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PROMPTING AND STIMULUS SHAPING PROCEDURES FOR TEACHING VISUAL-MOTOR SKILLS TO RETARDED CHILDREN

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Stimulus shaping appears to be a highly successful way to teach discrimination skills. In stimulus shaping, the topographical configuration of the stimuli is gradually changed over trials so that discrimination is at first easy, and then gradually more difficult. Stimulus shaping procedures might also be effective for training visual-motor tasks. Two experiments were conducted to assess the relative effectiveness of stimulus shaping and "traditional" prompting procedures. Pegboard skills were trained in Experiment 1. In Experiment 2 a self-care skill was trained, in which children learned to hang a toothbrush or a washcloth on a specific hook. Six low-functioning retarded children were studied in each experiment, using a within-subject alternating treatments design. Each participant received concurrent training on two related tasks, using stimulus shaping for one and a standard prompting procedure for the other. Training with the stimulus shaping procedure required less training time to criterion, always resulted in fewer errors, always required fewer and less intrusive therapist's prompts, and always resulted in greater density of reinforcement. These results demonstrate the value of stimulus shaping strategies for training visual-motor skills.

DESCRIPTORS: retarded children, stimulus shaping, visual-motor skills

To reduce the number of errors that the retarded individual may produce during training, therapists often provide prompts as extra cues to guide the response. Prompts include pointing, modeling the correct behavior, and direct physical manipulation. These methods all involve an intervention by the trainer. An alternative procedure, known as stimulus shaping, has been found highly successful in training visual discrimination skills. In this study, we examined whether stimulus shaping is also valuable for teaching visual-motor skills, by evaluating the procedure against a commonly used prompting procedure.

Many studies have successfully used prompting programs to teach visual-motor skills. A wide variety of skills have been trained, including bench frame assembly (Gold, 1976), brake assembly (Gold, 1972), janitorial skills (Cuvo, Leaf, & Borakove, 1978), toothbrushing (Horner & Keilitz, 1975), card package assembly (Brown, Bellamy, Perlmutter, Sackowitz, & Sontag, 1972), and fishing reel assembly (Koop, Martin, Yu, & Suthons, 1980). Although a "standard" program does not exist, it is possible to identify some common procedural features: The training materials for each step in training are held constant across trials in the step (Cuvo et al., 1978); the instructional cues are presented on each trial; and then if necessary, a sequence of therapist's prompts is used. The specific sequence of prompts used varies across programs, and may include additional instructions, gestures, modeling, and physical interaction. The therapist may provide one or more of these prompts on a given trial. Mild prompts (e.g., verbal instructions, gestures) are usually delivered prior to more intrusive prompts (e.g., physical contact). This sequencing is designed to ensure that the least necessary assistance is provided. As training progresses, the client should require less prompting. Use of this sequence also ensures that the rate at

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which the prompts are withdrawn is controlled by the client's behavior.

The final characteristic of prompting procedures involves the delivery of reinforcement for prompted and unprompted responses. Reinforcement may be in the form of social praise (Gold, 1972, 1976), or social praise plus an edible or token (Cuvo et al, 1978; Horner & Keilitz, 1975; Brown et al., 1972). Koop et al. (1980) found that the combined reinforcement was more effective than praise alone.

The purpose of prompting is to increase the probability of a correct response. However, if the client attends only to the prompting stimulus and does not attend to the training stimuli, then the client will be unable to perform the correct discrimination when the prompt is removed. Some prompts may distract the child from the relevant stimulus dimensions (Cheney & Stein, 1974; Etzel & LeBlanc, 1979; Guralnick, 1975; Koegel & Rincover, 1976; Rincover, 1978; Schilmoeller & Etzel, 1977; Schilmoeller, Schilmoeller, Etzel, & LeBlanc, 1979; Schreibman, 1975; Wolfe & Cuvo, 1978), so that the child's behavior remains under the control of the prompting cues.

Retarded individuals often attend primarily to the stimulus being manipulated (Etzel & LeBlanc, 1979). Prompts that manipulate stimuli that are spatially isolated from the critical stimulus dimension may be inferior to prompts manipulating stimuli that are close. Schreibman (1975) compared two kinds of prompts. For the "extra-stimulus" prompt the therapist pointed to the correct stimulus and then, over trials, gradually increased the distance of the finger from the stimulus materials. For the "within-stimulus" prompt the therapist gradually introduced the critical elements of the S−. The "within-stimulus" prompt was more effective. Other studies have found that providing no prompt, or trial-and-error learning, may often be more effective than using prompts that are not related to the criterion discrimination (Cheney & Stein, 1974; Gollin & Savoy, 1968; Guralnick, 1975; Koegel & Rincover, 1976).

