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THE EFFECTIVENESS OF A CONSTANT TIME-DELAY PROCEDURE TO TEACH CHAINED RESPONSES TO ADOLESCENTS WITH MENTAL RETARDATION

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The effectiveness of a 5-s constant time-delay procedure to teach three chained food preparation behaviors to four moderately retarded adolescent students was evaluated within a multiple probe design across behaviors. Results indicate that the procedure was effective in teaching all four students to make a sandwich, boil a boil-in-bag item, and bake canned biscuits. The skills maintained with at least 85% accuracy over a 3-month period. Training generalized from the school to the home setting for the 2 subjects that completed generalization probe sessions. The percentage of errors across all skills and students was less than 9%.

DESCRIPTORS: time delay, independent living skills, chained responses

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Despite the stated benefits of errorless learning and the disadvantages of student failure (Etzel & LeBlanc, 1979), the published literature is virtually devoid of studies using errorless or near-errorless instructional procedures (time delay) to teach chained, functional tasks (e.g., meal preparation skills) to individuals with developmental disabilities (Snell, 1982). Time delay is an effective, near-errorless instructional procedure that has been used extensively with discrete behaviors (Handen & Zane, 1987).

Time delay, described by Touchette (1971), is a method for transferring stimulus control by systematically varying the delay interval between the natural cue and a controlling stimulus. When initially employing a time-delay procedure, the controlling stimulus (i.e., a prompt) is paired (0-s delay) with a second stimulus (i.e., the target stimulus) to which control is to be transferred. Over successive trials or sessions, a delay is inserted between the target stimulus and the presentation of the controlling response prompt, allowing the student an opportunity to perform the response independently. This occurs until stimulus control is transferred from the prompt to the task request. Two types of time delay have been used: constant time delay, in which a fixed number of seconds is inserted between the target stimulus and the prompt; and progressive time delay, in which the delay interval is gradually increased over trials or sessions. Although time-delay procedures have been effective in teaching a variety of behaviors to a variety of students (Browder, Morris, & Snell, 1981; Kleinert & Gast, 1982; Kowry & Browder, 1987; Stevens & Schuster, 1987), and is more efficient than the system of least prompts (Bennett, Gast, Wolery, & Schuster, 1986; Godby, Gast, & Wolery, 1987), only progressive time delay has been investigated in teaching chained tasks (Snell, 1982; Walls, Haught, & Dowler, 1982). This investigation evaluated the effectiveness of a constant time-delay

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This study is based on a dissertation completed by the first author in partial fulfillment of the requirement for an Ed.D. degree in the Department of Special Education at the University of Kentucky. A more complete description of this study is available from the first author. Additional data were collected on student baseline probe performance, measures of expressive and receptive language acquisition during the course of the study, and social validation measures.

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Table 1
Task Analysis for Making a Sandwich

1. Take bread from cabinet.
2. Carry cold-cut container from refrigerator.
3. Pick up knife from drawer.
4. Select mayonnaise from refrigerator.
5. Open bread.
6. Remove two pieces of bread; lay flat on counter.
7. Close bread and return to cabinet.
8. Open jar of mayonnaise.
9. Pick up knife and dip into mayonnaise.
10. Spread mayonnaise with knife on top of both slices.
11. Close mayonnaise and return to refrigerator.
12. Open cold-cut container.
13. Place one slice of meat on one side of bread.
14. Place one cheese slice on top of meat.
15. Place lettuce on top of cheese.
16. Place remaining bread slice on top of lettuce, mayonnaise side down.
17. Close cold-cut container and return to refrigerator.
18. Get a plate from the cabinet.
19. Place sandwich on plate.
20. Cut sandwich in half diagonally.
21. Place knife in sink.

procedure in teaching three chained cooking skills to four moderately mentally retarded high school students.

