Two methods for teaching simple visual discriminations to learners with severe disabilities

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Abstract

Simple discriminations are involved in many functional skills; additionally, they are components of conditional discriminations (identity and arbitrary matching-to-sample), which are involved in a wide array of other important performances. Many individuals with severe disabilities have difficulty acquiring simple discriminations with standard training procedures, such as differential reinforcement. Errorless training methods may be more effective with this population. We used multiple-probe designs to compare two potentially errorless procedures for teaching simple discriminations among three pairs of photos of preferred items (S+) and colored rectangles (S−) to three youths with severe disabilities. In Experiment 1, baseline trials conducted with differential reinforcement yielded near-chance performances on all stimulus sets. A progressive delayed prompt training procedure was then implemented, with stimuli presented flat on the tabletop for one participant and at a 45° angle to the tabletop for the other participants. After 120 teaching trials, accuracy remained near chance. Next, a stimulus control shaping procedure was implemented using an adapted Wisconsin General Test Apparatus (WGTA), with stimuli at a 45° angle to the tabletop. Accuracy increased when this procedure was implemented with each stimulus pair in succession. In Experiment 2, for the participant whose stimuli were presented flat on the tabletop during the progressive delayed prompt training procedure, baseline trials were presented on the WGTA as at the end of Experiment 1, with differential reinforcement; accuracy remained high. On probe trials with stimuli placed flat on the tabletop, accuracy

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decreased to near-chance levels, indicating that the orientation of the stimulus array was a controlling variable.

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Conditional identity matching skills are the foundation for a wide range of important repertoires in individuals with developmental disabilities, including the symbolic (arbitrary) matching that is required to perform many academic, communication, and everyday living skills. Standard differential reinforcement and errorless teaching methods have proved sufficient for teaching conditional identity matching to some learners with severe disabilities, but it is often necessary to teach prerequisite skills in order to establish conditional identity matching performances with such learners. One critical prerequisite is simple simultaneous visual discrimination (Dube, Iennaco, & McIlvane, 1993; Dube, McIlvane, & Green, 1992; Dube & Serna, 1998; Saunders & Green, 1999). Again, differential reinforcement may not suffice to establish simple discrimination performances in many learners with severe disabilities. Training procedures designed to minimize errors are often required (e.g., Moore & Goldiamond, 1964; Sidman & Stoddard, 1966; Terrace, 1963a,b; Touchette, 1968, 1971).

Typically, errorless training begins with a simple discrimination that is already in the learner’s repertoire, or can be established readily. Then, through a series of graduated training steps, a new discrimination is established. A number of procedures have been developed to accomplish this while minimizing errors. For example, Sidman and Stoddard (1967) established a new discrimination between a circle (S+) and an ellipse by presenting a flat ellipse as S− on initial training trials, and presenting ellipses with gradually increasing diameters on subsequent trials following correct responses. Participants came to respond reliably to the circle when it was presented with an ellipse with a diameter that was only slightly shorter than that of the circle. Procedures that involve gradual physical transformation of stimuli over successive trials have often been referred to as stimulus shaping (e.g., Etzel & LeBlanc, 1979), but the term stimulus control shaping more precisely characterizes the behavioral processes involved in establishing or altering stimulus control topographies (McIlvane & Dube, 1992). Another errorless training procedure entails presenting the S− at very low intensity on initial trials and increasing its intensity progressively over subsequent trials, commonly referred to as intensity fading (e.g., Terrace, 1963a,b). Alternatively, a stimulus that already controls responding (a prompt) may be presented with a stimulus that does not yet control responding (the target S+). Initially, the two stimuli are presented concurrently; over succeeding trials, presentation of the prompt is delayed either gradually in small increments (e.g., 1 s) or by a fixed duration (e.g., 5 s). Procedures like these are often termed time delay, though delayed cue or delayed prompt is more accurate, as it is the prompt rather than time that is delayed. If responses come to be made reliably to the target
S+ before the prompt is presented on delay trials, the procedure has effectively established a new discrimination (Touchette, 1968, 1971).

Most potentially, errorless discrimination training procedures involve gradual, programmed changes that are designed to transfer stimulus control from the original stimulus dimension to a new one. For transfer to be successful, the transfer sequence must begin with easy discriminations and progress gradually through more and more difficult discriminations, and the learner must observe the features of the stimuli involved in both the original and the new discriminations (e.g., Doran & Holland, 1979; Sidman & Stoddard, 1966). Even with careful programming, however, transfer of stimulus control can be difficult to achieve with participants who have severe learning difficulties. Some errorless discrimination training procedures have been shown to be effective with some participants, but no single procedure or set of procedures has been uniformly efficacious (see Lancioni & Smeets, 1986; Oppenheimer, Saunders, & Spradlin, 1993).