A prompting procedure that manipulates "criterion-related cues" has been labeled "stimulus shaping" (Bijou, 1968; Etzel & LeBlanc, 1979; Schilmoeller & Etzel, 1977; Schilmoeller et al., 1979; Sidman & Stoddard, 1966; Stoddard & Sidman, 1967). Stimulus shaping may be defined as "manipulating the topographical stimulus configuration" of a criterion-related stimulus (Schilmoeller et al., 1979). "Such alterations of the stimuli should focus the child's attention on the essential differences involved in the final discrimination." Thus "transfer should be aided" (Etzel & LeBlanc, 1979, p. 370). One of the first stimulus shaping procedures was developed by Stoddard and Sidman (1967). Subjects were required to discriminate circles from ellipses. A circle (S+) and relatively flat ellipses (S−) were simultaneously presented. The axes of the ellipses were then gradually made more nearly equal over trials, increasing their similarity to circles.

Relatively little research has been done on the use of stimulus shaping strategies for training visual-motor skills. Apparently only one study has systematically compared a "standard" prompting procedure with a stimulus shaping procedure for such a task. Gold and Barclay (1973) attempted to train retarded individuals to sort bolts into two piles, according to length. One group (Hard Group) began with the criterion pile. A second group (Easy Group) was trained on bolts of greatly differing lengths, and subsequent piles were increasingly similar. Verbal instructions were provided, and pointing prompts were used to correct errors. All individuals in the Easy Group, but none of the subjects in the Hard Group, learned the task.

Our study assessed the effectiveness of a stimulus shaping strategy to teach visual-motor discrimination skills to retarded children. These skills involved position and length discriminations. Two training procedures were compared. The prompting only procedure was a "standard" method which incorporated the three procedural features outlined earlier. It involved: (a) presenting the task at the criterion level; (b) providing a sequence of therapist's prompts on each training trial, to ensure correct responding on each trial; and (c) providing social plus edible reinforcement at the end of each trial. The second training procedure was labeled shaping plus prompting. This method differed from prompting only in that it included a procedure to gradually shape the task materials using criterion-related cues. A backstep correction routine was also used in the shaping procedure (Stoddard & Sidman, 1967).

General Method

The experimental design was a multielement, alternating treatments, within-subject design (Barlow & Hayes, 1979; Hayes, 1981; Hersen & Barlow, 1976; Ulman & Sulzer-Azaroff, 1975). Each day, for each child, two tasks were trained which the experimenter judged to be approximately equal in level of difficulty. One was trained under the prompting only format, and the second under the shaping plus prompting format. One task was trained in the morning, and the other in the afternoon. The assignment of procedure to training task was counterbalanced across children. The daily order of training for the two tasks varied randomly within children, across days. Two therapists were used, one for each study. Both therapists had several years experience in the use of behavioral procedures with the retarded. They were trained in the shaping and prompting procedures to be used for this study using a conbination of lectures, role playing, modeling, and immediate feedback for performance.

Training sessions took place in a small room. The therapist escorted the child into the room, and both sat at a small table, with the therapist to the child's right. For the task trained using prompting only, the final difficulty level was trained. For the task trained using shaping plus prompting, a sequence of levels was trained.

Two safeguards were taken to ensure that the treatment procedures were implemented accurately. The therapist's actions were periodically observed by the first author, and the therapist was given feedback about deviations from the required procedure. Also, to prevent treatment bias, the therapists were not informed of the experimental hypothesis.

Dependent Measures

For each presentation of the stimulus materials, the trainer recorded whether or not a correct response was made, and what type of prompting, if any, was used.

Interobserver Agreement

Interobserver agreement was assessed across both treatment methods. An observer in the observation room recorded the child's responses as correct or incorrect and the types of prompts delivered. Agreement was calculated using the formula: number of agreements/number of agreements plus disagreements × 100.

EXPERIMENT 1

This experiment compared the relative efficacy of the shaping plus prompting and the prompting only procedures, for training two pegboard skills. These skills were selected as characteristic of preacademic visual-motor skills that are expected of children like those trained here, and as sufficiently similar to be suitable for use in an alternating treatments design.

METHOD

Participants

Six children from three local facilities and schools for the retarded were studied. Selection criteria were: (a) the child was diagnosed as either moderately or severely retarded; (b) a low rate of correct responding occurred during baseline testing; (c) there were no physical handicaps that might impede performance of the motor skills; and (d) the child could be readily trained in appropriate sitting and attending. The brief descriptive material which follows was taken from the assessment data collected by the treatment institution. The six children (C1 through C6) were two females and four males. Their mean age was 4 years 3 months. C1 was a 5.4-year-old female. She had been diagnosed as severely retarded, with major deficits in the areas of productive language and motor behavior. C2 was a 6.1-year-old male, diagnosed as brain damaged and severely retarded, with high rates of noncompliance, hyperactivity, self-abuse, and aggression. C3 was a 4.6-year-old male, diagnosed as severely retarded, with major language deficits but with strengths in visual-motor skills. C4 was a 1.8-year-old female, diagnosed as moderately retarded, with particular deficits in expressive language and motor skills. C5 was a 3.1-year-old male, functioning in the upper range of moderate retardation. C6 was a 4.8-year-old male, diagnosed as autistic and intellectually untestable. He was estimated to be functioning in the moderate range of retardation.

