# Comparison of Consequences for Errors During Discrete-Trials Teaching with Children with Autism Spectrum Disorders

by

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A Thesis submitted to the Faculty of Graduate Studies of

The University of Manitoba

in partial fulfilment of the requirements of the degree of

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Department of Psychology

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# Comparison of Consequences for Errors During Discrete-Trials Teaching with Children with Autism Spectrum Disorders

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A Thesis/Practicum submitted to the Faculty of Graduate Studies of The University of Manitoba in partial fulfillment of the requirement of the degree

Of

## Master of Arts

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Abstract

In discrete-trials teaching, a trial involves presenting an antecedent for a target response and presenting a consequence immediately following the child's response. A correct response is usually followed by a reinforcing consequence and an incorrect response is followed by a correction procedure. Using an alternating-treatments design, I compared two multiple-practice procedures and a no-practice procedure following errors, during discrete-trials teaching of 3-choice matching-to-sample discriminations with 3 boys with autism spectrum disorders. In the Static Antecedent procedure, a child practiced the correct response 5 times following an error using the same task stimuli that occasioned the error. In the Varied Antecedent procedure, the practice was the same as the Static procedure except that two irrelevant features of the antecedent were varied across the practice trials. In the no-practice procedure, an error was ignored for 5 s. There were little differences between the procedures in the number of sessions required to reach the predetermined mastery criterion, but the no-practice procedure was substantially less time consuming when practice trials were taken into account.

# Comparison of Consequences for Errors during Discrete-Trials Teaching with Children with Autism Spectrum Disorders

Autism spectrum disorders or ASDs include Autistic Disorders, Asperger Disorders, and Pervasive Developmental Disorders-Not Otherwise Specified. All three are classified as pervasive developmental disorders characterized by marked impairments in social interaction, communication, repetitive behaviours, and a limited range of interests (American Psychiatric Association, 2000). Prevalence of ASDs has been rising over the last 10 years with reports ranging from approximately 30 to 60 per 10,000 individuals (Fombonne, 2003; Ouellette-Kuntz et al., 2006). Intensive behavioural treatment using applied behaviour analysis principles and procedures is the most effective early intervention program for teaching children with autism spectrum disorders (Eikeseth, 2009; New York State Department of Health and Human Services, 1999; Perry & Condillac, 2003). Discrete-trials teaching is commonly used in early intensive behavioural intervention to teach a variety of academic, vocational, and daily living skills to individuals with developmental disabilities, including autism (e.g., numerous published studies using this technique have appeared in the *Journal of Applied Behaviour Analysis* since its inception in 1968). Perhaps partly because discrete-trials teaching has been so successful, relatively little research has examined its procedural components. This study extended research in this area by examining consequences for errors during discrete-trials teaching with children with ASDs.

*Structure of Discrete-Trials Teaching*

A discrete trial consists of an antecedent, a behaviour, and an immediate consequence (Martin & Pear, 2007). These trials are often presented in rapid succession of each other and continue for a designated number of trials. For example, when teaching a child to perform a matching-to-sample discrimination, the tutor might provide three pictures (referred to as comparison stimuli) in front of the child and then present a picture (referred to as the sample stimulus) that is identical or related to one of the three comparison stimuli. The tutor would then give an instruction such as "Match" and provide the necessary prompts needed to evoke a correct response. The pictures, instruction, and prompts combined constitute the antecedent. The child's response (e.g., correctly or incorrectly matching the stimuli) is the behaviour. The consequence for the behaviour often involves presenting praise and a preferred item if the response is correct, or conducting a correction procedure if the response is incorrect.

*Research on Consequences for Errors in Discrete-Trials Teaching*

In studies that compared different consequences for errors, all aspects of the discrete-trials teaching procedures were controlled except for the consequences for errors. For example, when comparing two consequences for errors, both procedures would have the same one-to-one teaching format as described above, the same number of trials per session, and the same consequence procedure for correct responses.

