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Evaluation of Single and Mixed Verbal Operant Arrangements for Teaching Mands and Tacts

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The purpose of this series of experiments was to evaluate the effects of mixed mand-tact arrangements on the acquisition of mands and tacts in preschool-aged children. In Experiment 1, the effects of three training arrangements (mand-only training, tact-only training, and mand-tact training) were investigated with 3 typically developing children. Rates of acquisition in single (mand-only and tact-only) versus mixed (mand-tact) presentation were comparable, in contrast to earlier investigations. Experiment 2 attempted to clarify the equivocal findings of Experiment 1 by directly replicating the Carroll and Hesse (1987) investigation with 2 typically developing children. Results again demonstrated no clear benefit of mixed verbal operant training on tact acquisition. In Experiment 3, these same arrangements were evaluated with a boy with autism and included assessments to determine that a relevant establishing operation was in effect prior to each mand training session. Experiment 3 again failed to demonstrate the facilitative effects of mand-tact training on the acquisition of mands or tacts. Taken together, the data from these three experiments fail to support the improved efficiency of mand-tact training suggested by prior studies. Findings are discussed in the context of future research investigating mixed verbal operant arrangements.

Key words: mands, mixed trials, tacts, task interpersal, verbal behavior

Many intervention programs for children with autism frequently teach language in the context of a single skill arrangement (e.g., Lovaas & Smith, 2003). For example, in a verbal imitation program, the novel target ''cookie'' may be interspersed with trials of mastered verbal imitation targets ''book,'' ''shirt,'' and ''clap.'' Some intervention programs, particularly those that employ a verbal behavior approach (Barbera & Rasmussen, 2007; Carr & Firth, 2005), frequently teach novel language in the context of multiple verbal operant arrangements. Commonly termed *mixed verbal behavior*, this involves a special kind of task interspersal of various novel and acquired exemplars across verbal operant categories (''Advanced verbal behavior principles,'' 2005; ''Autism Learning Center,'' 2010; Koenig, 1999; ''Our approach,'' 2010). In this arrangement, the same target is taught simultaneously as two or more different verbal operants (e.g., Arntzen & Almas, 2002; Carroll & Hesse, 1987). For example, the target ''cookie'' might be concurrently taught as a mand and a tact by arranging a situation in which the instructor prevents access to a cookie when the child is hungry and teaches the response in that moment (the mand), alternated with opportunities for the child to respond to the question, ''What is this?'' in the presence of the cookie (the tact). The proposed benefits of this arrangement are to produce stronger stimulus control and more efficient acquisition of

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novel language targets.[1] To date, only two empirical studies have evaluated this type of interspersal. Both studies compared mixed mand-tact training to tact-only training and reported that mixed mand-tact training resulted in faster acquisition of tacts than tact-only training.

Carroll and Hesse (1987) conducted the first experiment that compared single and mixed verbal operant arrangements with 4 typically developing 3- to 4-year-old children. A-B replication and multielement designs were used to evaluate the effects of tact-only and mand-tact training on the acquisition of tacts. Three objects were trained in each condition, and the order of conditions was counterbalanced across participants. One replication with different toys and sets of objects was conducted with each participant, with the replication sets being more difficult. During the tact-only condition, participants learned to tact three objects by responding to the question, ''What is this?'' and receiving praise for correct responses. Tact trials were alternated with other instructions (e.g., ''Touch your nose,'' ''What color is this?'') to match the pacing of mand-tact sessions, which required more time for toy assembly and play during mand trials. In an attempt to contrive an establishing operation (EO) for mand trials, each participant was first taught to build a toy from various parts. During mand trials, the experimenter instructed him or her to build the toy, but the experimenter hid the last piece. When the participant asked for the last piece correctly, the experimenter provided it so he or she could complete the toy and play with it (i.e., an interrupted-chain procedure). During mand-tact training, the participant received trials of tact training (as described above) alternated with mand trials, both for a second toy and three objects. In other words, during mand-tact training for the first object, the participant emitted tacts and mands of the same topography on alternating trials until mastery.

Across all participants and evaluations, Carroll and Hesse (1987) found that tacts were acquired in fewer mean tact trials to criterion in the mand-tact training condition than in the tact-only training condition. During follow-up retention tests, overall, mand-tact training (64%) resulted in a higher percentage of correct tacts than tact-only training (27%). These results should be interpreted with caution, however, because conclusions about the effects of mand-tact interspersal were based heavily on means across targets. Analysis of the data for individual targets shows small (range, 3 to 10 tact trials) and often inconsistent differences between conditions. When examined this way, the effect of mand-tact interspersal on tact acquisition appears less robust, suggesting the need for further research.

There are several other considerations in evaluating the Carroll and Hesse (1987) investigation. First, a difference between mand and tact trials was that tact trials were always preceded by a question, ''What is this?'' Because of this, responses during these trials are best conceptualized as impure tacts (i.e., tacts trained under the multiple control of verbal and nonverbal stimuli). Although this commonly occurs both in contrived language training situations and in the natural environment, training impure verbal operants may introduce confounding effects that prevent conclusions about the variables that are responsible for changes in behavior. Second, specific information about the tasks interspersed during the tact-only condition was not provided. Finally, mands may have been trained in the presence of stimuli similar to the item being manded, in that the partially completed toy may have created a space that clearly resembled the target item being manded. If this was the case, this could have increased the role of the nonverbal stimulus during mand training, thereby facilitating tact training.

Arntzen and Almas (2002) systematically replicated the Carroll and Hesse (1987) investigation. The experimental design and most of the procedures appeared to be identical to those in the prior investigation. Because the Arntzen and Almas study was published as a brief research report, some

[1] This procedure has also been employed in multiple-exemplar instruction to generate functional interdependence between verbal operant classes (e.g., tact and listener relations). In such studies, however, the efficiency of this mixed verbal operant procedure has not been directly assessed (e.g., Fiorile & Greer, 2007; Greer, Yuan, & Gautreaux, 2004).

methodological details were not included; however, several between-study differences were identified. First, participants were 2 typically developing 3-year-old girls and 3 boys (3, 15, and 17 years old) with developmental disabilities and characteristics of autism. Second, tokens were delivered in addition to praise for tact trials. Third, training materials were different and varied across participants. For 4 participants, a letter puzzle was used to train six letters in the first evaluation (three letters per condition) and six different letters in the replication (three letters per condition). For 1 participant, a photograph album with pictures of objects was used to train six objects in the first evaluation (three objects per condition) and six objects in the replication (three objects per condition). During mand trials, he was instructed to find the object that matched each picture in the album, with the last object hidden from view. During the tact-only condition, intraverbal-tact trials were interspersed with other types of tasks.