General Procedure

Each child was trained on both tasks. The shaping plus prompting procedure was used to train task 1 for C2, C4, and C5, and the prompting only procedure was used to train this task for the other three children.

Both tasks were pegboard-insertion tasks. Final criterion performance was to place two pegs (7.6 × 0.9 cm) into two specific (S+) holes of a six-hole Plexiglas board. The configuration of the holes differed for the two tasks, as did, therefore, the correct locations for the pegs. Criterion related cues were manipulated by gradually increasing the number of incorrect holes and their similarity (in size) to S+ holes. To facilitate discrimination between tasks, the board and pegs for each task were differently colored, and the verbal instructions differed.

Each task was divided into 13 levels, of increasing difficulty. For each child one task was trained through these levels (shaping plus prompting) and the other was trained only at the criterion level (prompting only). To differentiate the 13 levels, small S− holes were introduced, and then gradually made larger in successive levels. A new S− hole was introduced in levels 2, 5, 8, and 11. At first each S− hole was too small to receive a peg, but it reached full size in two steps; that is, on steps 4, 7, 10, and 13. Once introduced, the holes did not change location. Figure 1 shows the board at four representative levels.

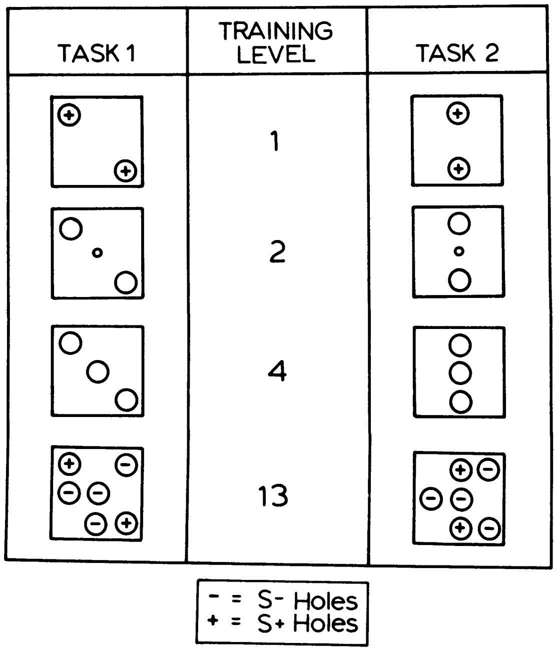

Figure 1. Representative training levels for the two pegboard tasks in Experiment 1.

Each trial included from one to four opportunities to respond correctly, with an increasing degree of prompting after each error, until a correct response occurred. A trial began when the therapist presented the Plexiglas square and two pegs and gave a verbal instruction: "Put the pegs in the corner holes" (Task 1) or "Put the pegs in the outside holes" (Task 2). A completed response was to place the pegs into two holes within approximately 5 seconds, and to remove the hand, leaving the pegs standing. A specified sequence of prompts was given, until a correct response occurred, as described in the next section. A trial ended when correct performance occurred, with whatever type of prompting was required. Edible reinforcement was delivered at the end of each trial, even though prompting had occurred. This tactic may sometimes encourage reliance on the prompt, but it ensures that reward is provided even for low levels of performance, and encourages increases in performance by providing shorter and more frequent rewards. Training was terminated on the day the child reached a criterion of 8 of 10 correct unprompted responses at the criterion level, on either task. Each training session lasted approximately 20 minutes, and included however many trials could be conducted during that time.

Shaping and Prompting Procedures

A sequence of instructions and prompts were given on each trial. First, the instruction only was used (with no prompt). If correct responding did not occur, there followed instruction plus pointing, instruction plus modeling, instruction plus physical prompt, and instruction plus hand-over-hand guidance, in sequence, until a correct response occurred. If the child failed to respond correctly to the initial instruction, or a subsequent prompt type, within 5 seconds, the next prompt type was delivered, and the child again had 5 seconds to respond. Each error resulted in delivery of the next prompt type until the child performed the correct response, with hand-over-hand guidance if necessary. Thus, as many as four errors could occur for a single trial, but only one correct response.

For instruction plus pointing, the therapist gave the instruction and pointed at the square, but not at the specific S+ holes. For instruction plus modeling, the therapist repeated the instruction and demonstrated the correct response, placing the pegs in the correct holes for approximately 1 second, then placing them before the child. For physical prompting, the therapist repeated the instruction and touched the back of the child's hand without guiding it. For hand-over-hand guidance, the therapist repeated the instruction and used the least amount of manual guidance that seemed necessary to ensure correct performance.

