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The Acquisition of Tacts, Mands, and Intraverbals by Individuals With Traumatic Brain Injury

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Two individuals who sustained traumatic brain injuries from motorcycle accidents were taught several verbal responses by using tact, mand, and intraverbal training procedures. The rate of acquisition for each operant and the transfer to untrained verbal operants involving the same response topography were measured. The results showed that tacts and intraverbals were acquired quickest, and training on the tact produced the greatest amount of transfer to the untrained verbal operants. Intraverbal training also resulted in transfer for both subjects, but to varying degrees. Direct mand training proved to be the least efficient way to generate a mand repertoire, and when acquired showed least amount of transfer to the untrained operants. These results seem to be in contrast with the findings of similar research with developmentally disabled individuals, and may have implications for methods of language instruction for the brain injured population.

Individuals who sustain a traumatic injury to the brain frequently experience severe and long-term physical and verbal deficits. Rehabilitation after strokes, comas, vehicle accidents, and the like, often takes years and may be only marginally successful. Verbal deficits, such as aphasia, tend to be especially difficult to remediate. Hagen (1984) noted that aphasia produced by a traumatic brain injury "presents the speech-language pathologist with a unique and complex diagnostic, prognostic, and treatment challenge" (p. 245).

Furthermore, professional opinion on the most effective assessment and treatment strategies for those suffering from aphasia, as well as other verbal disorders resulting from head injury, varies considerably (see Chapey, 1986; Darley, 1972; Doyle, Goldstein, & Bourgeois, 1987; Holland, 1984; Mowrer, 1988; Sidman, 1971). There is an extensive body of experimental research on the topic (e.g., Chapey, 1986), but most of it is derived from traditional psycholinguistic theories which emphasize cognitive or neurological causes of language (Muma, Hamre, & McNeil, 1986). As a result, the focus of the clinical assessment and intervention is often on the assumed underlying causes of the deficits. For example, in his review of the literature on post-closed-head-injury (CHI), Hagen (1984) states that

> this literature indicates that the CHI patient incurs impairments in concentration, attention, memory, nonverbal problem solving, part/whole analysis and synthesis, conceptual organization, abstract thought, and speed of processing...it would seem reasonable to assume that post-CHI-language dysfunction is heavily influenced, and in some instances created, by cognitive dysfunction. (p. 249)

The research supporting this cognitive position is complicated by the fact that the independent and dependent variables in experimentation are often not clearly identified, and methodological problems result which make replication nearly impossible. Sidman (1971) pointed out that "anyone who has attempted seriously to survey the

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literature on aphasia is familiar with the inevitable frustration" (p. 413). Salvatore and Thompson (1986) expressed a similar concern with the existing literature on global aphasia stating that "the specific treatment procedures employed in these investigations are lacking in operational specificity, making it impossible to determine what variables affected patient change and even more important for the clinician, the procedures cannot be replicated" (p. 410).

A new direction for the assessment and treatment of the language problems faced by the brain injured population may be derived from Skinner's (1957) analysis of verbal behavior and aphasia. Skinner writes:

> The pathological condition of verbal behavior called aphasia often emphasizes functional differences which are hard to understand from the traditional account. The aphasic may not be able to name an object, though he will emit the name immediately in manding it; or he may be able to name the object although he cannot repeat the name after someone else or read it from a text as he once was able to do. But it is only traditional theory which makes this surprising. The aphasic has lost some of the functional relationships which control his verbal behavior. A response of a given form may no longer be under the control of one functional relation, although it is still under the control of another. (p. 190)

While the effects of aphasia may not be surprising to the behaviorist familiar with Skinner's (1957) *Verbal Behavior*, the research on the behavioral treatment of aphasia remains sparse. One of the few attempts to apply behavioral methods to study this problem can be found in a series of studies conducted by Sidman and his colleagues (Kirshner & Sidman, 1972; Leicester, Sidman, Stoddard, & Mohr, 1971; Mohr, Sidman, Stoddard, Leicester, & Rosenberger, 1973; Sidman, Stoddard, Mohr, & Leicester, 1971). Like Skinner, Sidman proposed that a brain injury may affect specific classes of stimulus-response relations, but not others. For example, with a stroke patient Sidman et al., (1971) tested four different types of stimulus-response relations (simultaneous matching-to-sample, delayed matching, oral naming, and written naming), across three different modalities (vision, audition, and touch).

The results of this study demonstrated a clear separation in the strength of the operants tested. In addition, they showed "the existence of orderly but different recovery courses for the various stimulus-response relations" (p. 135). Some relations, such as the echoic and transcriptive repertoires, were clearly stronger than the others. The authors note that the

> patient was able to repeat words when he could not say them in response to appropriate visual and tactile stimuli. He was able to match and write visual and tactile word samples that he could not name. His naming deficits, therefore were not simply an amalgram of receptive and expressive elements; they were a distinctly separate category. (pp. 136-137)

The authors go on to suggest that these findings could have implications for the diagnosis and treatment of individuals suffering from aphasia. For example, if a specific repertoire can be identified as being weak, then an intervention can be designed to directly strengthen that repertoire.

The current research is an extension of Sidman's efforts to identify the effects of brain injury on specific verbal relations. In addition, the research incorporates the findings from the growing body of literature on the application of Skinner's (1957) analysis of verbal behavior (e.g., Braam & Poling, 1983; Carroll & Hesse, 1987; Hall & Sundberg, 1987; Lamarre & Holland, 1985; Lee & Pegler, 1982; Oah & Dickinson, 1989; Sigafoos, Reichle, Doss, Hall, & Pettitt, 1990; Watkins, Pack-Teixteira, & Howard, 1989).

Both of the subjects in the present study could easily emit echoic and textual responses, but they had great difficulty emitting correct tact, mand, and intraverbal responses. For example, one subject could echo the word *binoculars*, point to them when asked to, pantomime how to use them, and read the written word. But he could not say *binoculars* when asked to name them (tact), or ask for them when needed (mand), or correctly talk about them in conversation (intraverbal).

Most of the previous research on procedures for teaching weak or missing verbal operants has been done with developmentally disabled individuals or young chil-

dren (e.g., Braam & Poling, 1983; Carroll & Hesse, 1987; Hall & Sundberg, 1987). The current study attempts to replicate some of these procedures, while examining the issue of separate verbal functions as suggested by Skinner (1957). In addition, the study attempts to determine the effects of teaching one verbal operant on the development of others involving the same response topography. Specifically, the research addresses the following questions. (1) Which verbal operant will be acquired first? (2) Will a response established under mand conditions occur under tact and intraverbal conditions without direct training? (3) Will a response established under tact conditions occur under mand or intraverbal conditions without direct training? And finally (4), will a response established under intraverbal conditions occur under mand or tact conditions without direct training?