Arntzen and Almas (2002) found that across all participants and evaluations, tacts were acquired in fewer mean tact trials to criterion in the mand-tact training condition than in the tact-only training condition, although a range for individual evaluations could not be ascertained from the data provided. In contrast to the findings of Carroll and Hesse (1987), there was little difference in performance on follow-up probes between items trained in tact-only and mand-tact arrangements. As in the Carroll and Hesse investigation, conclusions should be interpreted cautiously due to heavy reliance on an analysis of across-target means. Although the finding was more robust than that observed by Carroll and Hesse, individual target data were more variable.

There are several other points worth noting in evaluating the Arntzen and Almas (2002) study, three of which are similar to those of Carroll and Hesse (1987). First, specific information about the reinforcement delivered during the tact-only condition was not reported. Information about the number of tokens exchanged, the items for which tokens were exchanged, and the relative reinforcer potency of the tokens, puzzle, and photograph album was not provided but may be critical to the outcomes. In addition, the extent to which there was an EO for puzzle and photograph album completion is unclear. Second, mands were trained in the presence of stimuli similar to the item being manded, thus enhancing stimulus control and possibly facilitating tact training. Third, specific information about the tasks interspersed during the tact-only condition was not provided.

In determining the reliability and potential utility of mixed verbal operant teaching arrangements, one must consider the potential conceptual basis for their proposed outcomes. There are several possible mechanisms by which this type of arrangement could facilitate acquisition. First, it is possible that mand-tact training could result in faster acquisition of tacts than tact-only training when reinforcement for the mand is more potent. Second, it is possible that mand training facilitates tact training because the reinforcement for the mand is more specific, and specific reinforcers facilitate faster acquisition than nonspecific reinforcers or increase motivation during training (Shafer, 1994). Third, because visually similar stimuli are sometimes present during mand trials (e.g., Carroll & Hesse, 1987), learners might engage in covert tacts during mand training. This procedure, then, could essentially be better described as enhanced tact training, in that tact trials are alternated with mand trials with additional built-in tact practice. For example, Petursdottir, Carr, and Michael (2005) demonstrated that mand training was more likely to result in emergent tacts than tact training was to result in emergent mands in a task procedure similar to that employed by Carroll and Hesse and Arntzen and Almas (2002).

Given the limited research on mixed verbal operant arrangements (Arntzen & Almas, 2002; Carroll & Hesse, 1987) and contemporary clinical use of the procedures (‘‘Advanced verbal behavior principles,’’ 2005; ‘‘Autism Learning Center,’’ 2010; Koenig, 1999; ‘‘Our approach,’’ 2010), further research on this procedure is warranted. The purpose of the present series of experiments was to evaluate the effects of mixed mand-tact arrangements on the acquisition of mands and tacts in preschool children. In Experiment 1, the effects of three training arrangements (mand-only

training, tact-only training, and mand-tact training) were investigated with 3 typically developing children. Experiment 2 attempted to clarify the equivocal findings of Experiment 1 by directly replicating the work of Carroll and Hesse (1987) with 2 typically developing children. In Experiment 3, a more clinically relevant procedure was used to evaluate mand-tact training with a boy with developmental delays. Assessments were included to ensure that a relevant EO was in effect during mand training.

EXPERIMENT 1

The purpose of Experiment 1 was to replicate and extend previous research on single and mixed verbal operant arrangements, with the following modifications: (a) an assessment of mand acquisition to determine potential effects of mand-tact training on mand acquisition, (b) use of stimuli with low probability of exposure outside the study, (c) analysis and presentation of data on sessions to criterion-level performance, (d) elimination of verbal antecedents in tact training, (e) application of rigorous mastery criteria to avoid false-positive mastery, (f) immediate (rather than delayed) interspersal of tasks in mand-only and tact-only conditions to resemble more closely the mand-tact condition, (g) interspersal of novel tasks reinforced with high-preference tangible items, (h) delivery of equivalent reinforcers across mand and tact trials, and (i) access to preferred items at the end of sessions to facilitate child participation.

Method

Participants and Setting

Participants were 2 girls and 1 boy, ranging in age from 3 years 3 months to 3 years 7 months, who were recruited from local preschools. All participants were typically developing and displayed language skills within a normal range for their age, as identified via the Expressive Vocabulary Test (EVT; Williams, 1997) (Anne, 4 years 4 months; Brooke, 3 years 11 months; Adam, 4 years 1 month). Sessions were conducted in a quiet area of each participant's home or school.

Dependent Variables and Data Collection

Sessions consisted of 10 trials and lasted between 5 and 15 min. Two to three sessions of each condition were conducted daily, 3 to 5 days per week. After each session, participants were given a 2- to 5-min break, during which they had an opportunity to choose and play with a toy from a box that contained several high-preference items (explained below). A graduate-student experimenter conducted all sessions with each participant at a table along with training materials, data sheets, and a video camera in a corner of the research area. Undergraduate research assistants sat at the table and remained disengaged from the task and interactions with the participants, with the exception of serving as primary data collectors. Undergraduate research assistants collected secondary data from videotape for the assessment of interobserver agreement. Trial-by-trial data were collected on correct (unprompted) trials per session, and were summarized as sessions to criterion performance. Criterion for mastery of each target was four of the five mand or tact trials correct (and unprompted), with the first trial correct, across two consecutive sessions. This criterion was chosen to demonstrate consistent correct responding and to rule out false-positive mastery if the participant repeated the experimenter's prompt during the first trial on subsequent trials.

Preference Assessments

Each participant's caregiver was asked to complete a questionnaire indicating 10 toys and 10 foods that his or her child seemed to prefer. Each participant was also asked to indicate preferred toys and foods by responding to the questions, ''What is your favorite toy [food] … what else?'' and ''What toys [foods] would you like me to bring when I come to play with you?'' Two separate multiple-stimulus (without replacement) preference assessments (MSWO; DeLeon & Iwata, 1996) were then conducted with these items to identify preferred toys to be used during breaks and preferred toys and foods to be used as reinforcers during tact trials. Each assessment was repeated two more times, yielding a total of three arrays.