METHOD

Participants

Four students enrolled in a self-contained special education classroom for trainable mentally retarded adolescents served as subjects. Students ranged in age from 14 to 17 years. All students attended a rural public high school and had measured IQs and Adaptive Behavior Ratings in the moderate range of mental retardation.

Each student demonstrated the following skills prior to the study: (a) auditory acuity and receptive language to follow simple commands and hear directions, verbal cues, and social praise; (b) visual acuity to see the prompts and the materials used; (c) volitional motor control to perform the motor requirements of the targeted skills; and (d) generalized gross motor imitation skills. The trainer assessed these skills directly. A reinforcer preference test also was conducted with each student using Striefel's (1974) procedures. All students had minimal experience with food preparation skills, although before this investigation, students had been exposed to and learned to prepare some simple foods using a microwave oven (e.g., french fries, hot chocolate, etc.).

Materials and Setting

For all training sessions, two sets of materials were required; one set each for student and trainer use. Numerous types of materials were used to ensure that students were subjected to multiple exemplars. When an oven and stove were used for training, gas or electric ranges were randomly selected across all experimental sessions. All sessions were conducted in a one-to-one instructional arrangement in the home economics room located in the high school building. This classroom contained four kitchens, each containing an electric or gas stove and oven, cabinets, a double sink, counter space, dishes, utensils, and a table with four chairs. A refrigerator/freezer was also in the room.

Task Analyses

The task analyses were developed by the first author by observing nonhandicapped persons perform the skills. Other special education teachers who had previously taught cooking skills provided feedback, and the analyses were revised accordingly. The final tasks contained 21 steps for making a sandwich and 23 steps each for boiling a boil-in-bag item and baking canned biscuits. A sample task analysis is shown in Table 1.

Experimental Design

A multiple probe design (Horner & Baer, 1978) across three tasks and replicated across four students was used to ascertain the effectiveness of the 5-s constant time-delay procedure in teaching the three chained cooking skills. Because correct student responding was reinforced during both probe and instructional sessions, the multiple probe design compared the effectiveness of the constant time-delay procedure used during treatment to a reinforced baseline probe condition rather than a traditional "no-treatment" baseline condition.

Probe Sessions

A graduate student in special education served as the primary trainer and data collector. Data also were collected by the students' classroom teacher. At least three instructional probe sessions were conducted prior to training each skill. Initially, a general verbal cue was delivered so that the student had an opportunity to perform the entire task from the beginning of the chain (see Snell, 1982). The trainer stood approximately 1 m from the student and said, "Ready to work?" When an affirmative answer was given, the trainer delivered a general task direction specific to each task (e.g., "Bake the biscuits"). The number of correct consecutive steps performed independently was recorded. After the initial probe condition, probe trials were conducted on untrained skills every 3 to 4 days.

In addition, during each probe session students were tested individually on the steps of each task analysis. The total number of steps in each task analysis was randomly divided into three subgroups; one subgroup was tested each day, resulting in each specific step being assessed every 3 days. These data were collected to assess the students' performance of each step in each task analysis rather than just at the beginning of the chain. Time constraints dictated testing only one third of the steps for each task per session. An error was recorded if the student did not initiate a response within 5 s of the verbal cue or failed to complete the response within 20 s after initiation. After a 5-s intertrial interval, the trainer arranged the materials so that the next targeted subtask could be tested. The trainer then provided the general verbal cue again. This procedure was used repeatedly to assess each step of each task analysis (see Certo, Mezzullo, & Hunter, 1985).

During probe sessions, responses were recorded as correct or incorrect. Correct responses (initiating the response within 5 s of the verbal cue and correctly completing each step within 20 s) resulted in descriptive verbal praise for each step completed correctly. Correct responses also were recorded if consecutive and subsequent steps of the chain were completed within 20 s of correctly finishing the previous step of the task analysis. Incorrect responses were recorded when the subject did not initiate or complete the subtask within 20 s or performed the step incorrectly. Incorrect responses were ignored. Social praise for attentional responses was delivered to each student on a variable-ratio (VR) 3 schedule.