METHOD

Subjects and Setting

Two males who sustained traumatic brain injuries from motorcycle accidents served as subjects. These individuals were chosen as subjects because of their severe verbal deficits. Subject 1 was 40 years old and was involved in an accident 19 years prior to the start of the study. As a result of the accident he sustained a severe head injury and was briefly comatose. He was treated with decompression of a predominantly left sided subdural hematoma, and a small portion of his left temporal brain was resected. He also had a treacheostomy. Currently, he has right spastic hemiparesis, and grand mal seizures for which he is receiving dilantin and phenobarbital. A verbal assessment (Sundberg, 1983) conducted at the beginning of the study showed that the subject had strong receptive, echoic and textual repertoires, and weak mand, tact, and intraverbal repertoires.

Subject 2 was 33 years old and was involved in an accident 10 years prior to the start of the study. As a result of the accident he sustained a severe closed head injury with brain contusions and cervical spine fractures. He was comatose for about one month, and received dilantin for seizures for about three years after the accident. Currently he has a right hemiparesis of the arm and leg. A verbal assessment (Sundberg, 1983) conducted at the beginning of the study showed the subject had strong receptive, echoic, and textual repertoires, and weak to moderate mand, tact, and intraverbal repertoires.

Both subjects attended a non-profit traumatic brain injury rehabilitation program in Berkeley 3-5 days a week. The study was conducted at the program in a 3 m x 5 m room. The experimenter and the subjects both sat along a counter where the materials and data sheets were kept. The subjects sat in a chair approximately 1 meter away from the experimenter, and were worked with individually. On days that reliability was taken the reliability observer sat along the wall opposite to the counter.

Materials

The materials used in the experiment consisted of 18 common objects. The objects were divided into six sets (using a procedure described later), with three sets for each subject. For Subject 1, set 1 consisted of a funnel, electrical tape, and a row of staples. Set 2 consisted of a plastic bag, a bottle brush, and a three pronged adapter. And set 3 consisted of an extension cord, a tire gauge, and a nut cracker. For Subject 2, set 1 consisted of a box of dental floss, binoculars, and a crow bar. Set 2 consisted of a staple remover, wire cutters, and a paper clip. And set 3 consisted of a night light, a lint brush, and a paint stirrer. These items were chosen because they were familiar to the subjects (correct receptive and functional use behaviors), but they failed to emit the correct tact, mand, and intraverbal responses during the baseline condition. Several other materials were used to contrive establishing operations (Michael, 1988) during mand testing and training. For example, bicycle tires were used to help create an establishing operation for the mand *tire gauge*, and wire was

used to help create an establishing operation for the mand *wire cutters*.

Response Definitions and Independent and Dependent Variables

A response was recorded as correct if the subject's first response corresponded with the item being tested. Often, responses such as *Ahh, Let's see, that's a...*, or *Oh yeah that's a...* preceded the targeted response. These were scored as correct as long as the key word was emitted. If the subject said a different word first, or part of a different word, the response was scored as incorrect. If the subject reversed the order of a pair of words such as calling a paper clip a *clip paper* the response was scored as incorrect.

The independent variables consisted of the specific training procedures (described later) used for each of the targeted verbal operants. Basically, the procedures involved the use of contrived establishing operations, prompting, fading, and differential reinforcement. In general, there were nine dependent variables: the acquisition of tacts, mands, and intraverbals for sets 1, 2, and 3. Specifically, the dependent variables consisted of the percentage of correct responses during the training and probe conditions, and the number of training trials required to meet the session termination criterion (described later).

There were two types of reinforced probes used in the study. One type was a first-trial probe in which the first trial of a training session constituted a probe. The other type was a one-trial generalization probe on the operants not targeted for intervention. These generalization probes were conducted on all the untrained operants prior to the training segment of a session. For example, during mand training probes were first conducted under tact and intraverbal conditions for each word (these were interspersed with probes from other sets). Then the first trial of the mand session constituted the mand probe. The generalization probes were conducted on approximately 33% of the sessions. These probes were always conducted by the first author. The training probes and sessions were mainly conducted by the first and second authors. Correct responses were reinforced with social praise (e.g., *Right!*), and the delivery of the manded item under mand conditions. Incorrect responses were followed by what was believed to be a neutral *Ok*.

Reliability

Reliability was assessed by having a second observer simultaneously but independently score the subjects' responses. Reliability measures were taken on approximately 20% of the sessions, including baseline and intervention, and used the formula (agreements/agreements + disagreements x 100). In baseline the mean reliability was 100%, and during intervention the mean reliability was 99%.

Procedure

For each subject, the nine items were randomly divided into three groups and assigned to one of three training sets (three words per set). The three sets were (1) tact training, (2) mand training, and (3) intraverbal training (Table 1). The randomization procedure consisted of listing the items on nine separate index cards and shuffling them. The second author picked a card out of the upside down stack while the first author, looking away, started a digital stopwatch with a 1/100 of a second reading. When the second author said *Stop* the watch was stopped, and if the 1/100 of a second was between 1 and 3 the word

Table 1
The three-word sets and assigned training conditions for Subjects 1 and 2.

Subject 1	Subject 2
Tact Training (Set 1)	
funnel	dental floss
tape	binoculars
staples	crow bar
Mand Training (Set 2)	
plastic bag	staple remover
bottle brush	wire cutters
adapter	paper clip
Intraverbal Training (Set 3)	
extension cord	night light
tire gauge	lint brush
nut cracker	paint stirrer

was assigned to the tact set, if it was between 4 and 6 it went to the mand set, and if it was between 7 and 9 it went to the intraverbal set. A zero resulted in repeating the procedure. For each subject all nine objects were individually assigned to a training condition using this procedure. Once a set was filled with three items the procedure was repeated until there was a number for an open set.

In the training conditions intervention occurred for the targeted verbal operants, while the other two operants were probed. All the probes of the untrained operants were conducted first, followed by the specific training conditions (Table 2). A typical session followed the order indicated by the numbers in the boxes of Table 2. This order of conditions remained constant across sessions, but the order of the individual words within a set was changed each session. Subject 1 received training prior to Subject 2.

Table 2
The training and probe conditions for each set of three words. The number in boxes indicates the order of the conditions.

	Probe	Probe	Training
Set 1 Tact Training	Mand Probe (1)	Intraverbal Probe (4)	Tact Training (7)
Set 2 Mand Training	Tact Probe (2)	Intraverbal Probe (5)	Mand Training (8)
Set 3 Intraverbal Training	Tact Probe (3)	Mand Probe (6)	Intraverbal Training (9)

Baseline and object selection. For both subjects a pool of familiar objects was gathered. The subjects were tested on their ability to emit tact, mand, and intraverbal responses appropriate for each item. During the tact condition the experimenter would hold up an item and ask *What is this?* All responses were followed by a neutral *Ok* from the experimenter and recorded. During the mand condition subjects were first asked to (nonverbally) complete a chain of behaviors, then an establishing operation was contrived using a procedure similar to the one used by Hall and Sundberg (1987). For example, after the subject had demonstrated the successful use of an adapter, the experimenter would give the subject a three pronged plug and a two pronged socket, but withhold the adapter. The experimenter would then ask him to connect them, thus creating a conditioned establishing operation by momentarily altering the value of an adapter (Michael 1982, 1988). All responses were followed by a neutral *Ok* by the experimenter and recorded. Intraverbal performance was assessed by presenting a verbal question such as *What do you use to connect a three pronged plug to a two pronged socket?* Again, all responses were followed by a neutral *Ok* from the experimenter and recorded. During the mand and intraverbal conditions stimulus objects were kept out of sight by either placing them in an opaque bag, or putting them under the counter.