Several studies have compared consequences for errors for teaching sight-word reading to participants with developmental disabilities. Barbetta, Heron, and Heward (1993) compared an *active-response* versus a *no-response* consequence using an alternating-treatments design. Participants were asked to read a presented word on each trial. Each incorrect response in the active-response condition was immediately followed by a correction trial in which the experimenter modeled the correct response and required the participant to repeat the response. During the no-response condition, however, the experimenter modeled the correct response but did not require the participant to repeat it. All participants read more words correctly in the active-response condition during training, during same-day, next-day, and weekly retention tests, and during generalization tests (learned words presented in sentences). Number of words read correctly was higher in active-response during 80% of the same-day tests and 77% of the next-day tests. Five participants read more words correctly during the two-week retention test in the active-response condition and 1 participant performed similarly in both conditions.

Barbetta, Heward, Bradley, and Miller (1994) compared *immediate* versus *delayed* consequences for sight-word reading with 4 students with developmental disabilities using an alternating-treatments design. The immediate consequence for errors was similar to the active-response condition in their previous study (Barbetta et al., 1993). For the delayed consequence, an incorrect response was immediately followed by a statement indicating that the word from that trial would be practiced later. Incorrect words emitted during the session were then practiced at the end of the session. Results showed that immediate correction produced better performance than delayed correction on all measures, including number of words read correctly during instruction, during same-day and next-day tests, and during one- and two-week retention tests.

Fabrizio and Pahl (2007) compared the effectiveness of *word supply* versus *discrimination* error correction procedures to teach sight-word reading to a 9 year old girl with autism. Correction procedures were evaluated in an alternating-treatments design. Following a misread word in the word-supply condition, like in the active response condition of Barbetta et al. (1993), the therapist modeled the correct word and prompted the child to repeat the correct response once. Following an error in the discrimination condition, the therapist wrote the word the way the child had incorrectly read it and then wrote the correct spelling of the word (as it appeared in the text). The therapist pointed to the correct word, modeled the correct response, and prompted the child to repeat the response. The child read from the same book in both conditions and the text was segmented into 20 word blocks. Text blocks were randomly assigned to each condition. Accuracy was measured by the number of error corrections required to teach the child to read lines of text with 100% accuracy. Results showed that both procedures increased reading accuracy, but the word supply procedure required fewer error correction trials per line of text read incorrectly and fewer sessions to reach 100% accuracy. Thus, the discrimination component did not enhance the practice procedure.

Cuvo, Ashley, Mars, Zhang, and Fry (1995) conducted 4 experiments to evaluate various error correction procedures while teaching spelling to individuals with developmental disabilities. In Experiment 1 oral practice was found to be superior to written practice. In Experiment 2, 5 written practice trials were found to be as effective as 10 or 15 practice trials. In Experiments 3 and 4, results showed that 1 practice trial was as effective as 5 practice trials, and 5 relevant practice trials (of the misspelled word) was as effective as 5 irrelevant practice trials (of words not in training) in terms of acquisition rates and efficiency. One limitation of this study was that either written or oral practice was accepted in Experiments 3 and 4. Thus, the separate effects of the two forms of practice were unclear. Also, it was not clear why written practice was used in Experiments 2 through 4 given the results of their Experiment 1.

Worsdell et al. (2005) conducted three experiments on consequences for errors for sight-word reading with adults with developmental disabilities using an alternating-treatments design. In Experiment 1, they compared *single-response* versus *multiple-response* repetition of the correct response following an error with three participants. The single-response condition was similar to the active-response condition in the Barbetta et al. study (1993). In the multiple-response condition, participants were prompted to read the word five times following an error. Results demonstrated that the multiple-response condition was superior to the single-response condition in that more words were read accurately per session, more words were mastered, and more words were retained on both short- and long-term retention tests for all three participants.

In Experiment 2, Worsdell et al. (2005) compared the effects of *continuous* versus *intermittent* correction with 6 participants. In the continuous condition, each incorrect response was followed by the multiple-response correction procedure described in the first experiment. In the intermittent condition, multiple-response correction was implemented on a variable-ratio 3 schedule (i.e., once after every 3 errors on average). Errors that were not corrected were ignored. Results showed that both procedures improved performance over baseline (differential reinforcement with no practice following an error). However, all participants read more words correctly in the continuous condition than in the intermittent condition.

