EFFECTS OF SERIAL VERSUS CONCURRENT TASK SEQUENCING ON ACQUISITION, MAINTENANCE, AND GENERALIZATION[1]

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Effects of serial and concurrent task presentation on skill acquisition, generalization, and maintenance were compared. Two severely retarded females participated. During serial training, items of one response class, tracing, were trained to mastery before those of a second task, vocal imitation. In the concurrent method, training on two different tasks, tracing and vocal imitation, alternated within sessions for fixed periods of time. There were no major differences between the serial and concurrent methods of instruction in the number of steps attained per behavior or in the number of trials required to reach criterion levels of performance. It was found however, that concurrent training resulted in more generalization. Retention results were not consistently related to training method.

DESCRIPTORS: educational programming, curriculum design, task sequencing, serial and concurrent formats, learning objectives, tracing, vocal imitation, retardates

Through the use of shaping, graduated guidance, fading, and chaining, behavioral technology has made significant contributions to the development of specific skills, such as self-feeding (O'Brien and Azrin, 1972), ambulation (Meyerson, Kerr, and Michael, 1967), speech (Sloane and MacAulay, 1968), and toilet training (Foxx and Azrin, 1973). These studies show marked gains within a single skill area. However, empirically based strategies are not available for structuring the curriculum when two or more response classes are involved. Such data on the appropriate scheduling of

tasks could be very useful in designing an instructional program for an individual who has multiple skill deficits.

Schroeder and Baer (1972) compared two types of sequencing arrangements, concurrent and serial, in teaching vocal imitation to two retarded females. These authors found no major differences between concurrent and serial training procedures in terms of acquisition time, but there were consistent differences in favor of the concurrent method on generalization tests. The teaching procedures these authors identified and examined with respect to intratask issues could also have implications for programming multiple tasks.

Therefore, an examination of the effects of concurrent *versus* serial programming was extended to an intertask level in the present study. Specifically, the relative effectiveness of serial training was compared with concurrent training. In serial training, tracing was trained to mastery before initiating training on a second task, vocal imitation. According to the concurrent method, training on two different tasks alternated within a single session before either task reached criterion levels of performance. These two training

procedures were compared as to their effects on acquisition rates, retention, and generalization.

METHOD

Subjects and Setting

Two female students residing at a state school for the mentally retarded participated. Joan was 22 yr old with a social quotient of 13.0 (Vineland social maturity scale); Rita was 19 yr old and had a Vineland social quotient of 25.9. These two students were selected because (1) they did not perform either the tracing or vocal imitation task in preliminary observations; (2) they had no physical impairments preventing them from engaging in these tasks, and (3) they had time available for additional programming.

Sessions were held twice daily for 15 min each Monday through Friday. Generally, they were held between 8:30 and 9:30 a.m. and 2:00 and 3:00 p.m. All sessions and tests were conducted by the senior author in a 2.1- by 2.7- by 2.4-m room furnished with a table, two chairs, training materials, edibles, a one-way mirror, and a sound system connected to an adjacent observation room.

Before the pretest, letters explaining the nature of the study were sent to the students' parents. Written permission was obtained from both sets of parents.

Experimental Design and Conditions

Each student was exposed to the serial (A) and concurrent (B) format twice in a ABAB or BABA sequence. Two letters and two sounds were presented during each training phase (cf. Table 1). The letters and sounds that were presented concurrently to Joan were presented serially to Rita and *vice versa* to control for item difficulty.

Pretest. The pretest, consisting of 16 training items, eight probe items, and eight competency items, was administered before the first training session. The competency items, those observed in the students' repertoires, were: raise

your hand, ring the bell, put the toy in the truck, clap your hands, touch your nose, tear the paper, pick up the spoon, and pull the beads apart. These commands were interspersed among the training and probe items to maintain the student's attention, and were reinforced if correct.

Concurrent training. During concurrent training, each 15-min session was divided into three consecutive 5-min periods. Training on one task (*e.g.,* tracing) was conducted during the first 5 min; during the second 5-min segment a different task (*e.g.,* vocal imitation) was presented, and training on the original task (tracing) resumed during the final 5 min. The following session began with the task trained during the middle 5 min of the previous session, *i.e.,* vocal imitation. This procedure continued until all four items (two sounds and two letters) were mastered or until 200 trials per training item were reached, whichever occurred first.