Each operant was tested twice for each item across two sessions, except under mand conditions where it was only tested once (due to a procedural error). If the subject was correct on any single trial for any operant during baseline the item was not used. The baseline procedure was continued until 9 items met the zero-correct criterion (twice for the tact and intraverbal and once for the mand). For Subject 1 a pool of 12 items was needed, and for Subject 2, who had stronger verbal behavior, a pool of 35 items was needed to meet the zero-correct criterion. Subject 2 received one additional tact and intraverbal baseline session on the specific words used by Subject 1.

Once the 9 items were obtained for both subjects they were tested under echoic and textual conditions to assess the strength of those repertoires. During the echoic assessment the experimenter would present the subject with the verbal stimulus *Say_____*. All responses were followed by a neutral *Ok* and recorded. During the textual assessment the subject was presented with the word printed on a flash card, or on a piece of paper, and asked *What word is this?*

All responses were followed by a neutral *Ok* and recorded.

Intervention: Phase I. Each subject's nine words were divided into three sets using the procedure previously described. During Phase I either tact, mand, or intraverbal training was given on each of the three sets. For Subject 1 intervention began with tact training only. Intraverbal training was added after the sixth session, and mand training was added after the twelfth session. For Subject 2, who had stronger verbal behavior and easily handled the large number of trials, all three conditions began simultaneously.

Tact training. Each session began with a tact probe for each word. Correct responses were reinforced with praise, and incorrect responses initiated the start of the training procedure. The procedure used for tact training was essentially the same procedure used by Sundberg (1980, 1987) with developmentally disabled individuals. Stimulus control was transferred from echoic control to tact control by use of prompting, fading, and differential reinforcement. The experimenter would hold up an object and say *What is this*? If no response, or an incorrect response occurred within approximately 5 seconds an echoic prompt was given. Following a correct echoic response, the experimenter re-presented the original verbal prompt *What is this*? Correct responses were followed by social praise, and the next object was presented. Incorrect responses were followed by a mild *No*, and the repetition of the transfer procedure (the correction loop). Echoic prompts were gradually faded from the full word to the initial sound of the word. The tact training session ended when the subject correctly tacted all three objects in a row (starting with the first item on the list) without the echoic prompt, or when five transfer trials (tact-echoic-tact) on each word had been given, whichever came first. (Initially the session terminated after 10 trials, but Subject 1 began to show signs of fatigue, so beginning with the sixth session, and the addition of intraverbal training, the criterion was reduced to 5 trials. Subject 2 started with only 5 trials on each word.)

Mand training. Each session began with a mand probe for each word (see Table 3). Correct responses were reinforced with praise and the presentation of the missing object. Upon receipt of the missing object the subject would complete the chain. Incorrect responses initiated the start of the

Table 3
The contrived establishing operations and the targeted response for the mands used with Subjects 1 and 2.

Subject 1		Subject 2	
Contrived establishing operation	**Response**	**Contrived establishing operation**	**Response**
1. The subject was given a three pronged plug and a two pronged socket and asked to connect them.	Adapter	1. The subject was given a card with a staple in it and asked to remove it.	Staple remover
2. The subject was given a deep bottle and asked to clean the bottom.	Bottle brush	2. The subject was given a piece of wire and asked to cut it.	Wire cutters
3. The subject was given a cracker and asked put it in something to keep it fresh.	Plastic bag	3. The subject was given a few pieces of paper and asked to connect them.	Paper clip
4. The subject was given a Calistoga bottle with a small opening and a bottle of water and asked to pour the water in the small bottle.	Funnel	4. The subject was asked to clean between his teeth.	Floss
5. The subject was given a hose with a hole in it and asked to fix it.	Tape	5. The subject was asked to read a poster on the opposite side of a room visible through a window.	Binoculars
6. The subject was given an empty stapler and asked to connect some papers together.	Staples	6. The subject was asked to separate two boards nailed together.	Crow bar
7. The subject was asked to plug in an appliance which was too far from the outlet.	Extension cord	7. The lights were turned off and the subject was asked what he needed to turn on if he were sleeping.	Night light
8. The subject was presented with a tire and asked to check it.	Tire gauge	8. The subject was shown a pair of pants with lint on them and asked to clean them.	Lint brush
9. The subject was given a hard nut and asked to open it.	Nut cracker	9. The subject was given a can of paint and asked to mix it up.	Paint stirrer

training procedure. The mand training procedure was essentially the same procedure used by Hall and Sundberg (1987) with developmentally disabled individuals. Conditioned establishing operations were contrived by removing an item from a stimulus array and asking the subject to complete a response chain (often the experimenter would add the prompt *What do you need?*). Completion of the chain was impossible without the missing item. Correct responses were followed by praise and the presentation of the missing object. Incorrect responses were followed by a mild *No*, and the correction procedure consisting of an echoic prompt, reinforcement (praise) for correct echoic behavior, and the re-presentation of the initial verbal request to complete the chain. The missing item was only presented when the response occurred without the echoic prompt. Echoic prompts were gradually faded from the full word to the initial sound of the word. Mand training ended when the subject correctly manded for all three objects in a row (starting with the first item on the list) without the echoic prompt, or five transfer trials (mand-echoic-mand) on each word, whichever came first.

Intraverbal training. Each session began with an intraverbal probe for each word (see Table 4). Correct responses were reinforced with praise, and incorrect responses initiated the start of the training procedure. The intraverbal training procedure was essentially the same procedure used by Braam and Poling (1983) with developmentally disabled individuals, except echoic rather than tact prompts were used. Stimulus control was transferred from echoic control to intraverbal control by the use of prompting, fading, and differential reinforcement. Attempts were made to avoid the same verbal stimuli that were given during the mand probes on these words, although that was not always possible (see Table 4). The experimenter would present the subject with a verbal stimulus (e.g., *What do you use to fix a hole in a radiator hose?*), and reinforce correct responses. If no response, or an incorrect response, occurred within approximately 5 seconds an echoic prompt was given. Following a correct echoic response, the experimenter re-presented the original verbal stimulus. Correct responses were followed by social praise, and the next object was presented. Incorrect responses were followed by a mild *No*, and the repetition of the transfer procedure. Echoic prompts were gradually faded from the full word to the initial sound of the word. Intraverbal training ended when the subject correctly responded to all three questions in a row

Table 4
The verbal stimulus and the targeted response for the intraverbals used with Subjects 1 and 2.