Table 1
Target responses by condition and activity for Experiments 1, 2, and 3

Experiment	Tasks	Condition		
		Mand-only	Tact-only	Mand-tact
1	Flat puzzles	boosha	doso	heeny
	Photograph albums	middy	bindo	nover
	Cube puzzles	lacket	meecot	cheynoo
	Felt boards	voggy	yerba	simger
2	Plastic blocks		xyphoid	ulna
	Plastic blocks		femur	sternum
	Plastic blocks		talus	lumen
3	Word Set 1	guitar	yo-yo	train
	Word Set 2	dinosaur	microphone	helicopter
	Word Set 3	ambulance	remote	bulldozer

Note. boosha, middy, lacket, voggy, doso, bindo, meecot, heeny, and nover were used as targets by Petursdottir et al. (2005).

Procedure

Design and materials. The effects of three different training arrangements (i.e., mand-only training, tact-only training, mand-tact training) on the acquisition of mands and tacts were evaluated using an adapted alternating treatments design in which each of a set of three targets was randomly assigned to each condition. The daily order of conditions was determined quasirandomly.

Participants were exposed to multiple evaluations of the training arrangements by using two to four different sets of stimuli. Three different flat puzzles, photograph albums, cube puzzles, and felt board activities were used for each of three training arrangements (i.e., mand-only training, tact-only training, mand-tact training). Target pieces were asymmetrical, unfamiliar in shape, and did not depict any one item, so that participants did not learn nonsense responses for real shapes or pictures. Flat puzzles consisted of four pieces, were contiguous, and were set inside a board. Photograph albums consisted of four pages with one silhouette on each page, with the first three silhouettes corresponding to small objects around the research area (e.g., toy car). During mand trials, participants were instructed to ''match the pictures'' by turning one page at a time and retrieving each item; all matching objects were provided except one. Cube puzzles consisted of four three-dimensional pieces. Felt board tasks consisted of four pieces that could be affixed to a vertically mounted felt board on which an outline of each felt piece was provided. Responses trained were two-syllable nonsense words (Table 1).

Mand-only training. All sessions in this condition began with the experimenter asking the participant to complete the task. The last object required to complete the task was hidden by the experimenter (i.e., an interrupted-chain procedure). When the child correctly stated the name of the hidden object, the experimenter provided it to the child without saying anything. Participants were taught to complete tasks prior to experimental sessions. Mands were interspersed with receptive discrimination tasks in a 1:1 ratio (described below). As in previous studies, mands were trained in the presence of stimuli that resembled the target object (e.g., the outline of the missing puzzle piece in the board was identical to the shape of the actual piece).

Tact-only training. The experimenter placed the target object in front of the participant. If the participant correctly stated the name of the object, the experimenter provided praise (e.g., ''Great! You got it!'') and a tangible reinforcer. Tacts were interspersed with receptive discrimination tasks in a 1:1 ratio.

Mand-tact training. During this condition, participants were taught to respond to one

item as both a mand and a tact. The mand trial was always first, as was the practice in previous studies, and mand and tact trials were alternated in a 1:1 ratio. Procedures for the mand and tact trials were conducted as above; however, interspersal with other tasks was not included.

Task interspersal. During mand-only and tact-only training, other tasks were interspersed with the target mand or tact to rule out the possibility that interspersal alone produced more efficient acquisition in the mand-tact training condition. Interspersed tasks were novel three-choice receptive discrimination tasks with nonsense stimuli. These stimuli were different than the stimuli used during mand and tact training. Incorrect interspersal tasks were prompted as described above, and correct responses received praise and high-preference tangible items. Interspersal was conducted with novel tasks and reinforced with high-preference tangible items to avoid inadvertent increased acquisition of mands and tacts.

Reinforcement and prompts. When the tasks were completed during mand trials or correct tacts were emitted during tact trials, tangible reinforcers were randomly delivered from a group of six toys and foods that ranked the highest in the MSWO preference assessments (three toys and three foods). Small pieces of food were given, and only toys that could be played with in less than 30 s were used. This nonspecific reinforcement procedure was incorporated in an attempt to provide equivalent reinforcer strength across mand and tact trials and to eliminate the possibility that one verbal operant would be acquired more quickly due to differential reinforcer strength.

A response was considered correct if it was independent and matched (or improved from) the articulation of the response following the first vocal prompt at the beginning of training. During each condition, if the participant did not respond during a trial, the experimenter waited 5 s (i.e., constant prompt delay), provided a model prompt for the participant to imitate, and then provided an opportunity for the child to respond independently to the object again. If the participant did not imitate vocal prompts for three consecutive opportunities or attempted or requested to leave three times, the session would have been terminated; however, this never occurred. If the participant responded incorrectly, the experimenter provided a model prompt for him or her to imitate. If correct, this trial was scored as prompted, and the child received the reinforcer appropriate to that condition.

Facilitation of participation. Following each trial, the experimenter marked 1 of 10 boxes on a small dry-erase board to indicate completion of the trial to the participant to reinforce responding and to depict trials to completion of the session. When all boxes were marked, the experimenter indicated to the participant that the session was over and that he or she could play with a toy from the toy container. A timer was then set for 2 to 5 min, depending on the nature of the toy (i.e., an appropriate amount of time required to play with the toy). When the timer sounded, the experimenter indicated to the child that it was either ''time to play with the other toys now'' or that they were ''finished playing for today.'' This procedure was intended to facilitate continued voluntary participation in the study.

Interobserver Agreement

Overall interobserver agreement on correct responses was assessed by dividing the number of agreements by the number of agreements and disagreements and multiplying by 100%. An agreement was defined as both observers recording the mand or tact response as correct or incorrect per trial. Mean agreement for Anne's sessions was 99% (range, 80% to 100%) and was assessed during 47% of sessions. Mean agreement for Brooke's sessions was 99.7% (range, 90% to 100%) and was assessed during 59% of sessions. Data on interobserver agreement and procedural integrity for Adam are unavailable due to equipment failure.

