57*
Jessica	78	72	49*	51*
Troy	96	78	77	87
Karen	92	76	45*	88
Jordan	92	80	53*	42*
Average	93	83	73[4]	71[4]

* did not meet criterion.

point, which was reached with several of the selection-based values.

Mand compliance or stimulus equivalence. Table 6 shows each subject's performance on the test for spontaneous occurrence of the mand compliance relation, which is taken here as a form of stimulus equivalence[5]. Six of the subjects showed more correct mand compliance with the topography-based than with the selection-based relations, and one subject (Jessica) had no correct mand-compliance responses with either relation.

It must be noted, however, that when there are only four objects (two with each paradigm), unless the subject fails to indicate either object, s/he has a 25% chance of making a correct identification on the first opportunity to identify the object when told its name, just by guessing. (It is not

Table 6

Mand compliance (stimulus equivalence).

Subject	Topography-based	Selection-based
Amelia	2 out of 2	1 out of 2
Jesse	3 out of 3	2 out of 3
Kathleen	1 out of 2	None out of 2
Jessica	None out of 2	None out of 2
Troy	3 out of 3	2 out of 3
Karen	2 out of 3	1 out of 3
Jordan	1 out of 3	None out of 3

[4]As with the average values of the trials-to-criterion across subjects, in those cases where the cut-off point was reached, the true averages are not actually available.

[5]The mathematical definition of equivalence requires reflexivity, symmetry and transitivity. No test of symmetry was involved in this research, only transitivity. For this reason the use of equivalence here might not be considered appropriate from this most stringent basis.

easy to arrive at a probability of chance success when the second opportunity is taken into consideration, because the two are not really independent—there might be some tendency to repeat the first guess.) With six objects (three with each paradigm) the probability of a correct response by chance on the first opportunity to choose is only 17%. In one sense these results might not be considered very robust, but given the limitations of the method, they are certainly more than just suggestive.

Individual Data

Correct trials per session for Amelia, Jesse, Kathleen, Jessica, and Jordan do not reveal anything of importance that is not available in the preceding overall tables. The correct trials per session data for Troy and Karen, however, provide information that was not available in the overall data, and are the data justifying the use of interspersal as a way of obtaining more comparative information. First, with respect to Troy (see Table 7), who worked with three objects, the first relation trained was the selection-based tact. It took three sessions, 144 trials for him to reach criterion with this relation. Next, he was trained on the topography-based tact as a new relation, with trials on the previously learned selection-based tact interspersed. He reached criterion on this new relation in two sessions (45 trials), and then was trained on the topography-based intraverbal, which required three sessions and 72 trials to reach criterion. During this training the two preceding relations were being interspersed, 12 trials with each. Finally, he was trained on the selection-based intraverbal, which took five sessions and 135 trials to reach criterion. This pattern of performance permits a comparison of topography-based and selection-based interspersal performance. During sessions 4 through 11 Troy continued to make quite a few errors on the selection-based tact. With the topography-based tact he made almost no errors after reaching criterion (sessions 6 through 13), and with the topography-based intraverbal his performance was also quite

Table 7

Troy's correct trials per session.

Session	S-B Tact	T-B Tact	T-B Inv	S-B Inv
1	33 out of 48	not trained	not trained	not trained
2	34 out of 48	not trained	not trained	not trained
3	44 out of 48	not trained	not trained	not trained
4	17 out of 24	22 out of 24	not trained	not trained
5	15 out of 24	24 out of 24	not trained	not trained
6	9 out of 12	12 out of 12	15 out of 24	not trained
7	9 out of 12	12 out of 12	20 out of 24	not trained
8	10 out of 12	12 out of 12	21 out of 24	not trained
9	6 out of 9	9 out of 9	7 out of 9	21 out of 27
10	6 out of 9	9 out of 9	9 out of 9	22 out of 27
11	7 out of 9	9 out of 9	9 out of 9	24 out of 27
12	8 out of 9	8 out of 9	8 out of 9	24 out of 27
13	8 out of 9	9 out of 9	9 out of 9	26 out of 27

Table 8

Karen's correct trials per session.