Subject 1		Subject 2	
Verbal stimulus	**Response**	**Verbal stimulus**	**Response**
1. "What do you need to use to plug a three pronged plug into a two pronged socket?"	Adapter	1. "What do you use to pull a staple out of something?"	Staple remover
2. "What do you use to clean the bottom of a deep jar?"	Bottle brush	2. "If you're setting up your stereo and you need to cut the speaker wire what do you use?"	Wire cutters
3. "What do you put food in to keep it fresh?"	Plastic bag	3. "What can you use to connect a few papers together?"	Paper clip
4. "What do you use to pour oil into your car so you won't spill any?"	Funnel	4. "What do you use to clean between your teeth?"	Floss
5. "What do you use to fix a hole in your radiator hose?"	Tape	5. "What do you use to see something that is far away?"	Binoculars
6. "If a stapler is empty, what do you need to put in it?"	Staples	6. "What do you use to pry apart two boards nailed together?"	Crow bar
7. "If an electrical cord won't reach a plug what do you need to get?"	Extension cord	7. "If you're going to bed and you want a little light in your room what do you turn on?"	Night light
8. "If you have a tire that is low, what do you use to check the air pressure?"	Tire gauge	8. "What do you use to clean the bits of dirt off your clothes?"	Lint brush
9. "If you have a hard nut that you can't open what do you need to use?"	Nut cracker	9. "If you want to paint a house, what do you use to mix up the paint?"	Paint stirrer

(starting from the first item on the list) without the echoic prompt, or five transfer trials on each word, whichever came first.

Intervention: Phase II Following the successful acquisition of the tacts for both subjects, the tact training condition (set 1) was discontinued. Also, following acquisition intraverbal training (set 3) was discontinued for Subject 2. The remaining conditions, mand training for both subjects and intraverbal training for Subject 1, were changed to tact training. Specific mand and intraverbal training was discontinued, but mand and intraverbal probes were still conducted. In Phases II all aspects of the training procedure described above for tact training were implemented for all the remaining words (set 2 for both subjects, and set 3 for Subject 1).

RESULTS

Baseline and Object Selection

The subjects' performance during the assessment and the object selection conditions is presented in Figure 1. Both subjects displayed relatively weak tact, mand, and intraverbal behavior during baseline. The data for these three operants are based on all the items from the initial pool of items (12 for Subject 1, and 35 for Subject 2).

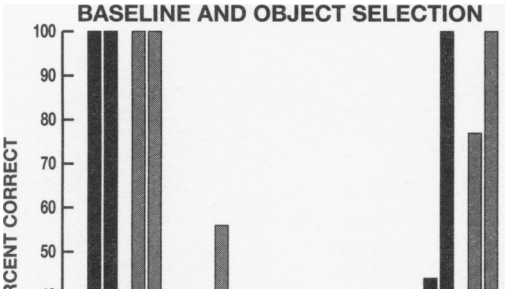

Fig. 1. The percentage of correct responses on the five verbal operants tested during the baseline assessment and the object selection procedure for Subjects 1 and 2. The numbers under the data indicate sessions.

Subject 2's verbal behavior was stronger as indicated by the fact that he was able to emit a correct tact or intraverbal for each of the words used with Subject 1 (shown by his first session in Figure 1), and a larger pool of items was required to find unknown words. Figure 1 also shows that both subjects demonstrated strong echoic and textual responses for the final 9 words selected.

Tact Acquisition and Transfer

Figures 2 and 3 show the acquisition and transfer of the verbal operants trained for Subjects 1 and 2, respectively. All the data represent performance during the probe conditions, and the shaded portions of the graphs indicate a specific training condition. The top three panels of both graphs show the acquisition of tacts, and the effects of specific tact training on the emergence of mand and intraverbal responses. In baseline both subjects were unable to correctly respond to any of the stimuli presented. Following specific training both subjects acquired the tacts, and effortlessly showed a transfer to mand and intraverbal contingencies. For Subject 1, performance was actually better under mand and intraverbal conditions (initially), even though no training had been given under those conditions. This subject showed a greater session to session variability, and there was less consistency in specific words missed. Subject 2's performance was quite stable and he generally missed the same word each session, and under all conditions. The training sessions were continued past the initial observance of transfer in order to assess the degree to which the effects would be maintained.

Mand Acquisition and Transfer

Mand training had quite a different effect for both subjects. The middle three panels of Figures 2 and 3 show that mand acquisition was much slower for both subjects. Subject 1 showed very poor performance under the mand conditions. On the seventh session following baseline he finally got his first correct response on a mand probe, which was the word *plastic*