Procedural Integrity

Following each trial, a plus or minus was scored on the experimenter's correct or incorrect presentation of stimuli and reinforcement during the trial, and the data were summarized as percentage of correct trials per session. Correct presentation of stimuli during mand trials included instructing the

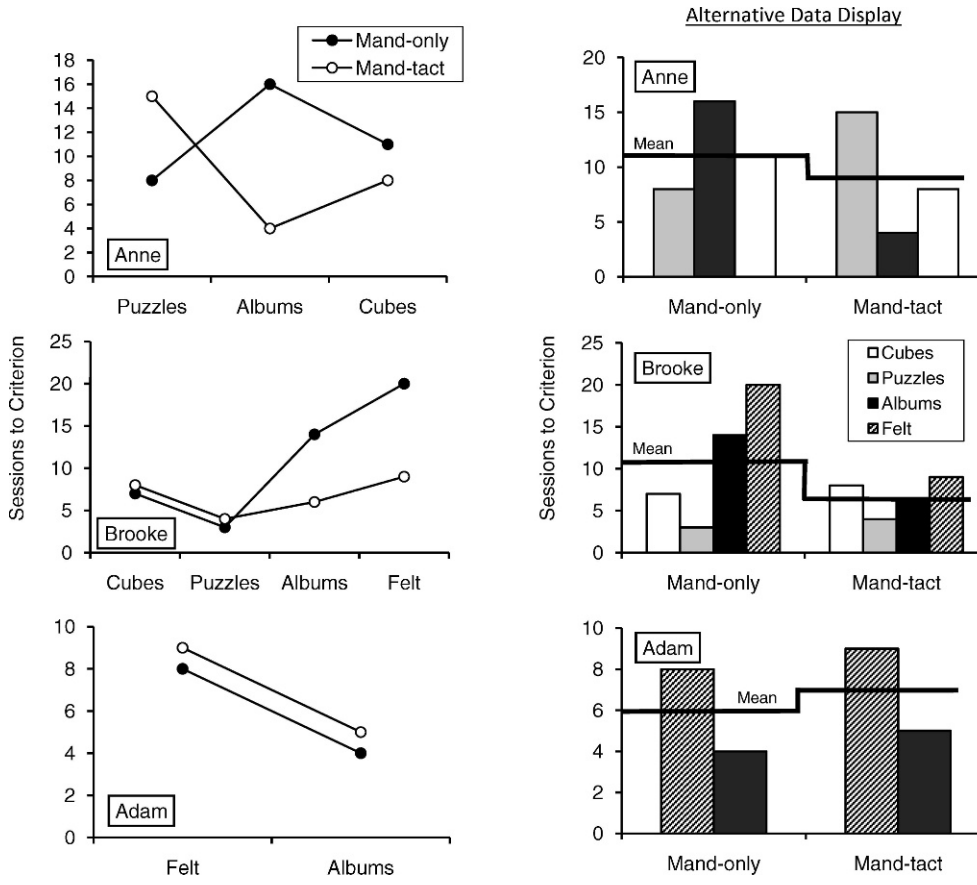

Figure 1. The left column depicts sessions to criterion for mands across stimulus sets and training conditions for Anne (top), Brooke (middle), and Adam (bottom) (Experiment 1). The right column depicts the same data in bar-graph form, with horizontal mean lines for each condition.

participant to complete the task and hiding the target part; during tact trials this included presenting the target part without saying anything; during receptive discrimination trials this included instructing the participant to point to one of the pictures. Correct reinforcement during mand trials included giving the hidden part to the child without saying anything; during tact and receptive discrimination trials this included presenting a tangible reinforcer and praise.

Interobserver agreement on procedural integrity was calculated using the overall agreement method. Anne's mean procedural integrity score was 99% (range, 80% to 100%) and was assessed during 89% of sessions. Mean agreement was 100% and was assessed during 28% of these sessions. Brooke's mean procedural integrity score was 99% (range, 80% to 100%) and was assessed during 52% of sessions. Mean interobserver agreement was 100% and was assessed during 28% of these sessions.

Results and Discussion

Due to variable participant access, not all tasks could be evaluated with all participants. However, participants did not appear to acquire responses more or less quickly when trained with certain tasks or materials. Mand acquisition graphs across stimulus sets for each participant are depicted in Figure 1 (left). Although not standard for measures that are not scaled in units of time along the *x* axis, line graphs are presented to more clearly depict the effects of mand-tact interspersal across tasks for all participants. Anne acquired the mand for the puzzle piece more quickly in the mand-only condition, but

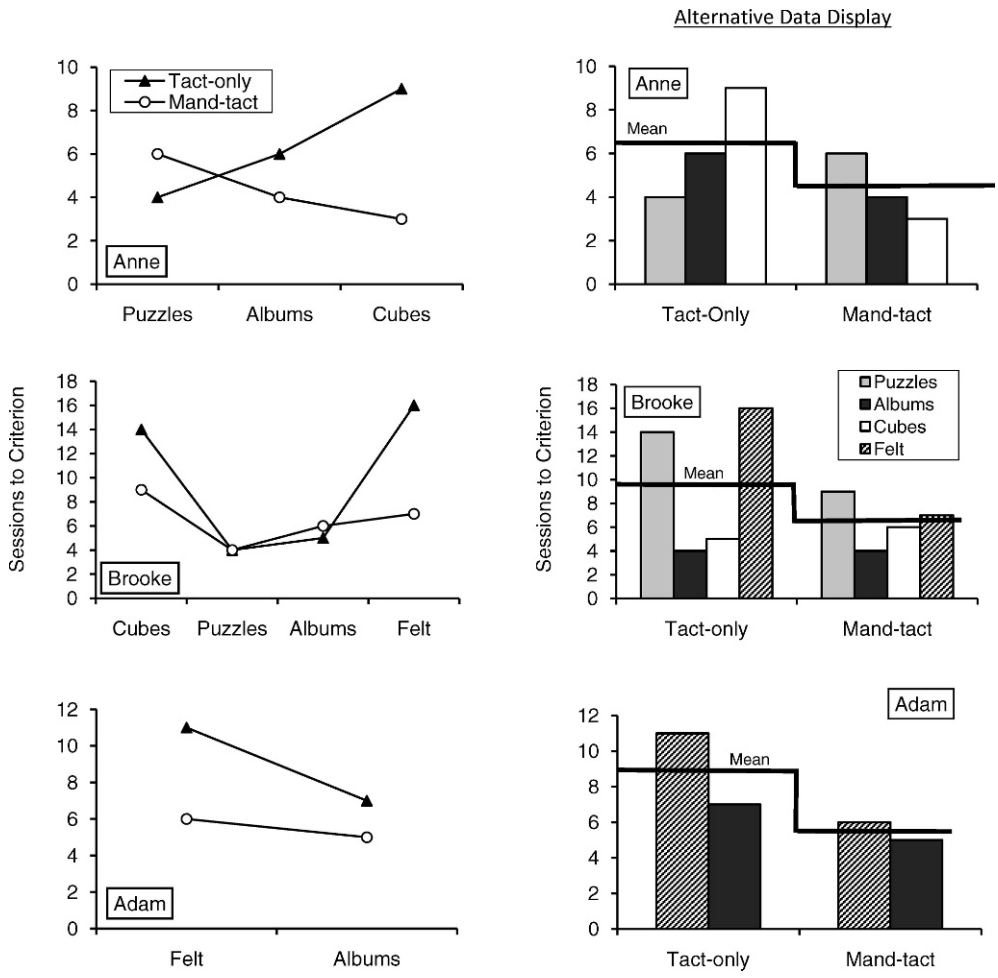

Figure 2. The left column depicts sessions to criterion for tacts across stimulus sets and training conditions for Anne (top), Brooke (middle), and Adam (bottom) (Experiment 1). The right column depicts the same data in bar-graph form, with horizontal mean lines for each condition.