In Experiment 3, Worsdell et al. (2005) compared a *relevant* and an *irrelevant* multiple-response repetition procedure. The relevant procedure involved repeating the misread word, whereas the irrelevant procedure involved reading a word not being trained. Results showed that more words were read correctly in the relevant condition for 7 of the 9 participants and more words from the relevant condition were retained on short-term retention tests for 5 of the 9 participants. One participant mastered 50% more words in the irrelevant condition. This experiment showed that both error correction procedures enhanced performance. However, the mixed results suggest that the procedures may have two effects: (1) they increase correct responses by strengthening the control of the antecedent over the practiced response, and/or (2) they increase correct responses by functioning as a punisher, which is avoided by engaging in a correct response.

All of the above studies have focused on reading or spelling. Only two studies have compared error correction procedures for teaching match-to-sample discriminations to people with developmental disabilities. Rodgers and Iwata (1991) compared three consequences for errors in an alternating-treatments design. Seven adults with developmental disabilities were taught identity and non-identity matching-to-sample discriminations with geometric shapes. In the *differential reinforcement* procedure (baseline condition), the trainer stated that the response was incorrect and then presented the next training trial. In the *practice* procedure, following an error, the trainer prompted the participant verbally or physically until he/she engaged in the correct response once before presenting the next training trial. The third procedure was also a practice procedure, except that, following an error, the participant was asked to practice with stimuli not used for training (the authors referred to this as the *avoidance* condition). The number of trials presented during the avoidance condition was yoked to the average number of repetitions for the practice condition. All participants showed improvements but with mixed results on the relative effectiveness of the procedures. One participant demonstrated his highest performance during differential reinforcement while another showed similar improvements across all three procedures. For the remaining 5 participants, two performed better in the Practice condition and 3 performed better in the Avoidance condition. The mixed results suggest that required practice following an error may strengthen stimulus-control and/or function as a punisher.

Smith, Mruzek, Wheat, and Hughes (2006) examined three error correction procedures in an alternating-treatments design while teaching matching tasks to 6 children with autism. In the *error statement* condition, the instructor said "no" immediately following each error. In the *modeling* condition, following each error, the instructor said “this is matching” and modeled the correct behaviour. In the *no feedback* condition, the instructor provided no feedback following an error (i.e., ignored errors) and proceeded to the next trial. Results were mixed and did not favour any one condition. Two of the participants performed as well in the error correction conditions as they did in the no feedback condition, 2 participants learned more quickly in the error correction conditions than in the no feedback condition but demonstrated no difference between the error correction conditions, 1 participant performed best in the modeling condition and 1 performed better in the error statement condition.

In summary, research on consequence for errors during discrete-trials teaching is relatively sparse. Most studies have focused on reading and those studies suggest that consequences for errors: (a) should involve practicing the correct response rather than no practice; (b) should involve multiple practice trials (5 times) rather than a single practice trial; and (c) should be delivered immediately after every error. In addition, response practice following an error may have three effects on learning (Cuvo et al., 1995; Rodgers & Iwata, 1991; Worsdell et al., 2005). First, the procedure may be aversive and may reduce errors through punishment. Second, it may increase correct responses through avoidance conditioning (i.e., a student can avoid response repetition by engaging in correct responses in the presence of the antecedent). Third, it may increase future correct responses through strengthening the antecedent as a discriminative stimulus to evoke the correct response through rehearsal and reinforcement for correct practice in the presence of the antecedent.

*Statement of the Problem*

If strengthening the stimulus control relation between the antecedent and the correct response is one reason why practicing the correct response after an error increases future correct responses, can we improve upon this function of the procedure? In all previous studies, the task stimuli for response practice were identical to the ones used when the error occurred (except in experiments where irrelevant stimuli were used to control for practice). For example, in matching printed words as samples to pictures as comparisons (e.g., a Cup, Plate, and Bowl), if the printed word PLATE were mismatched to the picture Cup, the three pictures would remain on the table in the same positions and the participant would be asked to match the printed word PLATE to the picture Plate 5 times. I will refer to this as the *static antecedent* procedure in this thesis. This procedure might not be an efficient procedure for strengthening stimulus control because the practiced response could come under the control of the entire stimulus compound or of some irrelevant feature of the compound (e.g., the picture Cup on the right, or the trainer saying "match"). In this example, we wish to strengthen the stimulus control exerted by the features entailed in the picture Plate, independent of other irrelevant stimuli (e.g., position of the pictures, contents of other non-matching pictures, etc.). If so, the desired stimulus control might be sharpened and strengthened more effectively if the relevant stimulus is held constant, while irrelevant stimuli are varied across practice trials. No previous research has examined this *varied antecedent* procedure as a consequence for errors. Moreover, very little research on error correction has been conducted with match-to-sample discrimination learning in children with autism. Therefore, in this study I compared the *static* and *varied antecedent* procedures with children with autism. Specifically, I compared two multiple-practice error correction procedures, one with static antecedents similar to the multiple-response repetition procedure used in previous research, and one with varied antecedents in which some features of the antecedent that are irrelevant to the desired stimulus control were altered across practice trials. Both procedures were compared to a differential reinforcement (no-practice) baseline training condition in an alternating-treatments design, replicated across three children with ASDs. I expected that some learning would occur in each procedure, but children would perform best with the varied antecedent procedure, followed by the static antecedent procedure, and lastly, the differential reinforcement procedure.