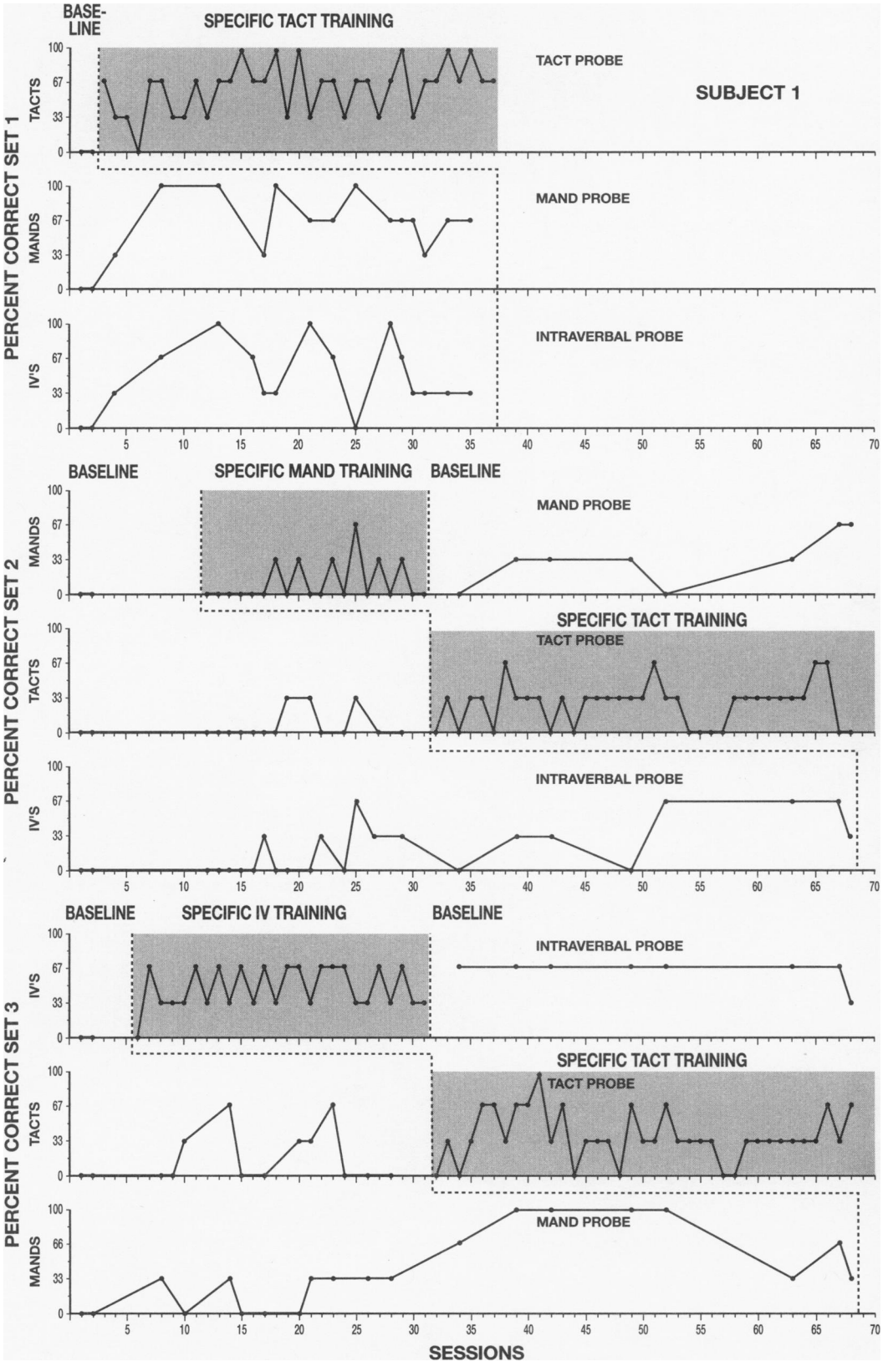

Fig. 2. Percentage of correct responses on tact, mand, and intraverbal probes across the three-word sets for Subject 1. Shaded panels indicate specific training conditions.

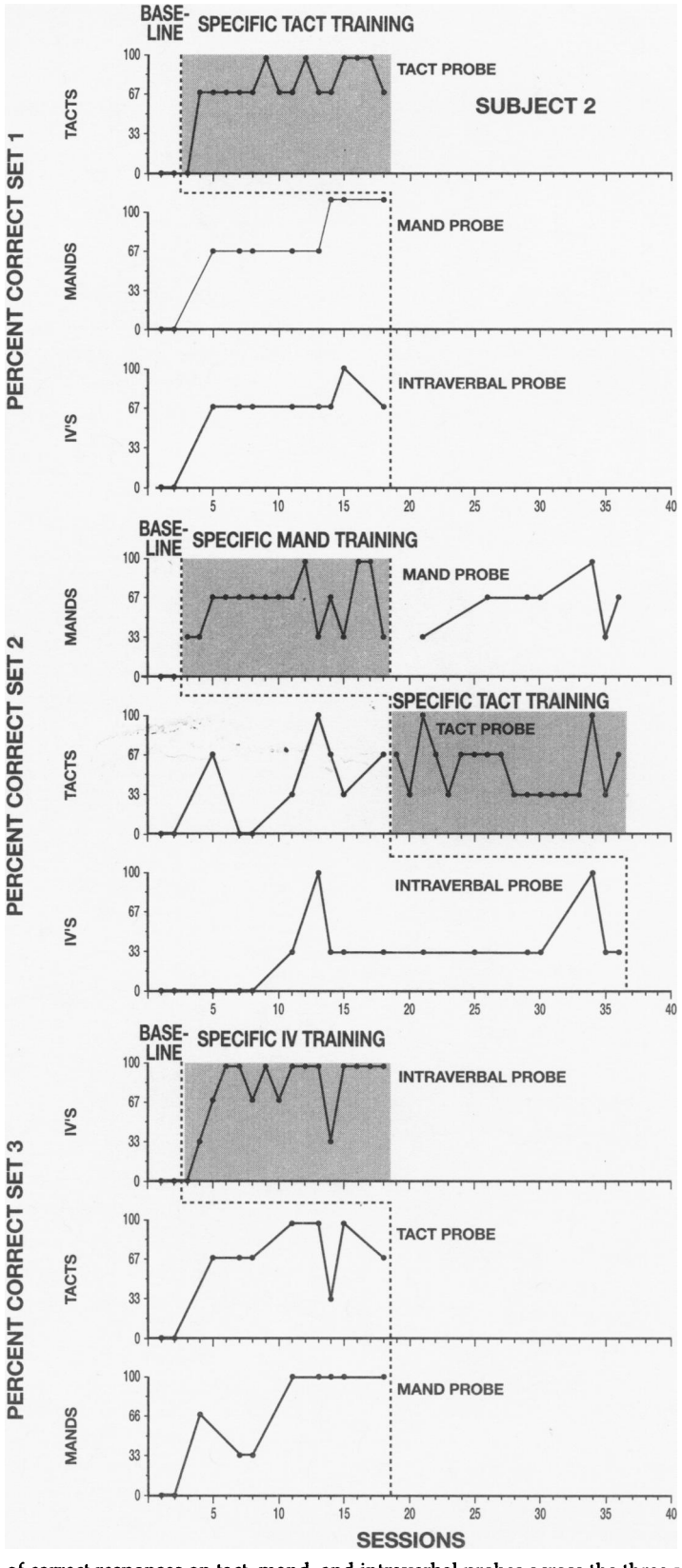

Fig. 3. Percentage of correct responses on tact, mand, and intraverbal probes across the three-word sets for Subject 2. Shaded panels indicate specific training conditions.

bag (initially the word was *sandwich bag*, but the subject manded for it as *plastic bag* and it was accepted as correct). Once he started getting that mand correct, he began to show some transfer to the other verbal operants, although only with plastic bag. On the 15th session he got a second word correct (bottle brush) on both the mand and intraverbal probes. The transfer to the untrained operants did occur, but was much less than the transfer that occurred with tact training. Transfer from mand to intraverbal was slightly better than transfer from mand to tact, possibly due to the intraverbal variables present in the mand conditions.

Subject 2 also demonstrated his worst performance under the mand conditions. Even when he began to get the mand correct there was no immediate transfer to the other operants. When transfer did occur it was always with the words that he was getting right under the mand conditions. The only word that showed a consistent transfer to tact and intraverbal conditions was *wire cutters*. This is interesting because this subject had been a telephone repair man previous to his accident. However, it still took ten training sessions under mand conditions before a consistent transfer to tact conditions occurred.

Intraverbal Acquisition and Transfer

The bottom three panels of Figures 2 and 3 show that both subjects performed relatively well under intraverbal conditions. Subject 1's performance on the probes oscillated between 33% and 67% correct, and some transfer of control to the untrained operants occurred, but it was not consistent. For this subject the pattern was similar to that of mand training, but substantially different from tact training where transfer was fast and consistent. Subject 2 acquired the intraverbal responses quickly, and showed transfer to the other operants in a pattern similar to, but slightly better than, tact training.