Constant Time-Delay Instructional Conditions

The tasks of making a sandwich, boiling a boil-in-bag item, and baking canned biscuits were taught using a 5-s constant time-delay procedure within a total task presentation format (Bellamy, Horner, & Inman, 1979). At the beginning of each session, the trainer obtained an attentional response by saying, "Are you ready to cook?" Once an attentional response was obtained, the general task direction was delivered (e.g., "Make a sandwich"). During the first two training sessions for each skill, a 0-s delay was used. The task direction was delivered and immediately followed by the controlling prompt: a trainer model of the appropriate response on a second set of materials and a verbal description of the correct response (e.g., "Spread the mayonnaise on both pieces of the bread").

During all subsequent training sessions a 5-s constant time delay was used. After the general task direction was given, the trainer waited 5 s and, in the absence of a student response, presented the controlling prompt. Upon initiation of a student response (before or after the controlling prompt), the student was allowed 20 s to complete each step. The 5-s interval began again immediately after the trainer delivered performance consequences (i.e., verbal praise or error correction procedures). A general verbal cue was not given again. This procedure had the advantage of not interrupting the chain by the presence of an unnatural intertrial interval in addition to the delay interval (Snell, 1982).

Student responses were recorded in five response categories: correct responses (anticipations and waits) and errors (nonwait, wait, and no response). Anticipations were defined as initiating a step of the task analysis before the prompt and completing the response correctly within 20 s. Correct waits were defined as completing a step of the task analysis correctly within 20 s after the prompt. Only correct anticipations counted toward criterion. Three types of errors were possible. Nonwait errors were defined as initiating a step of the task analysis before the prompt, but (a) not completing the response within 20 s (duration), (b) performing it incorrectly (topographical), or (c) performing out of sequence according to the task analysis (sequence). Wait errors were defined as incorrectly completing the response (topographical) or not completing the response within 20 s of the controlling prompt (duration). No response was scored when a response was not initiated within 5 s of the prompt.

All correct responses (anticipations and waits) resulted in descriptive verbal praise. Whenever a student completed a task with at least 90% correct responses (i.e., any combination of anticipations and waits) the opportunity to eat what he or she had cooked or to select from his or her reinforcement menu was provided. This menu was developed based on preference testing that had been conducted prior to the investigation. All errors (nonwait, wait, and no response) were corrected by the trainer saying "Wait," modeling the response on a second set of materials while providing a verbal description ("You need to make sure that the timer is set"), and, if necessary, correcting the error on the student's set of materials. Criterion for training was defined as completing the task analysis for each skill with 100% anticipations for one session at each of the following reinforcement schedules: continuous reinforcement (CRF), VR 3, and fixed-ratio (FR) 21 or 23 (i.e., at the completion of the entire skill sequence).

Skill Maintenance and Generalization Procedures

Maintenance sessions were conducted 4, 10, 18, and 28 days after each student reached criterion on each skill. These procedures were identical to those used during the time-delay condition when an FR 21 or 23 reinforcement schedule was used. Also, social praise for attentional responses was given to each student on a VR 3 schedule.

Programming for generalization was built into the study by training sufficient exemplars (Stokes & Baer, 1977). Specifically, different breads (rye, whole wheat, and white), various meats (ham, bologna, and chicken), cheeses (Swiss and American), boil-in-bag items (Lean Cuisine, Stouffer, and Kroger), and biscuits (Hungry Man, Kroger, and Randalls) were used. Plates, bowls, potholders, and hot plates were also varied by color, shape, and texture. In addition, two trainers, randomly distributed across days, were used. Data were analyzed by trainer to ensure that differences did not occur.

Performance was assessed in each student's home after all maintenance sessions had been completed. These sessions were identical to maintenance probe sessions except that students could perform the steps of each skill in any order as long as the final product was acceptable.