acquired mands for the album and cube pieces more quickly in the mand-tact condition. Brooke acquired mands for cube and puzzle pieces more quickly in the mand-only condition, but acquired mands for the album and felt pieces more quickly in the mand-tact condition. The resulting overlapping data paths of mand acquisition for Anne and Brooke demonstrate inconsistent effects of mand-tact interspersal. That is, during some tasks, acquisition was more rapid during mand-only training, and during other tasks, acquisition was more rapid during mand-tact training. For Adam, mands were acquired more quickly during mand-only training than during mand-tact training for both stimulus sets; however, the differences were negligible.

Tact acquisition graphs across stimulus sets for each participant are depicted in Figure 2 (left). Anne acquired the tact for the puzzle piece more quickly in the tact-only condition, but acquired tacts for the album and cube pieces more quickly in the mand-tact condition. Brooke acquired the tact for the album piece more quickly in the tact-only condition, but acquired tacts for the cube and felt pieces more quickly in the mand-tact condition. There was no difference in acquisition of tacts for the puzzle pieces. Again, the resulting overlapping data paths of tact acquisition for Anne and Brooke demonstrate inconsistent

effects of mand-tact interspersal. For Adam, tacts were acquired more quickly during mand-tact training than during tact-only training for both stimulus sets, demonstrating the most consistent replication of the 3 participants.

In summary, across all participants, three of the nine evaluations demonstrated the facilitative effects of mand-tact interspersal on mand acquisition; six of the nine evaluations demonstrated the facilitative effect on tact acquisition. Furthermore, many of the differences were negligible. Presented this way, these data demonstrate a relatively weak effect of mand-tact interspersal on acquisition.

The data were then plotted using bar graphs, and mean lines were examined to provide a better comparison with results from previous studies. The alternate data analysis of mand acquisition is depicted in Figure 1 (right). Anne acquired mands in fewer mean sessions in mand-tact training ($M = 9$) than in mand-only training ($M = 11.7$), ranging from 7 to 12 sessions. Brooke acquired mands in fewer mean sessions in mand-tact training ($M = 6.75$) than in mand-only training ($M = 11$), ranging from 1 to 11 sessions. Adam acquired mands in more mean sessions in mand-tact training ($M = 7$) than in mand-only training ($M = 6$), with mands differing by one session in both tasks.

The alternate data analysis of tact acquisition is depicted in Figure 2 (right). Anne acquired tacts in fewer mean sessions in mand-tact training ($M = 4.3$) than in tact-only training ($M = 6.3$), ranging from two to six sessions Brooke acquired tacts in fewer mean sessions in mand-tact training ($M = 6.5$) than in tact-only training ($M = 9.75$), ranging from one to nine sessions. Adam acquired tacts in fewer mean sessions in mand-tact training ($M = 5.5$) than in tact-only training ($M = 9$), ranging from two to five sessions. In summary, mean differences, although demonstrating a consistent effect of mand-tact interspersal, were negligible across participants (i.e., 2, 3.25, 3.5 sessions), with considerable within-participant variability.

As mentioned earlier, although the two existing studies in this literature (Arntzen & Almas, 2002; Carroll & Hesse, 1987) reported positive effects, a closer analysis of their findings reveals relatively weaker-than-reported effects and substantial variability within participants. It appears that the previous authors' reliance on mean differences heavily influenced data interpretation. When tact data from the present experiment were evaluated using mean lines as the basis for the analysis, the effects of mand-tact training on tacts are more consistent with previous studies. However, the same analysis of mand data does not indicate a reliable facilitative effect of mand-tact training on mand acquisition.

Working under the assumption that a robust mand-tact effect is demonstrable under some conditions, we hypothesized that failure to produce a more robust demonstration of this phenomenon may have been due to differences in reinforcement between conditions. It is possible that participants had higher rates of reinforcer delivery during mand-only and tact-only conditions because of the receptive tasks interspersed during these conditions and not during mand-tact sessions. These receptive tasks were arguably easier in nature, perhaps resulting in more reinforcers delivered earlier in trials. If so, this might have reduced the difference in acquisition between mand-only and tact-only conditions and mand-tact conditions. Figure 3 depicts the mean number of programmed reinforcers delivered during each condition for Brooke and Anne. (These data are unavailable for Adam due to equipment failure.) Although the mean number of reinforcers delivered during mand-only sessions was higher than during mand-tact sessions for one stimulus set (i.e., Brooke, puzzles), and higher during tact-only sessions than during mand-tact sessions for some stimulus sets (i.e., Anne, albums; Brooke, cubes, puzzles, albums), differences were negligible and did not occur across all other stimulus sets. Thus, it is unlikely that differences in reinforcer delivery across conditions greatly affected learning outcomes.

It should also be noted that it is possible that completion of the activities (i.e., albums, puzzles, felt, cubes) used in Experiment 1 was not sufficiently reinforcing, potentially weakening any facilitative effects of mand-tact training. With the procedures employed in this and previous studies (as well as

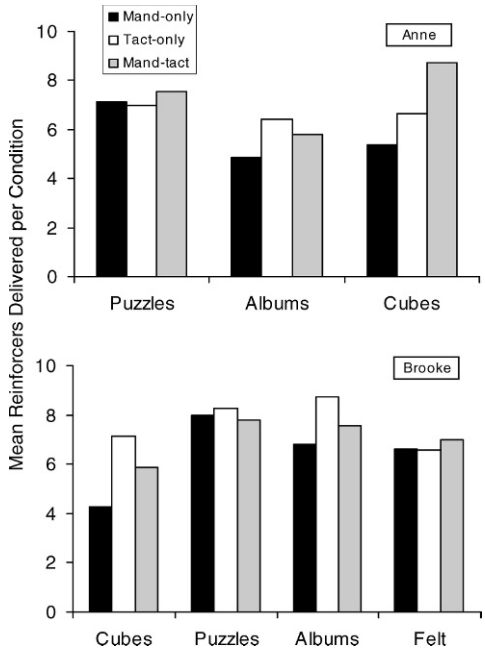

Figure 3. Mean reinforcers delivered during mand-only, tact-only, and mand-tact conditions for Anne and Brooke (Experiment 1).

information reported in previous studies), it is not possible to make comparisons about reinforcer potency. Although consequences were arranged such that mand and tact trials both ultimately ended in comparable tangible reinforcement, this reinforcement was slightly delayed during mand trials until the toy was completed. The more immediate consequence (and putative reinforcer) of completion may not have been sufficiently reinforcing.