Performance on the probes, as a measure of long-term retention, showed that both subjects demonstrated the strongest long-term retention under tact and intraverbal conditions, and the weakest under mand conditions. Subject 1 performed slightly better under tact conditions than under intraverbal conditions, while Subject 2 showed the exact opposite, performing better under intraverbal conditions than under tact conditions.

Phase II

The results of Phase II are presented in the right-hand columns of Figures 3 and 4. Since both subjects did not effectively acquire the mands during specific mand training, and Subject 1 did not effectively acquire the intraverbals during specific intraverbal training, it was speculated that specific tact training would result in a transfer pattern similar to that observed during Phase I. As a result, the mand and intraverbal conditions were simultaneously changed to tact training for Subject 1 (Figure 2), and the mand condition was changed to tact training for Subject 2 (Figure 3). Training on the tacts from set 1 was discontinued for both subjects. For Subject 1 tact training on the words that had been previously in the intraverbal condition had an immediate and robust effect on performance during the mand probes, thus replicating the effects observed in Phase I. Tacts were acquired in a pattern similar to Phase I, and tact training resulted in four consecutive sessions of 100% correct performance under the mand probe conditions. In addition, the tact training improved this subject's intraverbal performance, stabilizing it at 67% (he always missed the same word, *tire gauge*).

The change from mand training to tact training did not, however, have the same effects as the tact training in Phase I, or as the change from intraverbal to tact for Subject 1. In fact, tact training on these words was very slow and did not substantially improve the mand performance for either subject. Subject 1 did eventually show some improvement on the intraverbal, however, Subject 2 performed uncharacteristically poor on the intraverbal. The early history of failure in the mand condition of Phase I clearly affected the later

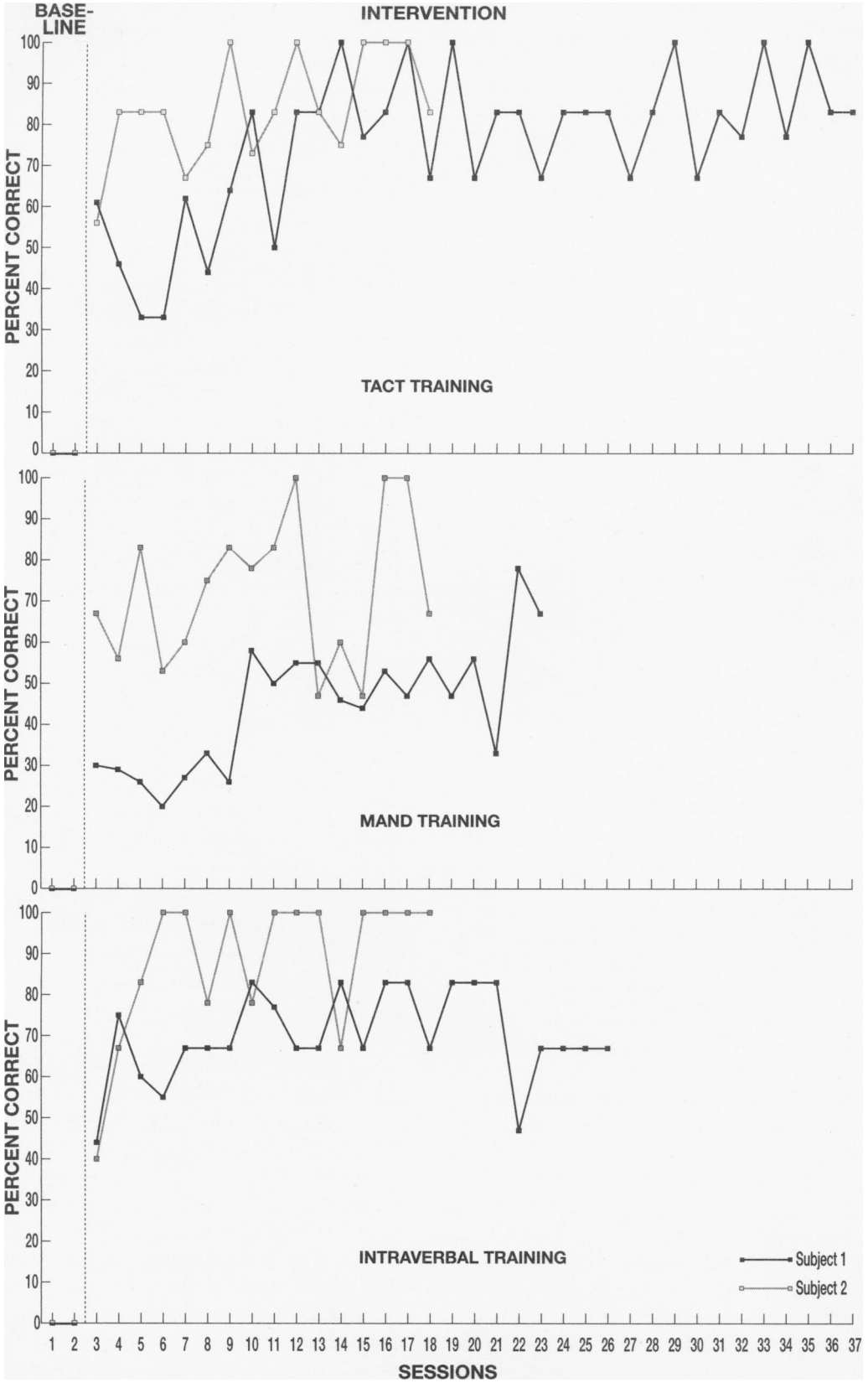

Fig. 4. The percentage of correct within-session responses during tact, mand, and intraverbal training for Subjects 1 and 2.