If both items of one task, vocal imitation, were mastered before criterion was reached on the alternate task, tracing, the sounds were reviewed during the middle 5-min segment of each session until criterion was attained on the letters or until 200 trials were completed.

Serial training. During serial training, the tracing or imitation stimulus was presented until the student reached criterion or 200 trials. Training on one item continued throughout the 15-min session. If mastery criterion was reached on that item before the end of a session, training began on the second item of the same task. If the second item was mastered in the middle of a serial training session, the session was terminated. Training began on the first item of the second task at the next session. Two letters and two sounds were taught during each serial phase.

Probe sessions. A probe session was conducted immediately after each training phase was completed. Thus, there were two probe sessions following serial training and two following concurrent training for each student. Each probe session included the training items that were presented during the previous phase and eight untrained or probe items. The eight untrained

items consisted of four letters and four sounds, each presented once. These probes were never reinforced. The training items, presented twice each, were interspersed among untrained ones and were reinforced if the accuracy level achieved at the end of training was met.

Posttests. A test identical in format and content to the pretest was administered at one-, two-, and six-month intervals following the fourth probe sesion. Again, only the competency items were reinforced.

Task Definition; Training and Scoring Procedures

The tracing stimuli consisted of the capital letters: L, C, D, V, K, J, H, and S. The probe letters were O, T, B, and A. Each letter, 10.2 by 14 cm was printed in black on a 22- by 28-cm sheet of paper. A red felt-tip pen was the tracing instrument.

The tracing task was divided into the following six steps: (1) The trainer guided the student's hand in making the stroke(s) over the model letter. After the student moved her hand along with the trainer's for 15 successive correct trials, training began on the next step. (2) The trainer made three-fourths of the letter with the student before removing assistance, and said "Trace this", while pointing to the remaining fourth of the letter. (3) The trainer traced one-half of the letter with the student and instructed the student to trace the remaining half. (4) The trainer traced one-fourth of the letter and instructed the student to trace the remaining portion alone. Criterion for advancement to a new step during Steps 2, 3, and 4 was 10 successive correct responses. (5) The trainer placed the printed letter in front of the student and instructed her to trace over the letter. Five successive correct responses were required for advancement to Step 6. (6) An item was considered mastered when the student reached this step. The instructional cues were the same as for Step 5. Nine trials were conducted and edibles and praise were given after the second, fifth, and last trial if correct.

Each tracing trial was scored as correct ("+") if all the pen marks were within 12.7 mm or less of the entire model letter. Overlays indicating the safety margins were drawn for each letter to determine if the marks were within the boundary. A "−" (incorrect) was scored if no marks were made within 10 sec from the time the trainer gave the command or if the pen marks did not touch any part of the area within 12.7 mm of the printed model. A "P" (partially correct) was scored if some of the pen marks were within 12.7 mm of the model.

The order of sounds for vocal imitation training were: t (try), m (man), k (kick), p (pit), d (dig), f (fly), n (no), and th (thin). The probe sounds were: s (say), g (giant), h (hot), and l (low). A tape of the proper pronunciation of each sound was made and played for the observers.

Vocal imitation training consisted of four steps. Step 1 consisted of the trainer holding the reinforcer next to her lips and saying, "(Child's name), do this", while modelling the correct mouth movement. Correct imitation of tongue placement and mouth position on 15 successive trials resulted in advancement to Step 2. During Step 2, the trainer said: "(Child's name) say, (sound)". The student was to imitate the mouth position, tongue placement, and produce some vocalization. Ten successive correct trials at Step 2 led to Step 3. The instructional cues of Step 3 were identical to Step 2, but the response requirements differed, in that the student was to imitate the complete sound. Ten successive correct responses led to the next step. An item was mastered when the student reached Step 4, which consisted of nine review trials. The second, fifth, and ninth trials were followed by edibles and praise if correct. The necessary number of correct trials for advancement to a new step could overlap successive sessions in both tasks.