EXPERIMENT 2

It was hypothesized that the weak effects observed in Experiment 1 may have been due to strategies employed to increase methodological rigor and to use more effective teaching strategies (e.g., prompts, reinforcers) than in prior studies. To evaluate this hypothesis, a direct replication of previous research was conducted. The Carroll and Hesse (1987) study was selected rather than the Arntzen and Almas (2002) study because the former contained more methodological details. Procedures were identical to those reported in Phase 2 of Carroll and Hesse, with the exception of using slightly different toys.

Method

Participants and Setting

Participants were 2 girls, Caroline (3 years 2 months) and Dara (2 years 10 months). Both participants were typically developing and displayed language skills within a normal range for their age, as identified via the EVT (Caroline, 3 years 8 months; Dara, 4 years 1 month). Sessions were conducted in a quiet area of each participant's home or school.

Dependent Variables and Data Collection

Sessions were conducted until six consecutive trials were correct or 20 min passed for Caroline, or until 15 min elapsed for Dara, whichever came first. One or two sessions of each condition were conducted daily, 3 to 5 days per week. Criterion for mastery of each target was six of six correct (and unprompted) responses across two consecutive sessions. As in the Carroll and Hesse (1987) investigation, training continued until six of six consecutive responses were made, but in analysis, tacts were considered mastered after the third consecutive tact trial. The rationale for this was to keep mastery in the tact-only condition equivalent to mastery in the mand-tact condition, in which only three tacts were required. Other data-collection procedures were identical to those in Experiment 1.

Preference Assessments

Preference assessments were conducted with both participants as described in Experiment 1. However, only toys were included in the assessment to identify items for the toy container that the participants accessed after sessions.

Procedure

Design and materials. As in Carroll and Hesse (1987), the effects of two different training arrangements on the acquisition of tacts were evaluated using an adapted alternating treatments design. Participants

were exposed to multiple evaluations of the training arrangements by using three pieces from each of two different structures. As in the earlier investigation, assembling the pieces resulted in structures that were toys appropriate to this age group (e.g., creatures with arms and legs). Two different structures were used for each of two training arrangements (i.e., tact-only training, mand-tact training). Structures consisted of three pieces to assemble, and target pieces were comprised of brightly colored, plastic toy parts. Specific pieces included a combination of rod- and gear-like pieces interconnected with pieces that ranged in shape and form from ovals to springs. Participants were taught to build the structures prior to experimental sessions. None of the pieces bore a resemblance to any familiar items known to the participants, as indicated by each participant's nonresponse or incorrect response when asked, ''What is this?'' prior to training. Responses trained were two-syllable technical terms for body parts (Table 1).

The daily order of conditions consisted of alternating between tact-only and mand-tact sessions until all tact-only sessions were completed. After the structure was completed, the experimenter provided praise.

Tact-only training. The experimenter placed the target object in front of the participant and said, ''What part is this?'' If she correctly stated the name of the object, the experimenter provided praise (e.g., ''Great! You got it!'') Tacts were interspersed with receptive and imitation tasks in a 1:1 ratio.

Mand-tact training. During this condition, participants were taught to respond to one item as both a mand and a tact. The mand trial was always first, and mand and tact trials were alternated in a 1:1 ratio. Procedures for tact trials were conducted as above. Mand trials began with the experimenter asking the participant to build the structure. The last piece required to complete the task was hidden by the experimenter (i.e., an interrupted-chain procedure). When the child correctly stated the name of the hidden object, the experimenter provided it without saying anything.

Task interspersal. During tact-only training, other tasks were interspersed with the target tact. Interspersed tasks were previously acquired motor imitation and receptive identification tasks reported to be easy by the participant's teacher or parent. Incorrect interspersal tasks were prompted as described below, and correct responses resulted in praise.

Prompts. A response was considered correct if it was independent and matched (or improved from) the articulation of the response following the first vocal prompt at the beginning of training. During each condition, if the participant did not respond during a trial, the experimenter waited 5 s (i.e., constant prompt delay), provided a model prompt for her to imitate, and then provided an opportunity for her to respond independently to the object again. If the participant did not imitate model prompts for three consecutive opportunities or attempted or requested to leave three times, the session was terminated. This occurred during nine sessions with Dara (all mand-tact sessions). If the participant responded incorrectly, the experimenter provided a model prompt for her to imitate. If correct, this trial was scored as prompted, and the child received the reinforcer appropriate to that condition.

Facilitation of participation. As in Experiment 1, at the end of each session, the experimenter indicated to the participant that the session was over and that she may choose a toy from the toy container to play with. However, the experimenter did not mark a box in front of the participants in Experiment 2, because neither the number of trials nor the duration of sessions could be predicted (being based on performance).

Interobserver Agreement and Procedural Integrity

Interobserver agreement and procedural integrity were assessed and calculated as in Experiment 1. Agreement for Caroline was 100% and was assessed during 50% of sessions. Mean agreement for Dara was 98% (range, 83% to 100%) and was assessed during 55% of sessions. Dara's procedural integrity score was 100% and was assessed during 35% of sessions. Mean agreement was 97% (range, 90% to 100%) and was assessed during 57% of these sessions. Caroline's procedural integrity data are unavailable due to equipment failure.