In the experiments described here, we compared the efficacy of one variation of the delayed prompt procedure with a new variation of some well-established procedures using the Wisconsin General Test Apparatus to establish visual discriminations in participants with severe disabilities.

1. Experiment 1

1.1. Method

1.1.1. Participants, setting, and sessions

Three youths enrolled in a comprehensive education and treatment program for students with severe learning and behavioral difficulties participated. Julie was a 9-year-old girl with diagnoses of autism and profound mental retardation. She had no functional vocal verbal behavior, but communicated with gestures and two approximations of manual signs. Julie engaged in several forms of challenging behavior, including extremely high rates of hand stereotypy. An objective on her education plan was learning to communicate with pictures, so she had had extensive classroom training designed to teach her to pick up a picture and hand it to an adult to request a preferred edible reinforcer (see Bondy & Frost, 1994). She had mastered that simple discrimination skill, but had not acquired conditional discriminations—reliably selecting one picture from an array of two or more that corresponded to the reinforcer that was available and visible to her on each of a series of trials—after protracted training with standard teaching procedures. A recently completed Vineland Adaptive Behavior Scales interview with her teacher yielded the following age-equivalent scores in each domain: communication, 0 year 9 months; daily living skills, 1 year 7 months; and socialization, 0 year 9 months. Andy was a 19-year-old male with diagnoses of severe mental retardation and behavior disorder whose communication skills were very similar to Julie’s, as were those of Mark, a 12-year-old boy diagnosed with autism. Vineland Adaptive Behavior Scales age equivalent scores for Andy.
were: communication, 1 year 1 month; daily living skills, 3 years 7 months; and socialization, 1 year 0 months. Mark’s Vineland age-equivalent scores were: communication, 1 year 1 month; daily living skills, 2 years 0 months; and socialization, 1 year 2 months. All three participants performed at chance levels on object–picture and picture–object matching to sample pretests; that is, they did not demonstrate conditional discriminations involving familiar objects and pictures of those objects.

1.1.2. Stimuli, apparatus, and sessions

Preference assessments (described below) were conducted to identify three preferred edible stimuli for each participant. Color photographs (9 cm × 12 cm) of those items served as S+ stimuli for discrimination training; S− stimuli were 9 cm × 12 cm cardboard rectangles colored blue, red, and green. All stimuli were laminated to increase their durability. Two small strips of Velcro were attached to the back of each stimulus, so that it could be attached to the adapted WGTA (as described below). Each of the S+ stimuli was paired with one of the S− stimuli.

The apparatus was an adapted version of the WGTA, a 20 cm × 13 cm × 8 cm wooden stimulus presentation device (see Fig. 1). It had two sunken circular wells, 6.5 cm in diameter and 2.5 cm deep, in which edibles could be placed. Two narrow strips of Velcro were glued along the sides of both wells. The top of the apparatus was angled at 45° from horizontal, such that participants could easily see into the wells.

Sessions were conducted in the participants’ classrooms. Two other students and one other teacher were present in the classrooms during some sessions. Each session consisted of 10 simple discrimination trials, and lasted approximately 5 min. Typically, one or two sessions were conducted each day, 4 or 5 days per week. Positions of the S+ and S− varied unsystematically across trials.

1.1.3. Preference assessment

A paired-stimulus preference assessment was conducted with each participant when they entered the study, using procedures described by Fisher, Piazza, Bowman, Hagopian, and Slevin (1992). Sixteen edible items were presented in the preference assessment, based on the recommendations of each participant’s educational team. On each trial, two stimuli were randomly selected from the pool.

Fig. 1. A representation of the Wisconsin General Test Apparatus (WGTA).
of 16 and placed about 0.3 m in front of the participant and about 0.5 m apart. Positions of the two items varied unsystematically from trial to trial. If the participant picked up one of the stimuli and consumed it within 5 s of the beginning of the trial, an approach was scored for that trial. The percentage of approach responses was calculated for each stimulus, and the three stimuli to which the highest percentage of approach responses was made were selected for use in this study. Items selected for each of the participants were: Julie—brownie, cheese curl, and M&M; Andy—jelly bean, peanut, pretzel; and Mark—cookies, popcorn, and gummy bear.

1.1.4. Experimental design and conditions

We used a multiple probe design across stimulus sets, with three experimental conditions. On each of the 10 trials presented in baseline sessions, the S+ and S− were placed over and completely covered the wells on the WGTA, and the edible corresponding to the S+ was placed in the well covered by the S+. Picking up the S+ was reinforced, in that the participant could access and consume the edible; responses to the S− were not reinforced. Responding to the S+ on at least 8 of 10 trials under these conditions for three consecutive sessions constituted terminal or criterion performance of the discrimination.