Each trial was scored as correct ("+") during vocal imitation training if the student completed the command correctly within 10 sec of the trainer's cue and independent of any outside

assistance. A "—" (incorrect) was scored if the student did not respond to the command within 10 sec after the trainer's cue, or if the student's response did not correspond to the command given. A "P" (partially correct) was scored if the student partially completed the command within the 10-sec period or if the student required assistance to complete the command, such as during Step 1 when the trainer manually shaped the student's lips to form the sound. During probe sessions, the trainer never provided assistance.

During tracing and vocal imitation training, each student was praised and received a small portion of cereal, potato chips, ice cream, or soft drink for each partially correct response until she made a correct response. Thereafter, edibles and praise were presented only after each correct response.

When the student made an incorrect response, the trainer said "no", removed the food from in front of the student, and waited 30 sec before presenting five trials of the preceding step. These trials were not reinforced and were not counted toward the 200 trials.

The trainer scored each response as "+", "—", or "P" after each trial. Two additional observers alternated in scoring the sessions at least once during each training phase, during the pretest, all probe sessions, and all posttests. The observers received a written description of the steps, tasks, code, and rating procedures, and scored responses from the observation room. The observers had recorded similar behavioral data on other occasions. In addition to scoring the students' responses, the observers indicated which responses were reinforced. Reliability levels were computed according to the formula

$$\frac{\text{\# of agreements}}{\text{\# of agreements} + \text{\# of disagreements}} \times 100.$$

Those instances in which both ratings were a "+", "—", or "P" were counted as agreements and any trials where the ratings did not correspond were disagreements.

RESULTS

Training

Twenty-four sessions were conducted during serial training and the same number during concurrent training for Joan. Rita's training totalled 41 serial sessions and 37 concurrent ones. Both students advanced beyond the initial steps for all the training items. Joan mastered all eight sounds but reached Steps 5 on only one tracing item. Rita, on the other hand, mastered five tracing items and four vocal imitation items within the 200-trial limit. The method of training, serial or concurrent, did not differentially affect the number of steps attained or the time to master an item for either student. The total number of trials for all tracing tasks across both students was 1529 during serial training, and 1546 during concurrent training. For the vocal imitation tasks, 1368 trials were conducted during serial training and 1194 trials during concurrent training.

It is possible that concurrent training methods could have produced a disruptive effect, due to the loss of training time in reorienting the student to the task. To determine the extent of disruption, the results of the last five trials of the first 5 min of each session were compared to those obtained on the first five trials of the last 5-min segment. For example, if the results for both five-trial blocks were identical, no change (0%) was reported (Figure 1). If the student scored P, P, P, P, and P on the last five trials of the first 5 min and P, P, P, +, and + on the first five trials of the last 5-min segment, a +40% change was reported. Figure 1 shows that there were twice as many instances of gains as losses during concurrent training; serial training produced eight gains and nine losses in terms of the percentage of accurate responses.

Generalization

Table 1 shows the ratings obtained on the probe items during the pretest and the probe sessions following each training phase. A change
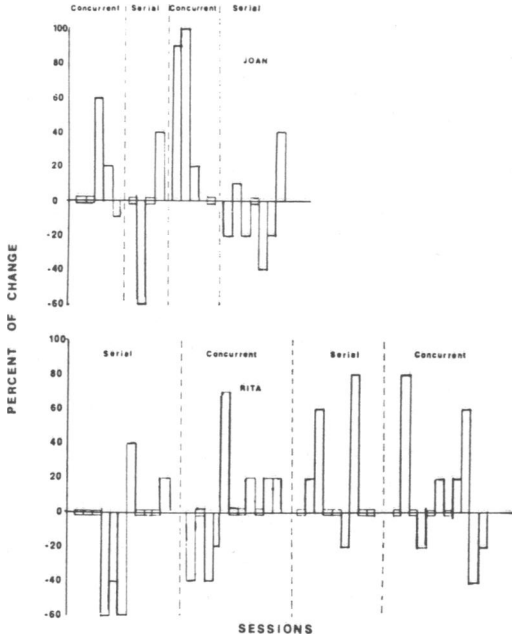
Fig. 1. Per cent of change from the last five trials of the first 5 min to the first five trials of the last 5 min.