Results and Discussion

Data are depicted using bar graphs and mean lines to maintain consistency with the Carroll and Hesse (1987) data display and the alternate data analysis depicted in the right columns of Figures 1 and 2 for Experiment 1. Caroline acquired tacts in fewer mean trials in tact-only training ($M = 36$) than in mand-tact training ($M = 45$) (Figure 4, top). Dara acquired tacts in fewer mean trials in tact-only training ($M = 14$) than in mand-tact training ($M = 19$), ranging from a difference of 3 to 17 tact trials ($M = 10$) (Figure 4, bottom). Line graphs are not depicted as in Experiment 1 because targets were not linked in pairs according to stimulus sets; however, examination of acquisition of individual targets on the bar graphs shows substantial variability for both participants. For Caroline, tact acquisition ranged from 23 to 59 trials to criterion in the tact-only condition and from 30 to 60 trials to criterion in the mand-tact condition. Similarly, Dara's tact acquisition ranged from 9 to 24 trials to criterion in the tact-only condition and from 12 to 26 trials to criterion in the mand-tact condition. In summary, tact-only training resulted in more efficient mean acquisition of tacts than did mand-tact training for both participants; however, as in Experiment 1, individual data were inconsistent.

Examination of both the individual and aggregate data in Experiment 2 demonstrates a failure to produce an effect of mand-tact interspersal on tact acquisition, in contrast with earlier studies. In addition, based on target means, interspersal of mands and tacts appeared to produce a detrimental effect on tact acquisition when compared to tact-only training. Anecdotal observations during sessions reveal at least four potential reasons for this outcome. First, building the structures appeared to be effortful, and their completion may not have been sufficiently reinforcing. For example, Dara appeared to respond more slowly, attempted to leave the experimental area, and declined to participate during mand-tact sessions. Second, these behaviors often led to fewer trials being conducted during mand-tact sessions than during tact-only sessions. Thus, there was a difference in density of trials conducted per visit

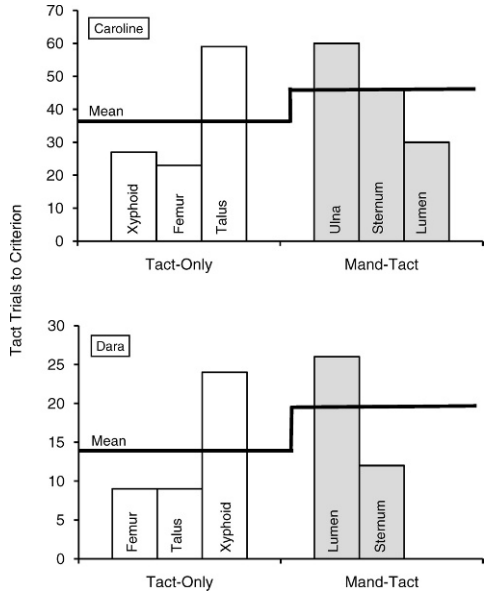

Figure 4. Tact trials to criterion across training conditions for Caroline and Dara (Experiment 2).

between these conditions. For example, although Dara reached criterion performance for the tact ''xyphoid'' and the mand ''lumen'' in a comparable number of trials (24 and 26, respectively), acquisition of the tact ''xyphoid'' occurred after only three sessions, but acquisition of the mand ''lumen'' occurred after nine sessions. Third, the nature of the structures was such that they could be played with before they were completed, thereby possibly decreasing the reinforcing value of the final piece. Finally, the interspersal of novel and previously acquired tasks in the tact-only condition (as was conducted in Carroll & Hesse, 1987) may have produced more rapid acquisition of tacts in the tact-only condition.

EXPERIMENT 3

It was hypothesized that the weak effects observed in the Experiments 1 and 2 may have been due to the low reinforcing value of completing the interrupted chain during mand trials. To evaluate this hypothesis, a systematic replication was conducted in which EO assessments were conducted prior to each session and a more clinically relevant language-training procedure was employed.

Method

Participant and Setting

Ezra was a 4-year-old boy who had been diagnosed with autism and was enrolled in a preschool classroom for children with developmental delays. His age-equivalent score on the EVT was less than 1 year 9 months. Sessions were conducted in the participant's home.

Dependent Variables and Data Collection

Sessions were conducted two to three times per week and averaged 14.5 min in duration. A session consisted of conducting three conditions (mand-only, mand-tact, and tact-only) or only applicable conditions when criteria for the other conditions had been met. Dependent variables and data-collection procedures were identical to those in Experiment 1.

Preference Assessments

Preference assessments were conducted as described in Experiment 1. Edible items were used as reinforcers for correct responses in tact trials and discrimination task trials. Toys were used as stimuli that the participant was taught to mand and tact and as the reinforcer in mand trials. The three toys calculated to have the highest selection percentages that the participant was not able to tact were assigned in a quasirandom order to each condition. The toy with the lowest selection percentage was classified as the low-preference item and was used in EO assessments.

Procedure

Design. As in Experiment 1, the effects of three different training arrangements on the acquisition of mands and tacts were evaluated using an adapted alternating treatments design. The responses trained are presented in Table 1. The order of the conditions was randomly determined before sessions. Mastery criterion for each condition was met when the participant responded correctly for all trials (excluding discrimination tasks) across two consecutive sessions at the independent step of the prompting procedure.

EO assessment. Before each condition began, an EO assessment was conducted in which the participant was asked to choose between the high-preference item to be manded or tacted and a low-preference item as identified by the MSWO preference assessment. Choosing the high-preference item helped to ensure the presence of an EO for that item, a necessary condition for a mand (Wallace, Iwata, & Hanley, 2006). If he chose the low-preference item, the session was terminated. An EO assessment was conducted before every session in each condition.

Mand-only condition. The mand-only condition consisted of a total of 10 trials, alternating between mand and receptive discrimination task trials in a 1:1 ratio. The experimenter held up the toy guitar for the participant to see and then placed it in an opaque bag (to facilitate a pure mand). When he correctly stated the name of the hidden object, he received praise and the object for approximately 30 s.

Tact-only condition. The tact-only condition consisted of a total of 10 trials, alternating between tact and receptive discrimination task trials in a 1:1 ratio. The experimenter held up the object and asked, ''What is this?'' If he correctly stated the name of the object, he was provided with an edible item and praise.

Mand-tact condition. The mand-tact condition consisted of 10 alternating mand and tact trials in which Ezra was taught to respond to one item as both a mand and a tact. These trials were conducted as described for the mand-only and tact-only conditions.

Interspersal. During mand-only and tact-only training, other tasks were interspersed with the target mands and tacts. Interspersed tasks were receptive identification of previously unmastered letters and numbers. Incorrect interspersal tasks were prompted as described below, and correct responses resulted in an edible item and praise.