A backstep tactic was used in the shaping plus prompting procedure to reduce successive errors at the same training level. The backstep procedure was used if any of three error criteria was met: a more extreme prompt type was given than had been given on the preceding trial at the same training level; five consecutive prompts of any type were given at the same level; or three consecutive modeling prompts, physical prompts, or hand-over-hand guidance prompts were given at the same level. When an error criterion was met, the child was retrained at an easier level and then readvanced one level at a time. The child was usually backstepped several levels (a procedure that was judged desirable from pilot work).

The new level after backstepping depended on the level that the error criterion was met. If the error criterion was reached during training through level 7, then retraining began at level 1. If the error criterion was reached after level 7, then retraining began from level 7.

Experimental Phases

All children received three experimental phases: baseline, treatment, and generalization.

Baseline. The child was presented with a block of 20 trials for each task, in two daily sessions. An instruction was given for each trial, but no additional prompts were given. The order in which the two tasks were presented each day was randomly determined. One task was trained in the morning and one in the afternoon. No baseline data were obtained in the generalization settings (different therapist or room).

Treatment: prompting only (PO). This procedure was used to train one of the two tasks (always the same task, for a given child). Training was given with the stimuli presented only at the criterion level (Level 13).

Treatment: shaping plus prompting (S + P). This procedure was used to train the other task. Training was given on the sequence of 13 levels, beginning at Level 1. The child advanced one level contingent on a correct unprompted response. If the child failed to reach criterion in one day, training on the following day began at Level 1 and only one trial at each level was given, with prompting as required, but with no backstepping, until the child reached the level mastered on the preceding day. These rehearsal trials were included in the error and trial count.

Therapist and setting generalization. When one task had been trained to criterion, generalization was tested across therapists and settings, for that task. In one session a different therapist gave a series of training trials at the criterion level. In another session the original therapist continued training at the criterion level in a different room.

Table 1

Data for Children in Experiment 1 (S + P = Shaping Plus Prompting Procedure; PO = Prompting Only Procedure)

Child	Criterion achieved S + P	Criterion achieved PO	Total prompts delivered S + P	Total prompts delivered PO	Total trials (& reinforcers) S + P	Total trials (& reinforcers) PO	Generalization (% correct) Therapist	Generalization (% correct) Setting
1	yes		80	158	113	43	100	100
2	yes		18	47	37	13	89	100
3	yes	yes	12	14	26	18	—	—
4	yes		38	79	58	26	100	100
5	yes		14	40	30	10	72	100
6	yes		319	562	394	151	—	73

Table 2

Distributions of Therapist's Prompts as a Function of Training, for Experiment 1

Child	Prompt types	Shaping plus prompting Total %	Shaping plus prompting Total % successful	Prompting only Total %	Prompting only Total % successful
1	Point	51	51	27	4.5
	Model	25	22	25	0
	Physical	14	7	25	9.5
	Hand-over-hand	10	20	23	86
2	Point	50	56	28	7.5
	Model	22	11	26	7.5
	Physical	17	11	23	0
	Hand-over-hand	11	22	23	85
3	Point	75	67	43	50
	Model	25	33	21.5	0
	Physical	0	0	21.5	17
	Hand-over-hand	0	0	14	33
4	Point	58	50	29	13
	Model	29	32	25	9
	Physical	10	14	23	0
	Hand-over-hand	3	4	23	78
5	Point	50	57	25	0
	Model	22	14	25	0
	Physical	14	0	25	0
	Hand-over-hand	14	29	25	100
6	Point	54	52.5	27	4.5
	Model	25	23	26	3
	Physical	13	10	25	11
	Hand-over-hand	8	14.5	22	81.5

Correct responses received praise only. Each session was conducted on a different day, and at least 10 trials were presented in each session.

Results

Interobserver agreement checks were made in 14 scattered sessions (16% of sessions). Checks were made for the number of trials, the number of errors, and the types of prompts presented for each trial. Scores for the three dependent measures ranged from 89% to 100%, with a mean of 98%. Baseline performance was 0% correct for most children, for both tasks. Child 1 performed two correct responses (of 20) on the prompting only task, and Child 4 performed two correct responses on the shaping plus prompting task.

Of the six children, five reached criterion first under the shaping plus prompting (S + P) procedure. Child 3 reached criterion on both tasks in the same day. The individaul results are presented in Figure 2. The cumulative number of errors is plotted as a function of the number of instructions (as many as five instructions and four errors per trial). The performances of C1, C2, C4, C5, and C6 are quite similar. Training under S + P produced quicker learning with a relatively low rate of errors. C3 differed somewhat. C3 made fewer errors with the S + P procedure, but reached criterion on both tasks, and at approximately the same time. In terms of the number of instructions presented, criterion was reached on the PO task first.