Reliability

Reliability observers included one of the classroom assistants and a graduate student in special education. The trainers and reliability observers reviewed response definitions and experimental procedures. They role-played the training procedures and recorded performance. The reliability observers obtained at least 90% agreement before the study was initiated. The trainers obtained at least 90% accuracy in conducting the training, determined by procedural reliability measures collected by the observers during the role-playing sessions. Both student response reliability (dependent variable) and procedural reliability (independent variable) on the instructor's fidelity to the experimental procedures were assessed. The point-by-point method of estimating reliability (the number of agreements divided by the number of agreements plus disagreements multiplied by 100) was used to calculate reliability percentages.

Overall, a total of 83 reliability checks were conducted (31 during probe sessions and 52 during instructional sessions). Reliability data were collected on the dependent variable (accuracy of recording responses) during 29% of all probe and instructional sessions and were recorded correctly 99% of the time during probe (range, 86% to 100%) and instructional sessions (range, 96% to 100%).

Independent variable reliability data were also collected during skill probe and instructional sessions. The reliability observer assessed the accuracy of the trainer in arranging the environment, obtaining attentional responses, delivering cues and prompts, waiting the delay, reinforcing correct responses and attentional responses, and correcting errors. During probe sessions, trainers followed program specifications with 98% accuracy (range, 67% to 100%). During probe sessions, all trainer behaviors were performed with at least 98% overall accuracy with the exception of reinforcing attentional responses, which was performed with 94% accuracy (range, 67% to 100%). During time-delay instructional session reliability checks, specifications were followed 99% of the time (range, 87% to 100%).

RESULTS

Time-Delay Effectiveness Data

The instructional probe and training session data for each student and the sequence of training are shown in Figure 1. The data shown for each probe session reflect the number of steps completed independently by each student after the general task direction was delivered for each probe session. These data were obtained using the procedures described by Snell (1982). In addition, the baseline data recorded by use of the Certo et al. (1985) procedures indicated that correct student responding during probe sessions was stable or decreased over time. The data indicate that each student successfully completed some ($M < 38\%$) steps of each task before the time-delay instruction was initiated.

All students completed none of the steps of each task during all probe sessions, with the exception of Erin who completed one step of the sandwich-making task analysis during the initial probe session. Only after the time-delay instructional condition was initiated for each skill did student responding increase to criterion levels.

Maintenance and Generalization

In all maintenance sessions, the students prepared food that was edible without prompts from the trainer. During the maintenance sessions, Erin independently completed 94% of the sandwich-making task, 96% of the boil-in-bag sequence, and 99% of the biscuit-baking steps. During the maintenance sessions conducted for making a sandwich, Andrew completed 98% of the steps independently. During the maintenance sessions conducted on the remaining two skills, Andrew independently completed 96% and 100% of the steps, respectively. Due to time constraints, both Mary and Allen received only three maintenance checks for the skill of baking canned biscuits. Mary completed the sandwich-making maintenance sessions with a mean accuracy of 99%. She independently completed 94% of the boil-in-bag task analysis and subsequently completed 99% of the steps on the biscuit-baking task analysis. Allen completed the sandwich-making maintenance sessions with 89% of the steps independently completed. During the boil-in-bag and biscuit-baking maintenance sessions, Allen independently completed 86% of the steps for both skills.

Following the maintenance probe sessions, two students completed the tasks in their homes. Parental cooperation and time constraints did not allow these sessions to be conducted with all students. Allen completed the sandwich-making task analysis with 100% accuracy. On the two remaining skills, Allen independently completed 91% and 95% of the steps of the boil-in-bag and biscuit-baking task analyses, respectively. Andrew independently completed 100% of all steps of each task analysis.

Time-Delay Instructional Data

The minimum number of sessions to criterion in which each subject could reach criterion on each skill was five (two sessions at 0-s delay and three sessions at 100% accuracy on a CRF, VR 3, and FR 21 or 23 schedule). Students required between 17 and 34 sessions above minimum to reach criterion on all three skills (6 to 14 sessions for making a sandwich, 2 to 13 sessions for boiling a boil-in-bag item, and 4 to 12 sessions for baking biscuits).