Prompts. A five-step progressive prompt delay procedure was used in all mand and tact trials. In Step 0, a 0-s prompt delay was used in which the experimenter immediately verbally prompted the name of the item to be manded or tacted. In mand trials, the verbal prompt immediately followed the sight of the toy in the bag and in tact trials, the prompt

immediately followed the experimenter asking ''What is this?'' If the participant did not respond after 5 s or responded incorrectly, the experimenter provided another verbal prompt. If the participant did not respond or responded incorrectly after a total of three opportunities, the session was terminated. In Steps 1, 2, and 3 the prompt delays were 1, 3, and 5 s, respectively. In Step 4, reinforcement in the form of an edible item (tact trials) or toy (mand trials) was contingent on independent responding. The experimenter provided a verbal prompt only if the participant did not respond or responded incorrectly. Praise was provided for prompted responses.

In discrimination trials, a five-step progressive prompt delay with a matching prompt was used. The steps were identical to those used in mand and tact trials with the exception that the presentation of a duplicate icon replaced the verbal prompt. If Ezra did not respond within 5 s or responded incorrectly, a physical prompt was used.

Interobserver Agreement and Procedural Integrity

Interobserver agreement and procedural integrity were assessed and calculated as in Experiment 1. Mean interobserver agreement was 99% (range, 83% to 100%) and was assessed during 100% of sessions. Ezra's mean procedural integrity score was 98% (range, 73% to 100%) and was assessed during 48% of sessions. Interobserver agreement on procedural integrity data was 100% and was assessed during 57% of these sessions.

Results and Discussion

Ezra acquired mands in one to two fewer sessions in mand-tact training for the first two word sets taught and two more sessions for the third word set (Figure 5). Tacts were acquired twice as fast in tact-only training in the first set, at the same rate for the second set, and in one fewer session in mand-tact training for the third set. Thus, acquisition rates varied across word sets for both mand and tacts, suggesting that mixed verbal operant training did not result in faster acquisition than single operant training.

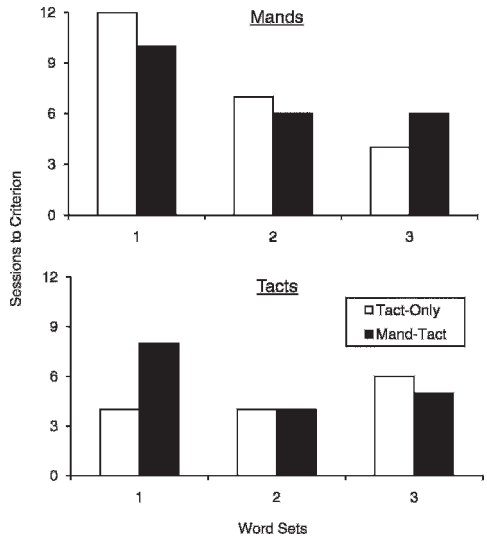

Figure 5. Sessions to criterion for mands (top) and tacts (bottom) across training conditions for Ezra (Experiment 3).

These findings are consistent with those of Experiments 1 and 2.

Several limitations of Experiment 3 are worth mentioning. First, the mand-only condition was discontinued during two separate sessions due to Ezra's failure to imitate the verbal prompt three consecutive times. These sessions were discontinued after nine and seven trials, respectively, and therefore did not provide the participant with the full 10 opportunities for possible reinforcement, as in other sessions. Second, during the EO assessment for one of the mand-only conditions, he chose the low-preference item. He chose the high-preference item during the third presentation of the EO assessment, after which the condition was conducted. This demonstrates that the EO for the toy was not as strong as it was initially. Third, the teaching environment was changed between the first and second word set due to a fire in Ezra's home. Finally, because sessions were conducted in the home, the learning environment contained several distracters (e.g., television, family members, and other toys).

GENERAL DISCUSSION

The current studies evaluated the effects of mand-tact interspersal on mand and tact acquisition relative to mand-only and tact-

only training arrangements in 5 typically developing children and 1 child with autism. In Experiment 1, a systematic replication was conducted to replicate, extend, and provide increased methodological rigor from previous research on this phenomenon. In Experiment 2, a direct replication of Phase 2 of the Carroll and Hesse (1987) investigation was conducted when robust effects were not observed during Experiment 1. In Experiment 3, the conditions were evaluated using a more clinically relevant procedure with a child with autism, and additional steps were taken to ensure EO control during mand trials. Taken together, the findings from these three experiments do not replicate those of previous studies on mixed verbal operant arrangements.

Failure to replicate previous findings should be cautiously interpreted in light of several issues and points to the need for carefully designed future research on this topic. First, it should be noted that a problem inherent to studies on skill acquisition is that acquisition strategies as independent variables are always treatment packages, consisting of a component being studied in addition to a variety of performance-enhancing teaching strategies offered by the most current behavioral technology. These include such strategies as stimulus preference assessments, reinforcer variation, prompt-fading techniques, task interspersal, and reinforcer-thinning techniques. In the current study, the component evaluated was mand-tact interspersal, but additional teaching strategies included prompting strategies, preference assessments, specific arrangement and delivery of reinforcers, and reinforcer variation (except following mands). Although the experiments were designed to evaluate one specific independent variable, these other components by themselves should, based on previous research, produce skill acquisition. Thus, there might be relatively little room to demonstrate an effect with one specific independent variable. Replication failures or weaker effects of the independent variable being studied may be observed because of a ceiling effect or because these strategies improve performance in conditions with and without the intended independent variable. In the current study, a direct replication was conducted, suggesting that these background independent variables probably did not produce the weak effects obtained. However, future research might be conducted such that other elements of the skill acquisition package are not optimized (e.g., massed trials, no preference assessment) such that the specific contribution of mixed trials can be better evaluated.

Another avenue for future research in this area is to evaluate other potential outcomes of using mixed verbal operant arrangements. Researchers might consider surveying clinicians who currently use this procedure to obtain anecdotal information toward this goal. Survey questions might include topics related to enhanced stimulus control (e.g., in contrast with massed-trial procedures), functional interdependence of verbal operants, skill maintenance, and social validity of mixed versus single verbal operant arrangements. This information might inform additional empirical research.

In conclusion, the data from the three experiments reported herein do not provide convincing support for the clinical use of mixed verbal operant arrangements for facilitating tact or mand acquisition. Future applied research on this use of the mixed verbal operant procedure should be weighed against the number of existing empirically supported alternatives for enhancing learning. The search for conditions that predict a modest and unreliable effect of an intervention (e.g., mand-tact interspersal) should be balanced with the knowledge that a variety of effective components that more reliably produce efficient skill acquisition are available.

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