Fig. 2. Per cent of change in accuracy of letter and sound probe items on generalization tests following each phase of the study.

from a "−" to a "P" on two adjacent tests for any given item represented a 25% gain; conversely, a change from a "P" to a "−" was a 25% loss. If a student scored a "−" on one probe item during one test and a "+" on the same item on the following test while the accuracy of the remaining three probe items did not change, a gain of 50% was reported. For example, Table 1 shows that Joan scored a −, −, −, and − for the four probe sounds during the pretest and a P, P, P, and P on the same items during the probe test after the first concurrent phase. This change represents a 100% improvement. A 200% change would have been the upper limit on adjacent tests.

The results of the probe tests reported in Table 1 are graphed as the per cent of improvement from the preceding phase in Figure 2. Increased generalization to untrained items should have been observed with each succeeding training phase. If two successive probe sessions showed no change in accuracy levels, one could conclude that the most recent training phase did
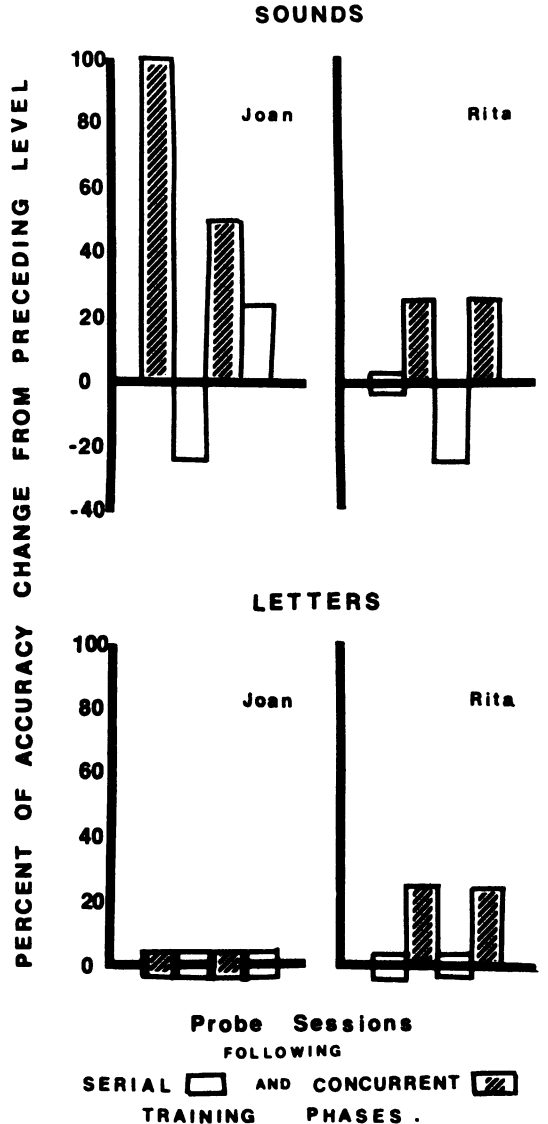
not enhance generalization. If there was a decrease in the accuracy levels, it could be concluded that the immediately preceding training phase deterred generalization. Figure 2 shows increases in generalization after concurrent training, whereas the generalization level following serial training remained the same or declined. One exception was Joan's performance on the letter probes, which showed no evidence of generalization.

Table 1

The sequence of concurrent and serial training phases and results of probe (generalization) tests following each training phase for Joan and Rita.

JOAN:	Pretest	Conc.	Serial	Conc.	Serial
Letters trained	None	L, C	D, V	K, J	H, S
Probes tested	O, T, B, A	O, T, B, A	O, T, B, A	O, T, B, A	O, T, B, A,
Probe results	P, P, P, P	P, P, P, P	P, P, P, P	P, P, P, P	P, P, P, P
Sounds trained	None	t, m	k, p	d, f	n, th
Probes tested	s, g, h, l	s, g, h, l	s, g, h, l	s, g, h, l	s, g, h, l
Probe results	—, —, —, —	P, P, P, P	—, P, P, P	P, P, +, P	P, P, +, +

RITA:	Pretest	Serial	Conc.	Serial	Conc.
Letters trained	None	L, C	D, V	K, J	H, S
Probes tested	O, T, B, A	O, T, B, A	O, T, B, A	O, T, B, A	O, T, B, A,
Probe results	P, P, P, P	P, P, P, P	P, +, P, P,	P, +, P, P,	+, +, P, P
Sounds trained	None	t, m	k, p	d, f	n, th
Probes tested	s, g, h, l	s, g, h, l	s, g, h, l	s, g, h, l	s, g, h, l
Probe results	—, P, P, P	—, P, P, P	P, P, P, P	—, P, P, P	P, —, P, +

Training items were also rated during the probe tests. Seventy-five per cent of the items trained concurrently remained at the level achieved at the end of the preceding training phase, while 69% of those trained serially were at the same level during probe tests.