Table 1 provides data summaries for each child. Columns 2 and 3 show which procedure reached criterion. Columes 4 and 5 show the total number of prompts delivered. For all children, the S + P procedure required fewer prompts. Columns 6 and 7 show the number of training trials, which is equal to the number of reinforcers delivered. This value can be considerably less than the number of prompts. For all children, more trials and reinforcers were presented with the S + P procedure, for equivalent training times. The last two columns show generalization across therapists and settings. Generalization data could not be obtained for C3 or C6, both of whom left the institution just after

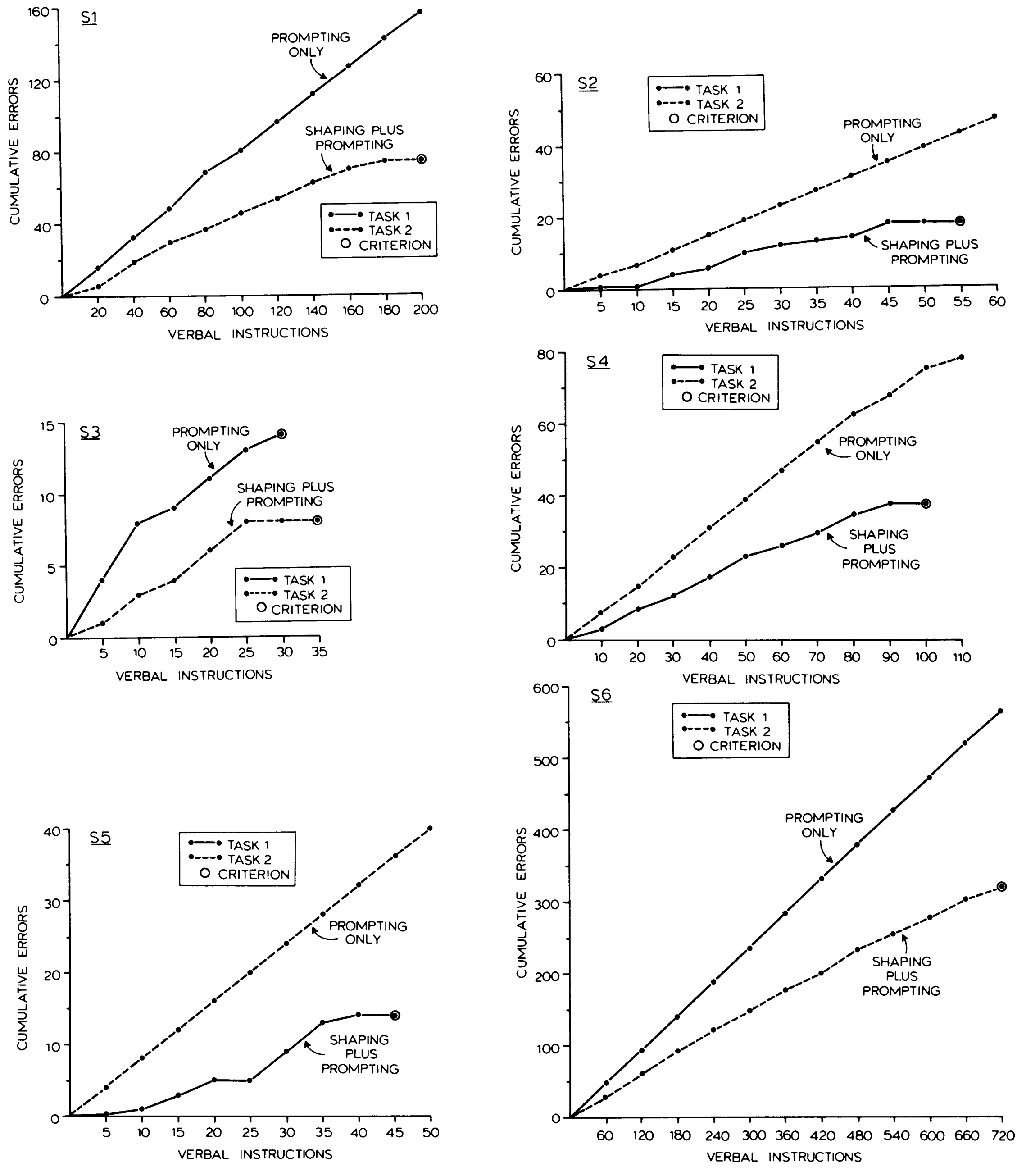

Figure 2. Cumulative errors for C1–C6, as a function of the number of instructions. The larger circle shows where criterion was reached.

training. Correct performance in the generalization situations was high. However, no pretraining data had been collected in these specific settings, to provide a baseline.