In the delayed prompt condition, which followed baseline, each trial began when the experimenter placed the stimuli in front of the participant. For Julie, the stimuli were placed flat on the tabletop; for Andy and Mark, stimuli were placed on the WGTA. Initially, the experimenter pointed to the S+ immediately after presenting the stimuli (0-s delay). If the participant picked up the S+ stimulus and handed it to the experimenter, the experimenter either immediately delivered the corresponding edible (Julie), or the participant removed the edible (Andy and Mark); the experimenter scored these responses as correct. If the participant picked up the S−, the trial was terminated (that is, the stimuli were removed from the table), an incorrect response was recorded, and the next trial was presented after an intertrial interval (ITI) of 15–20 s. If the participant did not pick up a stimulus within 10 s of presentation of the stimuli, the trial was terminated, the trial was scored NR (no response), and the ITI ensued. When a participant responded to the S+ on at least eight trials with the prompt delay at 0 s, the delay to the prompt was increased by 1 s in the next session. When the delay was 1 s or more, if the participant responded to the S+ on fewer than eight trials or made two consecutive responses to the S−, the delay was decreased by 1 s for the next session. After every three sessions, regardless of performance, a block of 10 probe trials was conducted under baseline conditions (i.e., differential reinforcement only; no prompt). Delayed prompt sessions continued until the participant responded correctly on at least 8 of 10 probe trials for three consecutive probes.

The modified WGTA was used in the stimulus control shaping condition. Before each trial, the experimenter placed the edibles and stimuli on the WGTA while holding it on his lap, below the top of the table and out of the participant’s view. When the WGTA was placed on the tabletop, the participant was to detach a stimulus from the WGTA and hand it to the experimenter. If S+ was detached, the
participant had access to the corresponding edible in the reinforcer well. If S+ was selected, the WGTA was immediately removed from the table, the ITI ensued, and the next trial was prepared. Responses on each trial were scored as described previously. The positions of the stimuli relative to the reinforcer wells varied systematically along nine shaping steps (see Fig. 2). On Step 1, the S+ and S− were placed above the reinforcer wells, such that 100% of the wells were visible to the participant. On Steps 2–4, S+ was positioned so that 75, 50 and 25% of the well was visible, respectively. At Step 5, the well associated with S+ was covered completely. On Steps 6–8, S− was positioned so that 75, 50 and 25% of the well was visible, respectively and at Step 9, both wells were covered completely. Training began with Step 1 in effect on all 10 trials in a session. If the participant responded to the S+ on at least eight trials, the program advanced one step in the following session. From Step 1 on, if the participant had fewer than eight responses to the S+ or made two consecutive responses to the S− in a session, the program backed up one step in the following session. After every three sessions, a block of 10 probe trials was conducted under baseline conditions (i.e., differential reinforcement only; no prompt), regardless of performance. Stimulus control shaping sessions continued until the participant responded correctly on at least 8 of 10 probe trials, or until performance stabilized below that criterion for three consecutive probes.

1.1.5. Dependent measure and interobserver agreement

The dependent measure was the percentage of responses to the S+ on probe trials, as recorded by the experimenter. A second observer independently recorded the participant’s responses on each probe trial in approximately 33% of probe sessions conducted with each participant. Experimenter–observer agreement was
calculated by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100%. Interobserver agreement was 100% for Julie and Mark; for Andy, mean interobserver agreement was 99% (range: 90–100%).

2. Results and discussion

Results are represented in Figs. 3–5. For all participants, baseline performances on all three stimulus pairs were near chance levels of accuracy. When the
delayed prompt procedure was implemented, performances remained at near chance levels on all stimulus pairs, even after 120 training trials. The stimulus control shaping procedure was implemented with stimulus pair 1, while the delayed prompt procedure remained in place with pairs 2 and 3. For Julie, after 180 trials, performance on pair 1 improved to near 100% accuracy, while it remained near chance on pairs 2 and 3 (see Fig. 3). Similar increases occurred when the stimulus control shaping procedure was implemented with pair 2, and then with pair 3. Those accuracy levels were maintained while the stimulus control shaping procedure was implemented with the subsequent stimulus pair(s). Performances in the delayed prompt condition remained at near-chance accuracy levels on pairs 2 and 3, even after 360 and 570 training trials, respectively. A similar pattern was seen with Mark (Fig. 4). During baseline and delayed prompting, Mark selected the stimulus that appeared on his left. When the stimulus control shaping procedure was implemented with each stimulus pair, accuracy increased to above 80% for all stimulus pairs. For Andy (Fig. 5), when
the stimulus control shaping procedure was implemented with pair 1, performance did not meet the mastery criterion after 330 teaching trials. Although Andy’s accuracy was 100% at Step 8, each time Step 9 was introduced, performance dropped back to near chance levels. At that point (indicated by the arrow in Fig. 5), an additional shaping step was added, where the well was approximately 90% covered. Accuracy then increased steadily, and the mastery