Session	S-B Tact	T-B Tact	T-B Inv	S-B Inv
1	17 out of 48	not trained	not trained	not trained
2	20 out of 48	not trained	not trained	not trained
3	27 out of 48	not trained	not trained	not trained
4	7 out of 24	22 out of 24	not trained	not trained
5	7 out of 12	11 out of 12	16 out of 24	not trained
6	5 out of 12	12 out of 12	18 out of 24	not trained
7	6 out of 12	12 out of 12	21 out of 24	not trained
8	5 out of 9	9 out of 9	9 out of 9	20 out of 27
9	6 out of 9	9 out of 9	9 out of 9	24 out of 27
10	4 out of 9	9 out of 9	9 out of 9	25 out of 27
11	3 out of 9	9 out of 9	9 out of 9	26 out of 27

good. In other words, the first learned relation, the selection-based tact, continued to be performed incorrectly even though criterion had been met, and even though it was practiced more than any other relation.

Karen's data (Table 8) are very similar to Troy's with respect to interspersal performance. She did not meet criterion with the first relation trained, the selection-based tact, and continued to make many errors on this relation throughout sessions 4 through 11. On the other hand, after reaching criterion on the next two relations which were topography based, she continued to perform perfectly on those relations when they were interspersed with new relations.

Whether interspersal facilitates or hinders the learning of new relations cannot be determined from the present experiment because this type of comparison is completely confounded with the type of relation being trained.

Tacts versus intraverbals. From Tables 4 and 5, and from most of the individual data, it was clear that the topography-based intraverbal relation was more difficult for these subjects to learn than the topography-based tact. Two of the subjects (Amelia and Jesse) had errorless performances on both, but four (Kathleen, Troy, Karen and Jordan) of the remaining five had considerably better performances on the tact than the intraverbal. With respect to the selection-based relations the results are not clear. Jessica and Jordan did not meet criterion with either tact or intraverbal, and of the remaining five subjects three (Amelia, Jesse and Kathleen) had better tact performances and two (Troy and Karen) had better intraverbal performances.

DISCUSSION

Success of the task difficulty adjustment. The present study attempted to provide a more complete comparison of the topography-based and selection-based verbal behavior than previous research on this issue (Sundberg & Sundberg, 1990; Wraikat, 1990). The training sessions consisted of a sequence of procedures, first using only two objects, then adding progressively more complex task requirements if the subject acquired the repertoire too easily to permit useful comparisons of the two paradigms. These complications,

consisting of a retention test, interspersal, and adding a third object, were added or subtracted from the procedure in such a way as to facilitate comparison of the two paradigms. In general, these efforts were somewhat successful, in that at least some useful comparison data were obtained from every subject.

Main conclusions. The main research questions for this study were: (1) With which paradigm (topography-based or selection-based) will tact and intraverbal relations be easier to learn (number of trials to mastery criterion)? (2) With which paradigm will tact and intraverbal relations be learned more accurately (percentage of correct responses)? And (3) will there be any differences between the two paradigms in the spontaneous development of a form of stimulus equivalence relation, the mand-compliance task?

With respect to ease of acquisition, the results clearly favored the topography-based language system. Trials-to-criterion were generally fewer for topography-based than selection-based relations. For the second question, the results are not so clear, although there would still seem to be somewhat more support for the topography-based than the selection-based system. In retrospect, the second research question is not well worded. It seems to be concerned with the asymptote of a learning curve, which is not really addressed by overall percent correct responses. Perhaps it would have been better to study percent correct for successive blocks of trials as the dependent variable, and then to compare the two paradigms with respect to both the rates of approach to the asymptote and the asymptotic values themselves. For the question concerning the spontaneous development of a new stimulus relationship, even though the probability of chance success was uncomfortably high, the question was still answered clearly in favor of the topography-based paradigm.

Although it was not a primary issue in this research, the results do bear on the general question regarding the relative ease of acquiring tact versus intraverbal relations. In the Sundberg and Sundberg (1990) study the intraverbal seemed in general more difficult to learn. The present data are somewhat similar, in that the tact was generally easier to learn for the topography-based relations; however, for the selection-based relations, two of the present subjects (Troy and Karen) had clearly more difficulty with the tact than with the intraverbal; and two subjects, Jessica and Jordan, found them about equally difficult. This interaction between type of verbal behavior and relative ease of tact and intraverbal relations might be considered further support for the notion that there are some fundamental differences between these two kinds of verbal behavior.