Table 2 shows the distribution of prompts among the four prompt types. The table shows the distribution of total prompts and the distribution of successful prompts. For total prompts, there were relatively fewer hand-over-hand prompts and physical prompts for the S + P procedure, and relatively more pointing prompts under S + P. The distributions of successful prompts are shown in columns 2 and 4. The pointing prompt was most successful for the S + P procedure. For the prompting only procedure, the hand-over-hand prompt was generally most successful.

EXPERIMENT 2

This experiment compared shaping plus prompting and prompting only for a self-care task.

METHOD

Participants

Six children from two local facilities and schools for the retarded were studied. The selection criteria were the same as in Experiment 1.

The six children (C7 through C12) were two females and four males. Their mean age was 5 years 2 months. All children had participated in structured skill training programs. C7 was a 9.9-year-old microcephalic female. Records of the institution rated her as intellectually untestable but she was estimated to be severely retarded. She was aggressive and noncompliant. C8 was a 4.4-year-old severely retarded female (Bayley Scales), with deficits in all areas of functioning. C9 was a severely retarded 8.1-year-old male (Stanford-Binet scales). He was both aggressive and noncompliant. C10 was a 2.5-year-old moderately retarded male (Bayley Scales) with deficits in all areas of functioning. C11 was a 3.1-year-old Down's Syndrome male, classified as moderately retarded (Bayley Scales). C12 was a 3.3-year-old male, classified as moderately retarded on the Bayley Scales. He was brain damaged, born with no corpus callosum, and showed severe deficits in all areas of functioning.

General Procedure

Each child was trained on two tasks (Tasks 3 and 4). The shaping plus prompting procedure was used to train one task (Task 3, for C7, C10, and C12, and Task 4 for the other children), and the prompting only procedure was used to train the other task.

Training tasks. A common activity of daily living involves placing self-care articles such as toothbrushes or washcloths in specific locations. In this experiment the child was given 5 seconds to hang a toothbrush (Task 3) or a washcloth (Task 4) on a specific peg on a board with four pegs, and to remove the hand from the object, leaving it in place. The location of the correct (S+) peg differed for the two tasks. The pegs and boards for the two tasks were of different colors, to enhance discrimination between them.

Each task was subdivided into 10 levels. The S+ peg was present for all levels. "Distractor" pegs were introduced, in steps, into the other positions on the board. The distractor pegs differed in length: short (0.95 cm), medium (1.9 cm), or as long as the S+ peg (4.3 cm). When first introduced, each distractor peg was short, then on the next trial it was medium, and for the remainder it was long. A new distractor peg was introduced at levels 2, 5, and 8. A horizontal wooden bar just below the pegs prevented the child from successfully hanging the toothbrush or washcloth from any but a long peg.

The pegboard was located on the table in front of the child. At the beginning of each trial the therapist placed the board and the self-care article in front of the child, and said: "Put the toothbrush (washcloth) on its peg." A correct response was defined as hanging the self-care item on the correct peg within 5 seconds. If necessary, to ensure correct responding, the therapist prompted during training trials. Training and data collection followed the pattern in Experiment 1.

Experimental phases. As in Experiment 1, all children received three experimental phases: baseline, treatment, and generalization. Children were trained in both tasks, using a different training method for each, as in Experiment 1. The back-stepping procedure depended on the level at which the error criterion was met. Error criteria were the same as in Experiment 1. If an error criterion was reached during training on Levels 1 through 5,

Table 3
Data for Children in Experiment 2 (S + P = Shaping Plus Prompting Procedure; PO = Prompting Only Procedure)

Child	Criterion achieved S + P	Criterion achieved PO	Total prompts delivered S + P	Total prompts delivered PO	Total trials (& reinforcers) S + P	Total trials (& reinforcers) PO	Generalization (% correct)	
7	yes		10	23	19	12	83	100
8	yes		5	20	15	6	100	100
9	yes	yes	0	11	13	9	75	73
10	yes		4	13	15	11	100	80
11	yes		5	19	13	11	83	100
12	yes		12	24	39	28	80	80

retraining began from Level 1; if the error criterion was reached during training on Levels 6 through 10, Level 5 was presented on the next trial. Generalization was tested using the same procedures as in Experiment 1.

Results

Interobserver agreement checks were made for the number of trials, the number of errors, and the types of prompts used. Five scattered reliability sessions were carried out (16% of sessions). All sessions showed reliability scores of 100% for the three dependent measures.

Baseline performance was 0% for all children but Child 11, who performed correctly on 4 of 20 trials on the Prompting Only task. All six children reached criterion first under the S + P procedure. Individual data are presented in Figure 3, with cumulative errors plotted as a function of the number of verbal instructions, as in Experiment 1. For all children, training under the S + P format produced a relatively low rate of errors.