A total of 27 hr and 18 min was required for training all students all three chained responses. Students required between 267 and 519 min of direct instructional time to learn all three skills.

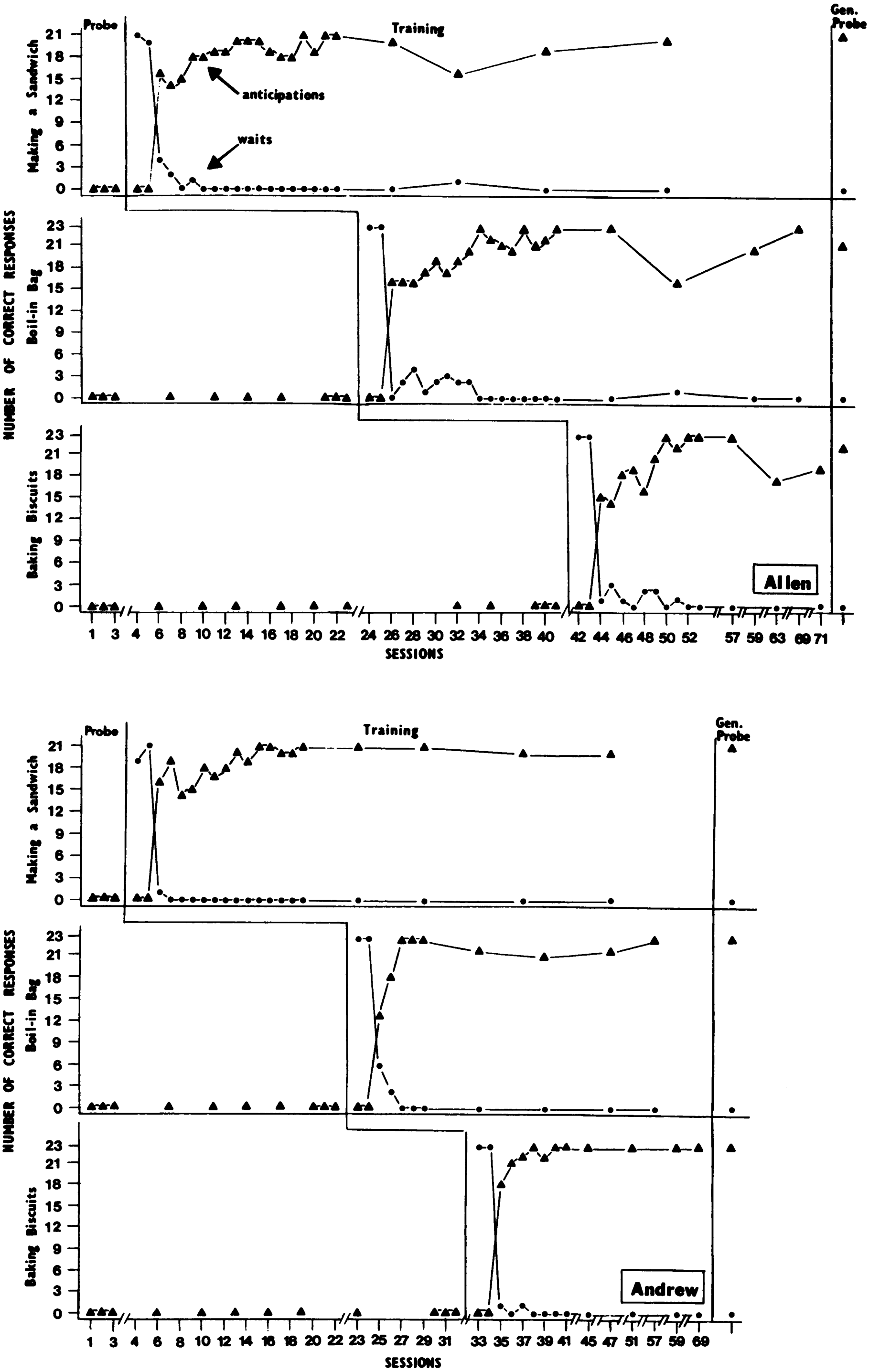

Figure 1. Number of steps correctly completed across all skills for Allen, Andrew, Mary, and Erin. The number of steps completed independently before the prompt (correct anticipations) are represented by closed triangles. Correct waits, those responses correctly completed after the prompt, are represented by closed circles.