Retention Data

Tests given one, two, and six months after training all showed retention percentages of 87.5% for Joan's tracing responses. This means that 87.5% of the training items on the posttests were at the accuracy level achieved at the end of formal training. Joan had retention percentages of 87.5%, 50%, and 75% after one, two, and six months respectively on the vocal imitation training items. Rita scored 62.5%, 50%, and 50% for the letter items and 87.5%, 50%, and 25% for the sounds during the first-, second-, and six-month posttests. These retention data were further analyzed to determine if any differences existed between those items trained serially and those trained concurrently. Thirteen items trained concurrently were maintained at their end-of-training accuracy level and 11 items decreased (from + to P, or P to —). Fourteen items trained serially stayed at their end-of-

training level and 10 items decreased in accuracy on the three posttests.

Results of the probe items on the three posttests were compared to the results of the fourth probe session. All of Joan's probe letters and 75% of her probe sounds remained at previously attained levels. Probe letters and sounds for Rita were both maintained at the 75% level.

Reliability

Reliability figures ranged from 80% to 100% for the vocal imitation items, with a mean of 93%, and from 82% to 100% for the tracing items, with a mean of 92%. Score on the pre-, probe, and posttests ranged from 81% to 100%, with a mean of 94%.

DISCUSSION

This study showed that two different training formats, serial and concurrent, had similar effects in terms of response acquisition and retention, but had different outcomes in terms of response generalization. Concurrent training procedures were consistently superior to serially arranged conditions for generalization to untrained items. Schroeder and Baer (1972) also

reported instances of response generalization following a concurrent training procedure.

Since it is costly in terms of time and manpower directly to train every single skill, the generalization data on the indirect effects of the two training procedures are significant. The expenditure of staff time was essentially the same during the concurrent and serial phases, yet more untrained items were learned following concurrent training. Thus, benefits in terms of the students' overall behavioral repertoires resulted from the concurrent instructional method.

There were no negative side effects of the concurrent procedure, in terms of it temporarily disrupting the training process. The disruption of training data (Figure 1) empirically discounts conjectures that switching tasks require additional time to reorient the student to the current task. Since there was no shift in location or trainer, but only a change of materials, the opportunities for disruption may have been minimized.

To program generalization more effectively across settings, some authors suggest equating the training conditions on as many dimensions as possible with those of the environment in which the behavior will ultimately be expected to occur (Atthowe, 1973; Walker and Buckley, 1972). The eventual goal of many institutional training programs is community placement, where individuals will engage in household and occupational tasks. These tasks require the utilization of many different skills. For example, cooking consists of reading, measuring, stirring, pouring, and time-telling components. Since the community environment often requires performance of distinct responses in close proximity, it seems logical that concurrent, rather than serial, training would effectively promote this goal.

The majority of studies in the area of rehabilitation of handicapped individuals and education in general have focused on techniques to develop new behaviors through the use of consequences (Gardner, 1971; Hanley, 1970; Thompson and Grabowski, 1972). The opera-

tional specification of an individual's treatment objectives permits the analysis of antecedent conditions as well as consequences. Setting variables, such as the type and number of trainers and length of task presentations, are several examples. Barrett and McCormack (1973) demonstrated the superiority of using multiple trainers over a single tutor in training retarded children. Favell, McGimsey, and Bost (Note 1) showed the merits of small-group instruction over individualized instruction with institutionalized students. Both of these approaches, varied tutors and group instruction, as well as the concurrent instructional method are at variance with common assumptions and established practices at institutions. Thus, there is a need to evaluate current practices, retain those that facilitate skill advancement, and delete or modify those that do not.

The present study measured generalization to items within the response classes being trained. The learning of one task may also facilitate the acquisition of activities from new response classes. Therefore, future studies could test for the extent of intertask as well as intratask response generalization.

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