Table 3 provides data summaries. Columns 2 and 3 show which procedure reached criterion. The next two columns show the total number of prompts delivered during training. For all children, for equal training times, the S + P procedure produced fewer errors, and required fewer prompts. The next two columns show the number of trials or reinforcers given. These were generally greater for the S + P procedure because these trials required fewer prompts. Generalization data are given in the final columns.

Table 4
Distributions of Therapist's Prompts as a Function of Training, for Experiment 2

Child	Prompt types	Shaping plus prompting Total %	Shaping plus prompting Total % successful	Prompting only Total %	Prompting only Total % successful
7	Point	50	60	48	55
	Model	20	0	22	9
	Physical	20	20	17	9
	Hand-over-hand	10	20	13	27
8	Point	40	0	25	0
	Model	40	50	25	0
	Physical	20	50	25	0
	Hand-over-hand	0	0	25	100
9	Point			46	20
	Model			36	60
	Physical			9	0
	Hand-over-hand			9	20
10	Point	50	0	69	78
	Model	50	100	15	11
	Physical	0	0	8	0
	Hand-over-hand	0	0	8	11
11	Point	80	75	58	45.5
	Model	20	25	32	45.5
	Physical	0	0	5	0
	Hand-over-hand	0	0	5	9
12	Point	83	80	83.5	90
	Model	17	20	8.5	5
	Physical	0	0	4	0
	Hand-over-hand	0	0	4	5

Table 4 shows the distribution of prompts. No prompts were required for C9 for the S + P procedure. As in Experiment 1, the successful prompts for the S + P procedure were typically less intrusive, although the difference is less marked than in the previous study.

GENERAL DISCUSSION

Relative to the tasks trained under the prompting only procedure, the tasks trained under the stimulus shaping procedure required less training time to criterion for all but one child, resulted in fewer errors, required fewer and milder therapist's