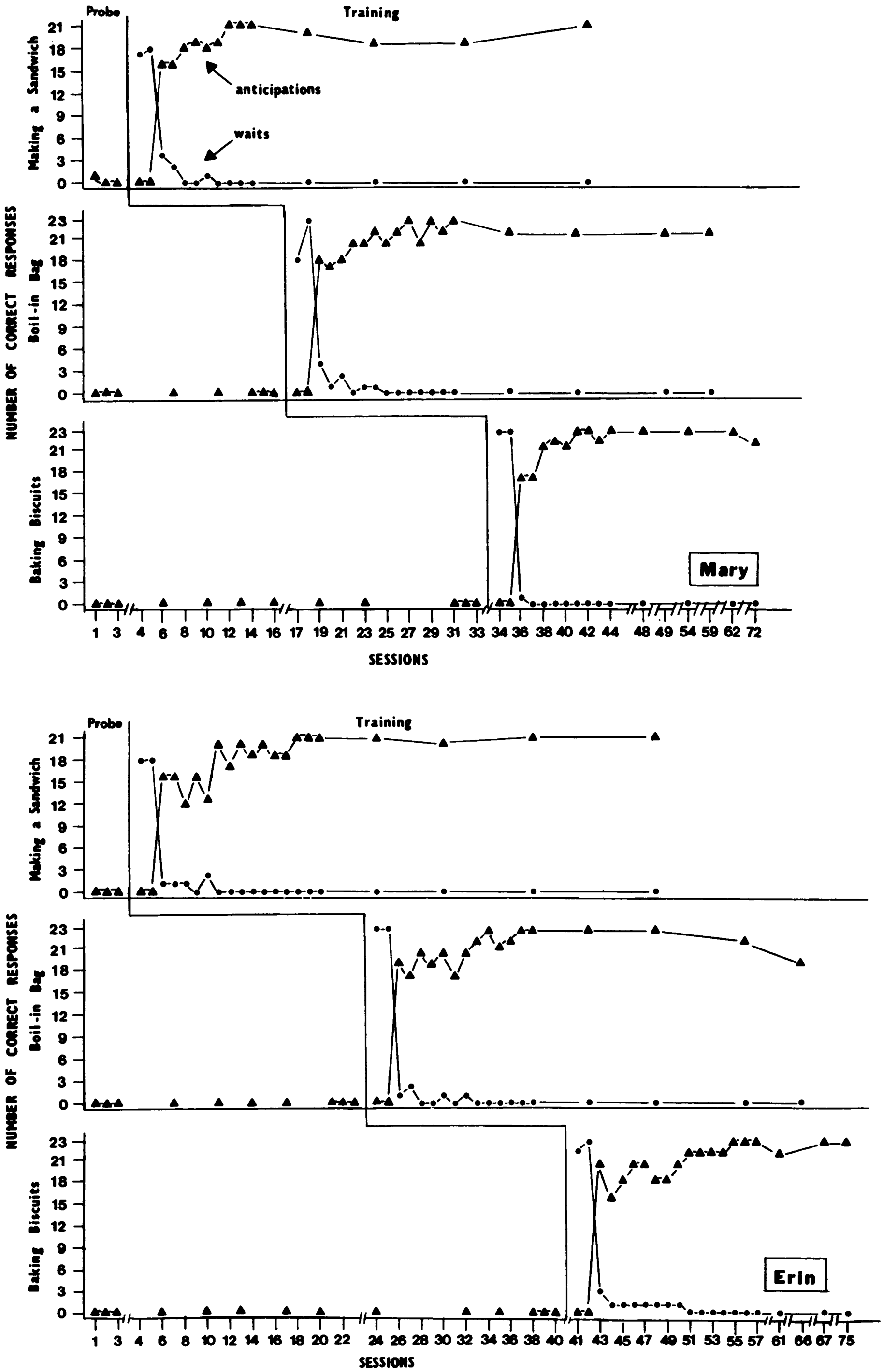

Figure 1. Continued.

Making a sandwich required the least amount of instructional time (372 min) with training time per student ranging from 72 to 133 min. For all students to reach criterion on the boil-in-bag task, 606 min of instructional time were needed (range, 64 to 207 min). Finally, baking canned biscuits required the most direct instructional time: 652 min (range, 130 to 244 min).

For all students and all time-delay sessions across all skills, 314 errors occurred. When the number of steps in each task is multiplied by the number of sessions conducted and divided by the number of errors, an overall error percentage of 8.4% is obtained. This low error percentage was found across skills. Of the 314 errors, 292 nonwait errors (93%) and 22 wait errors (7%) occurred. Of the 292 total nonwait errors, 266 (91%) were sequential errors, 26 (9%) were topographical errors, and none were duration errors. Wait errors included 14 (64%) topographical errors and 8 (36%) duration errors.

Cost Analysis

The total costs incurred during this study were $394.89. The cost of all materials and food supplies for all skills taught was $301.09—approximately $75.00 per student and $25.00 per skill per student. The average cost of a boil-in-bag item was $0.59 and each can of biscuits averaged approximately $0.54. The costs involved in training sandwich-making were variable depending on the type of meat, cheese, and bread used. Trainer costs, excluding reliability observers, totaled $93.90 (28 hrs of training time multiplied by $3.35 an hour).

DISCUSSION

Although all students learned and maintained the targeted skills over time, it cannot be determined whether the skills could have been taught more efficiently with other procedures (e.g., system of least prompts). However, several instructional variables, some of which measure efficiency of the constant time-delay procedure, reveal data that appear efficient.