## Method

### *Participants and Setting*

Three preschool-age boys with autism spectrum disorders were recruited through the St. Amant Applied Behaviour Analysis (ABA) Program. Child 1 was 4 years old and Children 2 and 3 were both 5 years old. All children had been diagnosed to be on the autism spectrum by the Child Development Clinic of the Children's Hospital in Winnipeg. None of the children were taking psychotropic medication. Children 1 and 2 had some one-word utterances such as "mom" or "upstairs". Child 3 was able to make 2-3 word requests such as "bathroom please" or "another cheezie please". All children could follow simple vocal instructions such as "sit down", "hands ready", and "wait" and could respond to the question "what do you want" by pointing or naming.

All research sessions were conducted in the child's home in an area with as little distractions as possible. Sessions were always conducted in the same location for each child. The University of Manitoba Psychology/Sociology Research Ethics Board approved the study, and I obtained written informed consent from each child's parent before the study began.

### *Materials*

The child and I sat at a table facing each other during all sessions. A variety of stimuli selected from the child's educational curriculum were used for training. A total of 21 3-choice matching-to-sample tasks were identified for training (see Table 1). Stimuli included black and white or color pictures and printed words.

During training, the comparison stimuli for each trial were printed on 22cm by 28 cm white paper. The stimuli appeared in a row on each page and each stimulus was framed within a 7 cm by 7 cm square. The positions of the stimuli were counterbalanced across 18 pages (trials). The pages were protected by clear sheet protectors and placed in a binder for presentation. The sheet protectors were cleaned after each session. The sample stimuli were printed on a 7 cm by 7 cm white card.

*Experimental Design*

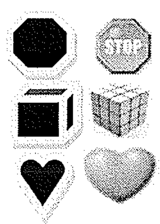
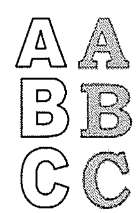
An alternating-treatments design (Martin & Pear, 2007) was used to compare the three procedures using three tasks including similar discriminations (e.g., non-identity matching). One task was randomly assigned to each training procedure and each procedure was conducted in one training session. Training procedures were separated by at least 5 minutes. The order of the procedures was randomized within every three sessions. After training had been completed for the first 3 tasks (Comparison 1), training was replicated with new tasks (Comparison 2) for each child.

*Procedure*

*Abbreviated preference assessment.* An abbreviated preference assessment was administered at the beginning of each baseline and training session. I presented 6 preferred edibles that had been previously nominated by the parent and asked the child to "pick the one you like best". The selected item was then used as a consequence for correct responses for the ensuing session (18 trials).

Table 1

*Task Stimuli Trained in Each Procedure During the First and Second Comparisons.*