Fig. 5. Experiment 1 probe data for Andy. The arrow indicates the addition of a shaping step between Steps 8 and 9.
criterion was reached. Performances in the delayed prompt condition remained at near-chance accuracy levels on pairs 2 and 3. When the stimulus control shaping procedure was introduced with pairs 2 and 3 (with the additional shaping step), accuracy increased to nearly 100%.

For these participants, the stimulus control shaping procedure proved superior to a delayed prompt procedure for establishing simple visual discriminations. One possible explanation is that the shaping procedure began with the reinforcer visible to the participants to start each trial in the first session, and the reinforcer remained at least partially visible throughout sessions at shaping Steps 2–4. Detaching the S+ and handing it to the experimenter to obtain the reinforcer may have represented only a slight topographical variation of the well-established response of reaching for a preferred edible—a variation that most of the participants had likely developed as a result of efforts to teach them picture-based communication skills. Moving the S+ gradually over successive sessions to cover the edible may have transferred stimulus control of reaching from the edible to the S+.

Fig. 6. Experiment 2 probe data for Julie.
The delayed prompt and stimulus control shaping procedures differed in other ways as well, however. For one, reinforcers were handed to participants by the experimenter in the delayed prompt procedure, while participants procured the reinforcers themselves in the stimulus control shaping procedure. Additionally, for Julie, the stimuli were placed flat on the tabletop in the delayed prompt procedure, but were placed on the WGTA at a 45° angle from horizontal in the stimulus control shaping procedure. It is possible that the physical arrangement of the stimulus array influenced discrimination performances.

3. Experiment 2

Experiment 2 assessed the effect of stimulus presentation on Julie’s discrimination performance. Stimuli, apparatus, sessions, and procedures were the same as in Experiment 1. Baseline sessions conducted on the WGTA with differential reinforcement (i.e., no prompt or shaping procedures) yielded results that were at or near the criterion levels achieved at the end of Experiment 1 with all three stimulus pairs (see Fig. 6). Next, probe sessions were conducted with stimuli in pair 1 presented flat on the tabletop, while baseline sessions continued with pairs 2 and 3 on the WGTA. Accuracy on pair 1 dropped immediately to chance, while accuracy on pairs 2 and 3 remained at criterion. Similar patterns were observed when probes were conducted on the tabletop with pairs 2 and 3 in succession. These results indicate that the manner in which the stimuli were presented—possibly their orientation relative to the participant’s line of sight—controlled Julie’s simple discrimination performances.

4. General discussion

Results of Experiment 1 corroborated findings from other studies showing that delayed prompt procedures are not uniformly efficacious for establishing discrimination performances in learners with severe disabilities (for a review, see Oppenheimer et al., 1993). Indeed, the performances of our participants did not improve from chance levels when delayed prompt procedures were used, nor after extensive training with those procedures. The stimulus control shaping procedure, on the other hand, produced fairly rapid acquisition with few errors in almost all cases.

Experiment 2 demonstrated that one feature of the stimulus control shaping procedure that accounted for its superior efficacy with one participant was the stimulus presentation, specifically the orientation of the stimuli. When stimuli were presented at a 45° angle, discrimination performances remained highly accurate, as they had been at the end of Experiment 1. When the stimuli were presented flat on the tabletop, discrimination performances decreased immediately to near-chance levels. One potential explanation is that the stimuli were more clearly visible to the participant when they were angled toward her than
when the stimuli were presented flat on the tabletop. This may have made it easier for Julie to observe the physical features of the S+ and S− stimuli, as well as the correspondence between features of the S+ stimuli and certain features of the reinforcers. In any case, results of Experiment 2 confirmed that seemingly minor components of training procedures can have a major impact on the performances of individuals with severe learning difficulties (cf. Kelly, Green, & Sidman, 1998).

The two procedures differed in another aspect, however, that may have contributed to the differences in performance: When a participant responded to the S+ presented on the WGTA, he or she obtained the reinforcer by retrieving it from the well. When a participant responded to the S+ presented on the tabletop, the experimenter handed the reinforcer to him or her. That procedural difference also seems small, but only further experimentation can determine whether it is functionally related to simple discrimination performances.

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References