Training time indicates that two of the skills (boil-in-bag and baking biscuits) required twice as much instructional time as making a sandwich. However, these skills involved "dead" time. A large proportion (about 60% for boil-in-bag items and 75% for baking biscuits) of the training time elapsed during the actual cooking time. Subtracting these times from the total instructional time reduces it to 2¾ hours. It may be beneficial to train other cooking-related skills during this dead time (e.g., setting the table, cleaning, preparing other foods). This would provide a natural setting and time for their instruction (Brown et al., 1980).

A common procedure for teaching chained skills is the system of least prompts (Doyle, Wolery, Ault, & Gast, 1988). This system involves a hierarchy of prompts that are presented systematically on each trial until a correct response occurs. The constant time-delay procedure used in this study is more parsimonious because only one prompt level was provided on each trial. This simplicity and the superiority of the delay procedure over the system of least prompts with discrete responses (cf. Bennett et al., 1986; Godby et al., 1987) suggest that comparisons of the two procedures are needed with chained tasks. Critical measures in these comparisons are instructional time, percentage of errors, trainer effort, and trials to criterion.

Delay procedures have been found to be efficient in teaching a variety of discrete responses with a small percentage of error (usually less than 4%; Wolery, Ault, Doyle, & Gast, 1986). Of the two published studies that taught chained responses using time-delay procedures, Snell (1982) reported error percentages between 0 and 8% during bed-making acquisition, and Walls et al. (1982) did not report an error percentage. The overall percentage of errors in this study was 8.4%. Students were required to complete each step of the task analysis in a predetermined order. Of the errors committed, over 86% were errors caused by subjects performing a correct step at the wrong time. If these sequence errors are not considered (allowing subjects to complete a task in a "functional" rather than a preset sequence), a total of 44 errors occurred during the 3,715 trials trained for an error percentage of 1.1%.