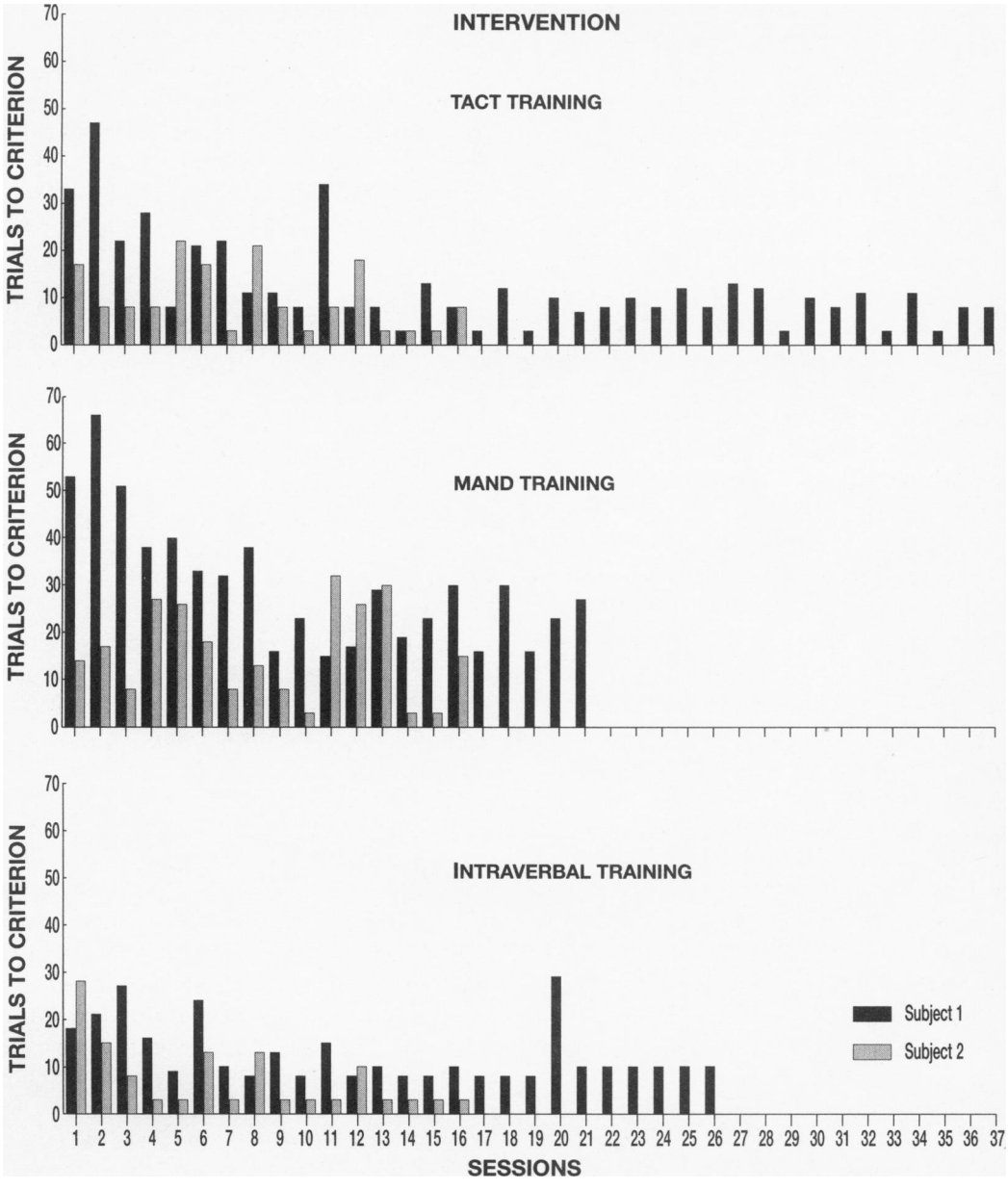

Fig. 5. The number of trials to criterion during tact, mand, and intraverbal training for Subjects 1 and 2.

acquisition of other verbal operants involving the same response topography.

Within-Session Measures

Figure 4 shows the percent correct during training on each condition. These data indicate that within-session performance, or short-term retention, was weakest under mand conditions for both subjects. Subject 1 had extreme difficulty with this condition, however, he did show a slow but steady acquisition rate. Only twice (during the last two sessions) did he score above 60% correct. Subject 2 also had difficulty with the mand condition, but he was able to obtain 100% correct on three sessions.

Both subjects' within-session performance was best on tact and intraverbal training. In terms of individual results, Subject 1 initially performed better during intraverbal training, but as training progressed he performed better during tact training reaching 100% correct on six sessions, while never reaching 100% correct

on intraverbal training. Subject 2 clearly performed better during intraverbal training reaching 100% correct on ten sessions, while reaching 100% correct only four times during tact training.

The results of the second within-session measure, trials-to-criterion, are presented in Figure 5. A trial was defined as a single stimulus-response-consequence relation, and a perfect score for a session was three trials (one for each word in a set, and all correct responses). These data show that there was a clear decrease in the number of training trials required to meet criterion for both subjects, for all conditions. This, along with the probe data, demonstrates that the specific training procedures employed were effective in generating the missing verbal operants. The data also show that mand training was the most difficult for both subjects. Subject 1 received an average of 30.2 mand trials per session (636 training trials over 21 sessions), compared to an average of 13 training trials per session for the tacts (456 training trials over 35 sessions), and an average of 12.5 trials per session for the intraverbals (326 training trials over 26 sessions). Subject 2 received an average of 15.7 mand trials per session (251 training trials over 16 sessions), compared to an average of 9.9 trials per session for the tacts (158 training trials over 16 sessions), and an average of 7.3 training trials per session for the intraverbals (117 training trials over 16 sessions).

These data indicate that both subjects demonstrated the strongest short-term retention under tact and intraverbal conditions, and the weakest under mand conditions. Subject 1 initially performed better during intraverbal training, but later in training performed better during tact training. Subject 2 performed clearly better during intraverbal training. These data are consistent with the long-term retention data, with the exception of Subject 1's initial performance during intraverbal training. In addition, a comparison of the subjects' acquisition rate on the long-term versus short-term trials shows there was a similar learning pattern. The within-session measures of trials-to-criterion and percent correct during Phase II tact training following intraverbal training were very similar to the results obtained on the tact condition in Phase I. However, the results of the trials-to-criterion and percent correct measures taken during Phase II tact training, following Phase I mand training, were very similar to those of Phase I mand training.

DISCUSSION

The results of this study suggest that tact and intraverbal training may be the most efficient way to generate mands for some individuals who have sustained a traumatic brain injury. Direct mand training proved to be the least efficient method to produce manding. These results were unexpected given previous research with the developmentally disabled that had shown mands were acquired faster than tacts (Sundberg, Milani, & Partington, 1977), and that direct mand training was necessary to establish reliable manding (Hall & Sundberg, 1987).

However, it is possible that the current data may simply demonstrate some of the differences between these two populations. The studies with developmentally disabled individuals involved naive subjects who exhibited very little verbal behavior at the outset of the studies. The subjects in the current study were at one time competent speakers, and even after the injury emitted some successful verbal behavior. These subjects could, for example, mand for a variety of other reinforcers, especially those controlled by unconditioned establishing operations, and it was clear that their mand repertoires were not completely absent. There is some evidence in the mand and tact literature that suggests that this manding history may play a key role in the transfer of control from tact to mand variables.

Skinner (1957) suggested that a *mand frame* could facilitate this transfer. For example, if a person has a successful history of manding with a frame such as I *want...*, then newly-acquired tacts could emerge within the mand frame without direct training. Hall and Sundberg (1987)

did find that newly trained tacts led to the emergence of untrained mands following a successful history of mand training. These effects were also demonstrated by Sigafoos et al., (1990) who found that the presence of the mand frame *Want...* was sufficient to obtain the transfer of control from tact to mand variables. In the current study, this transfer effect occurred for both subjects. In addition, transfer occurred from tact to intraverbal for both subjects, and from intraverbal to mand, and intraverbal to tact for Subject 2.