Informal Observations. As noted by Sundberg and Sundberg (1990) and also by Wraikat (1990) it appeared that the subject's attitudes toward the experiment and the experimenter were more positive during phases involving the topography-based paradigm. For example, in the present experiment during topography based training, as soon as Jordan saw the experimenter he would greet him with a smile and attempt to leave his coffee unfinished to do the experiment. This was not the case when training involved the selection-based paradigm. The experimenter was forced to skip several sessions with Jordan because of his attitude toward training with the selection-based paradigm.

Theoretical implications. The necessary and sufficient conditions required for the development of equivalent stimulus classes continue to be debated among researchers (e.g., D'Amato et al., 1985; Lazar, Davis-Lang and Sanchez, 1984; McIntire et al., 1987; Sidman, Rauzin, Lazar, Cunningham, Tailby, & Carrigan, 1982). McIntire et al. (1987) proposed that the important aspect of verbal behavior, as it relates to the formation of equivalence classes, is the occurrence of naming responses with different response topographies. The superior spontaneous stimulus class development of the topography-based behaviors in the present study can be considered a form of support for this analysis.

Practical implications. The present results

continue to support the notion that there are important advantages to a topography-based language system in terms of ease of learning, and now also ease of spontaneous stimulus class expansion. When these advantages are added to the practical advantages of such a system (e.g., freedom from environmental support), it becomes clearer that specialists in traditional psycholinguistics, speech pathologists, parents and teachers should reexamine their biases towards selection-based systems. If improved intellectual function by the developmentally disabled person results from the acquisition of a topography-based language such as signing, then the extra effort such a system imposes on parents, teachers, and other care givers may still be worth it. Of course, it is still be possible for a person with a signing repertoire to make use of a selection-based system for interacting with members of the community who are not familiar with the signs, much as is done by some deaf signers when they function in the normally hearing community. Also, signing can help improve vocal behavior, because the listener is more likely to understand an utterance if it is accompanied by a sign, and can more accurately react to and correct the vocal response.

Nor does the possible advent of selection-based computer devices that provide familiar auditory stimuli for the listener eliminate the necessity of a topography-based language system for the language producer. In this connection Trefler and Crislip (1985) noted that "In spite of the availability of microcomputer-based systems, it is still proposed that clients should always maintain competency in the use of nontechnical augmentative systems. This is particularly important if electronically based equipment requires frequent maintenance, or if there are environments in which the client would not have access to the electronic system" (p. 151).

Another implication of the present results for language training programs with the developmentally disabled population concerns the intraverbal relation. With this population the intraverbal repertoire is frequently one of the weakest (Sundberg, 1987). However, as shown by this study, if the developmentally disabled individual can develop a tact repertoire s/he might very well be able to develop intraverbal behavior if it were taught. The objection usually made to the teaching of intraverbal relations to a developmentally disabled learner is that "he won't understand it because it is beyond his cognitive level" (Sundberg, 1987, p. 40). This point of view obviously reflects the traditional cognitive approach to language training which dominates speech pathology, special education, and psychology, and this approach may well have limited the development of the educational potential of a large number of developmentally disabled individuals.

In general, the results of this study constitute further support for the previous conceptual and empirical analyses in this area (e.g., Michael, 1985; Sundberg & Sundberg, 1990; Wraikat, 1990). However, there is still need for further research along several lines. The process of subject selection relied basically on data in the subject's files which were not closely related to the experimental task, and on the casual observations of people who worked around these subjects. More accurate classification of a subject's verbal functioning level would not only facilitate further methodological refinements within subjects but would also allow between-subject comparisons to be made. It would probably be sufficient to present some experimental tasks prior to determining the final details of each subject's tasks.

In the present study not much time was given between learning the verbal relation and testing for retention, and responses during retention were consequated. This issue is of interest in itself as another type of comparison of topography-based and selection-based verbal behavior, which would justify further experimental analysis. In addition, the effect of retention testing and/or the retention-training procedure of the present experiment on the learning of new relations could be of practical and theoretical interest.

The current study also needs to be repli-

cated with other subjects, especially with higher functioning developmentally disabled individuals and normal children. These extensions might not be of great practical importance, but would have considerable theoretical significance in our efforts to understand the basic nature of verbal behavior. To extend the research to these populations, however, would require further refinement in the methodology in the direction of making the task more difficult, for example by considerably increasing the number of objects used.

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