The financial costs of teaching food preparation skills may prohibit teachers from targeting these skills for instruction. These costs are due to the nature of the targeted skills rather than the teaching procedure used. Several procedures can be used to limit the training costs involved. For example, Johnson and Cuvo (1981) reused food, and Schlein, Ash, Kiernan, and Wehman (1981) modified training supplies (e.g., used an empty but covered TV dinner tray when teaching baking). However, when supplies are reused or modified, the teacher does not have the opportunity to use the prepared food as the "natural" reinforcer. Future research should explore ways of teaching cooking skills at a minimal cost while still maintaining a normative, functional training program (e.g., group instruction).

Anecdotal information from the participants and parents found the goals of the program to be socially valid, the procedures effective and efficient, and the achieved effects educationally significant. The procedure was "not difficult" to use; it required one prompt level instead of numerous prompts (as used in the system of least prompts). The trainers stated that the time-delay procedure takes less time than the system of least prompts because students do not have to wait through several prompt levels before a controlling prompt is delivered. Because of its simplicity, the method should be easily used by paraprofessionals, parents, students, and other service providers.

Although training was conducted outside the subjects' home environments, generalization was programmed by the use of multiple exemplars (Stokes & Baer, 1977). Most materials were changed daily to include as many examples of the training materials as possible. Students used four types of bread, seven meats, and three cheeses in addition to a variety of salad dressings. Over 10 different boil-in-bag items including meats, vegetables, and potatoes and more than a dozen brands and types of biscuits were used with varying cooking times. Using multiple exemplars, students learned to complete over 40 different sandwiches, boil-in-bag items, and biscuits. Students also were exposed to different materials, equipment, and trainers, which may have resulted in less monotonous training conditions and possibly more on-task behavior. It seems logical that a variety of foods is more interesting than receiving the same food every day and may decrease the possibility of satiation.

In this study, students were required to complete each task analysis in a predetermined order so that trainer effort would be simplified and reduced, possibly leading to a higher percentage of trainer fidelity. By using a predetermined sequence, students were possibly taught a habit that would transfer more efficiently to other settings and skills (each student was required to obtain, use, and put away each material before obtaining another). This rationale should be empirically tested. Considering that over 86% of all errors in this study were "sequence" errors, the issue of requiring students to complete task analyses in a predetermined order or in a "functional" order should receive attention in the literature.

During the baselines of most chained-response studies in the literature, subject performance was not assessed on each step of the task analysis. In general, a task direction is given and the number of consecutive independent steps correctly completed is recorded. These types of baseline procedures may deflate subject responding: subjects may not correctly perform initial steps in the chain yet be competent in completing subsequent steps when stimulus conditions are arranged differently. In this study, baseline performance was assessed in two ways. A task direction was delivered and the number of steps completed correctly was recorded. Also, each step of the task analysis was assessed individually so that a "true" measure of baseline performance was obtained. There were several disadvantages to assessing "true" baseline performance: materials were depleted during each session (increasing training costs), and students often "gave up," expressed discontent, and engaged in bizarre behavior (repeating an incorrect step such as going to a cabinet, opening and closing it, and returning to his or her seat). Research efforts need to find the most effective and efficient procedures for assessing baseline performance.

A 5-s constant time-delay procedure was effective in teaching three chained responses. Results indicate that the skills were maintained with at least 85% accuracy over a 3-month period. Measures of efficiency suggest that the procedure resulted in a low percentage of errors (i.e., <9%). In addition, the data collected from other instructional measures (e.g., total training time to criterion, cost effectiveness data, and other unreported measures) indicate positive results. More research on the constant time-delay procedure with other chained responses should ascertain the effectiveness and efficiency of this procedure compared to other instructional methods.

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