It still remains unclear as to why the mand was so difficult to directly teach, especially since it emerged so easily after tact training. It could be argued that the conditioned establishing operations were simply not strong enough to evoke the behavior. However, *all* the mands in the study involved mild conditioned establishing operations occurring in daily living, and were randomly assigned to training conditions. The sizeable differences observed between the direct and indirect training conditions would seem to negate lack of controlling strength as a variable. Note also that on two occasions Subject 1's best performance across two consecutive sessions was under the untrained mand probe conditions.

The results are also inconsistent with Skinner's (1957) analysis of the order of damage in aphasia which suggests that the mand would be stronger than the tact and intraverbal. Skinner (1957) states that

> aphasia is a condition of lowered probability of response....Damage is usually most severe in verbal behavior receiving generalized reinforcement. The order of damage seems to follow the order of "difficulty" deducible from the availability of a minimal repertoire. Textual and echoic behavior often survive (unless relevant sensory defects are involved) while intraverbals and tacts appear to be most vulnerable....Verbal behavior which has been reinforced in relation to some special condition of deprivation or aversive stimulation [mands]...remains relatively accessible. (p. 218-219)

A possible explanation for this discrepancy concerns the two different types of mands identified by Michael (1988). Some mands did survive following the subjects' accidents, but they were those mainly controlled by unconditioned establishing operations. However, the current study involved relatively mild conditioned establishing operations. It seems possible that the controlling conditions for these types of mands are actually more complicated than those for unconditioned establishing operations. A mand controlled by a conditioned establishing operation involves the presentation of stimuli which alter the effectiveness of *other* stimuli as conditioned reinforcers. The targeted response may be harder to bring under the control of this rather complicated stimulus arrangement. In addition, the stimuli presented in order to contrive the establishing operation may have overshadowed the development of control by the conditioned establishing operation. This seems quite plausible since the subjects already had a history of emitting other verbal and nonverbal responses in the presence of these stimuli. For example, the subjects would frequently pantomime the action of the missing item, as in closing the hands as if cracking a nut.

Another possibility may be that these mand conditions resemble quite closely aversive problem solving contingencies which these subjects unsuccessfully encounter on a daily basis (e.g., trying to ask for a needed item at a store). Both subjects had long histories of failure, particularly under difficult conditions, and as Skinner (1957) further pointed out "verbal...behavior which as been punished is likely to be relatively weak" (p. 219). This point was supported by the subjects' poor performance in Phase II following the unsuccessful mand condition. It was noted that Subject 2 swore quite frequently during failed mand trials, often saying *Dammit, I know this, dammit,* or *Oh shit, shit....* It is also possible that these conditions, and others like them, have become conditioned aversive stimuli eliciting respondent behaviors which may compete with establishing operant stimulus control. During a trial in the baseline condition this same subject suffered a severe panic attack where he hyperventilated and stiffened his body for several minutes.

The other verbal operants may have been acquired faster than mands because it

was simply easier to bring the behavior under stimulus control. As Skinner (1957) pointed out, in the echoic and textual repertoires there is point-to-point correspondence between the stimulus and the response product, and they involve a minimal repertoire. This relatively tight form of stimulus control may partly explain why these repertoires remained at strength after the subjects' accidents. The tact relation used in the current study involved a form of stimulus control where a single stimulus controlled a single response, and the relation tends to be quite consistent (e.g., a nut cracker is always called a nut cracker). The intraverbal condition also involved stimuli which evoke specific responses in a consistent manner (e.g., you fix a hole in a hose with...tape). The mand, however, as stated previously, may have involved stimuli which evoked behaviors other than the targeted behavior.

There are some additional variables to consider in evaluating these results. The operants tested were not pure verbal operants. The mand condition also involved an intraverbal prompt such as *What do you need....* The tact condition also involved intraverbal variables with the verbal prompt *What is this?* And finally, the intraverbal condition often contained echoic variables in the question as in *nut* in the nut cracker trial. It might be noted, however, that in the later sessions of the mand and tact conditions both subjects frequently gave the answer before the experimenter could say the intraverbal prompt. In the intraverbal, however, there was initially some concern over the unavoidable echoic variable in some questions. This was especially of concern when, for Subject 2, the three most echoically prompted responses ended up (randomly) grouped together in the mand condition. However, that data show that the subject still consistently missed these in the early sessions, while correctly responding to other intraverbals both when trained directly on the intraverbals, and when trained indirectly via the tacts.

It is unclear what the effects of the transfer trials themselves were on the transfer process. The mand probes may have been necessary to get the effects, that is, there may need to be some contact with the mand conditions. It could be speculated that transfer would occur, but it is most likely that the opportunity to emit the responses under the control of the other variables played a role in the transfer, especially since correct responses were reinforced in the probe condition. This issue should be examined in future research.

The results support Sidman et al.'s, (1971) findings that there is a different recovery course for different operants. In addition, the results demonstrate the value of Skinner's analysis of verbal behavior for the assessment and treatment of verbal problems faced by brain injured individuals. Once these verbal deficits are identified, a more efficient verbal intervention program can be designed. For example, Subject 1 in the current study, could benefit from extensive tact training, a moderate level of intraverbal training, and the periodic arrangement of the establishing operations necessary to evoke a mand. Subject 2 could benefit from a similar program, but would probably benefit from more intraverbal training than Subject 1. These results are important because, for example, much of the focus of the verbal intervention prior to the study for Subject 1 had involved intraverbal training. In fact, it had taken hundreds of direct training trials to obtain some simple intraverbal relations. The current results demonstrate why acquisition was so slow—the tact repertoire was missing. This is important because often a substantial amount of the verbal intervention provided for brain injured individuals involves intraverbal-only training. This is exemplified by many of the standard activities in rehabilitation programs such as group counseling, verbal memory tasks, problem solving exercises, convergent and divergent thinking exercises, reading comprehension, computer tasks, etc. This may, in part, explain why this population tends to progress so slowly after the acute stages of rehabilitation.

In conclusion, the results have shown

that with brain injured individuals you can teach one verbal operant, and as a result, obtain as many as two additional operants without direct training. This is important given the well-recognized problems involving the acquisition of verbal behavior by individuals with brain injuries. The results also show that there are differences between tact, mand, and intraverbal repertoires. These differences may be seen in the rate of acquisition of each operant, and in the transfer effects observed between operants, such as the robust transfer effect observed with tact training, but not with mand training.

The current data provide further support for Skinner's (1957) assertion that there is an experimental basis to his conceptual distinction between the verbal operants (see Oah & Dickinson, 1989, for a review). There still, however, is a need for further research on this topic. Most importantly, the current study needs to be replicated with other subjects, especially those who have other types of brain injury. In addition, it would be interesting to conduct this study with normal children. Would their results look more like those of the developmentally disabled or the brain injured? While several questions remain to be answered in future research, it seems clear that Skinner's formulation of verbal behavior can make a substantial contribution to the assessment and treatment of the verbal disorders produced by traumatic brain injury.

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