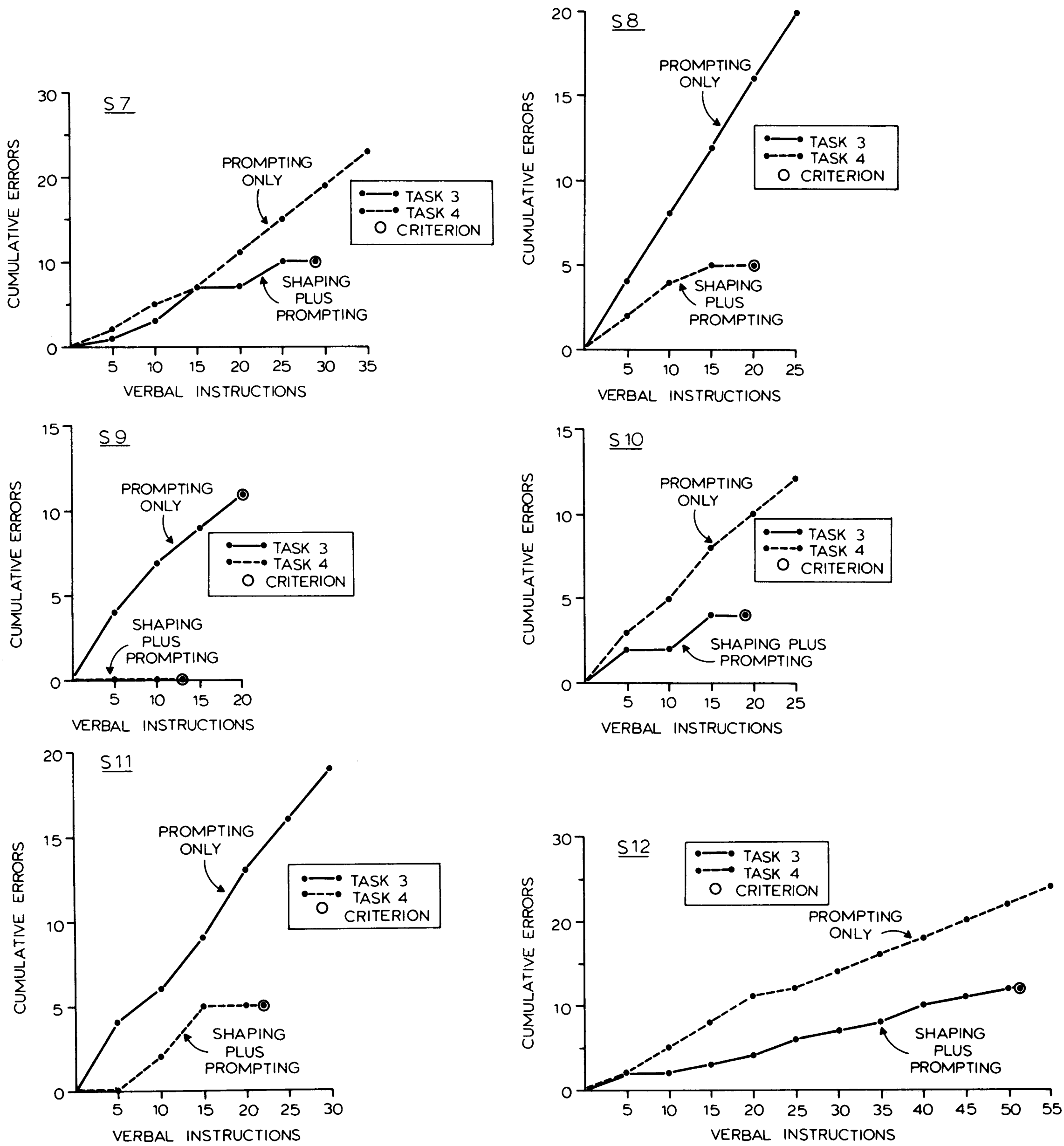

Figure 3. Cumulative errors for C7–C12, as a function of the number of instructions. The larger circle shows when criterion was reached.

prompts, and resulted in more frequent reinforcement. Training under the shaping procedure was characterized by many short trials and required fewer intrusive prompts. The prompts were typically minimal (e.g., gestures).

The use of this technology must be both time- and cost-efficient to be of practical value in the clinical setting, although training ease and time are not the sole considerations. The steps of the shaping program must be designed, and suitable materials must be procured. Some technology in facilitating program development is already available. The construction of a visual-motor shaping program need not be expensive. The costs involved in the construction of the self-care training apparatus in Experiment 2 were quite low. With increased experience and research, the efficiency of this technology should increase.

Several procedural features of the stimulus shaping program may not have been optimal, and could be subjected to further research. First, the S− stimuli were varied from trial to trial rather than the S+, and the dimension that was varied was not constant for all the steps. Shaping S− but not S+ may not be the best procedure. Two recent studies have systematically examined the effects of varying S+ or S− over trials (Schreibman & Charlop, 1981; Stella & Etzel, 1978). Both studies found fewer errors when only S+ was shaped and S− was presented at the criterion level. For both experiments here, however, S+ was held constant and S− was manipulated. There are studies which have successfully shaped S− (Bijou, 1968; Gold & Barclay, 1973; Schilmoeller et al., 1979; Sidman & Stoddard, 1966). Only the latter study, however, shaped only the S− stimulus. The other studies shaped both S+ and S−.

Second, in the Schreibman and Charlop (1981) and the Stella and Etzel (1978) studies, the topography of the response requirement did not change over trials. Only a cue selection response was required. For more complex responses, however, such as those used here, the response may not initially be in the subject's repertoire. Even if it is, it may be beneficial to begin with a reduced response requirement. For example, for Experiment 1, it might have helped for some children to begin with a larger peg and larger S+ holes, and then to shape the response requirement along with the stimulus display.

Third, another feature of the shaping method was physical prevention of incorrect responding on early training trials. In Experiments 1 and 2 this was done by limiting the diameter of the S− holes or the length of the S− pegs. In Experiment 1 the number of S− holes and the diameter of each hole were gradually increased over training levels. Thus, two S− cue dimensions were manipulated during the shaping process: position and diameter. During Levels 1 through 3 the child was not required to attend to the position cue because both hole position and hole diameter were available. However, at Level 4 one S− hole was the same diameter as the two S+ holes, so that only a position cue was present. If the child attended to size and failed to attend to position during the early steps, then the child would have been required to transfer to the position cue. Such shifts in the controlling cue dimensions may be undesirable, but they may also be difficult to avoid when a complex visual-motor skill is being trained. Shifting the cue-dimension that controls responding violates a recommendation by Goetz and Etzel (1977) that there be only one basis for making the discrimination, so that the child is "forced" to search for and use this dimension. Had this suggestion been followed in Experiment 1, we might have initially made the S+ holes very large, or presented the S+ hole in its correct positions, and presented the four S− holes at their full diameters in a cluster, from which they could have been "fanned out" to their correct positions.

Fourth, the backstep procedure may not have been optimal. There has been little systematic research on optimal backstep procedures. In the present experiments the backstep procedures used were based on pilot work. Their characteristics were intrinsic to the training being given, and their superiority to others that might have been chosen cannot be examined in our data.

Finally, a sequence of therapist's prompts was given to ensure correct responding on each trial. Therapist's prompts may be viewed as a graded sequence of cues to guide correct performance. As learning progresses within a training step, fewer prompts should be required. When prompting involves gestures or physical manipulation, the degree and character of the prompt will necessarily vary from trial to trial. No data are available here to assess changes of prompt characteristics within each training step. However, our data showed that the various types of prompts were not equally effective. In some individuals, specific types of prompts were totally ineffective, in that correct responding never followed that type of prompt. However, variability between children was such that none of the prompts could be judged satisfactory across a majority of cases.

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