| | Differential Reinforcement | Static Antecedent | Varied Antecedent |
|---|---|---|---|
| *Child 1*<br>Comparison 1 | Sock-Shoe<br>Screw-Hammer<br>Toothpaste-Toothbrush | Rain-Umbrella<br>Bat-Baseball<br>Cans of Paint-Paintbrush | Cake-Candles<br>Pants-Shirt<br>Spoon-Bowl |
| Comparison 2 | LEAF-Leaf<br>SOCK-Sock<br>BALL-Ball | FIRE-Flame<br>NAIL-Nail<br>TIE-Tie | RAIN-Cloud and Raindrops<br>BOOT-Boots<br>BELT-Belt |
| *Child 2*<br>Comparison 1 | Fish Bowl-Clown Fish<br>Dog Bone-Dog<br>Jar of Honey-Teddy Bear | Spider web-Spiderman<br>Train Tracks-Thomas Train<br>Spaceship-BuzzLightyear Astronaut | Bugs Bunny-Carrot<br>Mickey Mouse-Mouse Ears<br>Donald Duck-Feathers |
| Comparison 2 | Sock-Shoe<br>Screw-Hammer<br>Toothpaste-Toothbrush | Rain-Umbrella<br>Bat-Baseball<br>Cans of Paint-Paintbrush | Cake-Candles<br>Pants-Shirt<br>Spoon-Bowl |
| *Child 3*<br>Comparison 1 | Apple1-Apple2<br>Banana1-Banana2<br>Grapes1-Grapes2 | a-A<br>g-G<br>r-R | Anteater1-Anteater2<br>Gecko1-Gecko2<br>Seahorse1-Seahorse2 |
| Comparison 2<br>Shapes, Numbers & Letters Tasks |  |  |  |
| Comparison 2<br>Animal Tasks | Alligator1-Alligator2<br>Beaver1-Beaver2<br>Flamingo1-Flamingo2 | Owl1-Owl2<br>Shark1-Shark2<br>Kangaroo1-Kangaroo2 | Parrot1-Parrot2<br>Dolphin1-Dolphin2<br>Zebra1-Zebra2 |

*Baseline to identify training tasks.* The purpose of the baseline phase was to identify stimuli for training before each comparison. Stimuli were nominated by the child's ABA consultant based on the child's curriculum and existing skills. Stimuli were presented in a 3-choice matching-to-sample procedure until three 3-choice matching-to-sample tasks were identified for each child (Table 1). The identified tasks involved partial-identity matching, in which the sample and comparison stimuli shared some physical similarities (e.g., matching a red apple to a green apple instead of an orange), or non-identity matching, in which the sample and comparison stimuli shared no physical similarities (e.g., matching a sock to a shoe).

A baseline session consisted of 18 trials. On each trial, I showed the child 3 *comparison* stimuli (e.g., pictures of a Leaf, a Sock, and a Ball), and asked the child to look at each picture, and then placed them on the table in front of the child. I then showed the child a *sample* stimulus (e.g., the printed word LEAF), gave the sample card to the child, and said "find the same". If the child placed the sample on top of the correct comparison within 5 s, the response was considered correct and I immediately praised the child and provided an edible for consumption. If the child did not respond within 5 s or placed the sample anywhere other than on the correct comparison, the response was considered incorrect. Following an incorrect response, I said nothing, retrieved the materials and presented a new trial. The child's response was recorded at the end of each trial on a datasheet. Across the 18 trials, the positions of comparison stimuli were counterbalanced such that: (a) each stimulus appeared in each position an equal number of times, (b) each stimulus and each position were correct an equal number of times, and (c) the same stimulus or position could not be correct for more than two consecutive trials. All tasks were baselined and included for training if the child performed near chance level (33%) after 18 baseline trials.

*Alternating-treatments*. For each child, tasks were assigned randomly to three training procedures: Differential Reinforcement, Static Antecedent, and Varied Antecedent procedures. In all procedures, each session consisted of 18 training trials (not including practice trials following an error in the static and varied conditions) and each training trial began with an antecedent (presenting the comparison and sample stimuli and the spoken cue to "find the same"), and each correct response was followed immediately by praise and an edible (similar to the baseline procedure). The three procedures differed in the consequence for incorrect responses as described below.

The consequence for an incorrect response in the *differential reinforcement* procedure was identical to the baseline procedure. During this condition, each incorrect response was ignored for 5 s, and then the next training trial was presented.

During the *static antecedent* procedure, I required the child to practice the correct response 5 times after an error in the presence of the same antecedent stimuli that occasioned the error. Specifically, following an incorrect response, I: (a) said nothing, (b) removed the sample and comparison stimuli, (c) returned the sample stimulus and comparison stimuli to the table; (d) prompted the child to practice the correct response using physical and vocal (e.g., "it goes here.") cues if necessary; (e) said "good" after the child emitted the correct response; and (f) repeated the above 5 times as quickly as possible. During practice trials, prompts were provided immediately and were graduated to hand-over-hand guidance if necessary to ensure that a correct response would occur. The comparison stimuli remained in the same location on the table during the 5 practice trials, and the next training trial was presented after the practice trials.

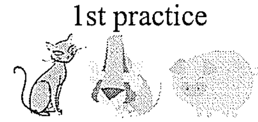
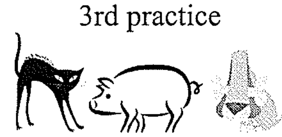
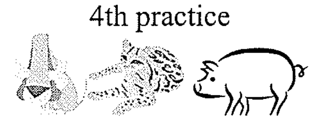
The *varied antecedent* procedure was the same as the *static* procedure with one exception: the comparison stimuli varied in two ways across the practice trials. First, I varied the positions of the comparison stimuli such that the correct stimulus was in a different position on each practice trial and that each of the three positions was correct at least once. For example, if an error occurred when the correct comparison stimulus was located in the middle, the stimulus might appear on the left for the first practice trial, on the right for the second, in the middle for the third, and so on. Second, across the 5 practice trials, I varied each incorrect comparison stimulus twice by replacing it with another stimulus (that was not used on training trials) from the same stimulus class, but only one incorrect comparison stimulus was changed on each practice trial. For example, if an error occurred when the correct comparison was the picture Leaf (among Leaf, Sock and Ball), I replaced the picture Ball with a different Ball on the first practice, replaced the picture Sock with a different Sock on the second practice, replaced the new Ball with yet another Ball on the third practice, and so on. Table 2 illustrates the consequences for the three procedures.

The mastery criterion for a task was predefined as a minimum of 15 correct trials in an 18-trial session with no more than one error for each comparison stimulus. For a 3-choice discrimination, the probability of meeting this criterion by chance is 343 out of 387,420,489 or slightly less than 1 in a million, assuming that responses across trials are independent.

The alternating-treatments comparison was terminated after stable effects were observed in all three procedures. The comparison was then replicated with new tasks for each participant.

Table 2

*Consequences in Differential Reinforcement, Static Antecedent, and Varied Antecedent Procedures.*

| | Baseline/ Differential Reinforcement | Static Antecedent | Varied Antecedent |
|---|---|---|---|
| Training trial: 3 comparisons (pictures) and a sample (printed word). |  DOG | | |
| Consequence for a correct response. | Praise plus edible, and then next trial. | | |
| Consequence for an incorrect response. | No practice, 5 s inter-trial interval, and then next training trial. | 5 practices using the same stimuli in the same positions as above and then next training trial. | 5 practices varying incorrect comparisons and positions, and then next training trial. |
| | | 1st practice  DOG | 1st practice  DOG |
| | | 2nd practice: Same as above | 2nd practice  DOG |
| | | 3rd practice: Same as above | 3rd practice  DOG |
| | | 4th practice: Same as above | 4th practice  DOG |
| | | 5th practice: Same as above | 5th practice  DOG |

*Interobserver Agreement*

For each child, one out of every three sessions during baseline and during training for each procedure was scored by an observer, and the recordings were compared to the experimenter's data. A trial was defined as an agreement if both had recorded the same response (correct, incorrect, or no response); otherwise, it was a disagreement. Percent agreement per session was computed by dividing the number of agreements by the number of agreements plus disagreements and multiplied by 100. Mean percent agreement on child responses across sessions was 99% for Child 1 (range, 97-100), 99% for Child 2 (range, 98-100), and 100% for Child 3. The observer also recorded the session duration in minutes, which was also compared to the experimenter's recordings. Percent agreement for session duration was computed by dividing the smaller number by the larger number and multiplied by 100. Mean percent agreement on session duration across sessions was 97% for Child 1 (range, 75-100), 88% for Child 2 (range, 86-100), and 98% for Child 3 (range, 88-100).

*Procedural Integrity*

For each child, all sessions were scored for procedural adherence. On each trial, the observer recorded whether the experimenter had: (a) presented the correct comparison stimuli in the designated positions; (b) presented the correct sample; (c) given the correct cues to prompt the target response; and (d) given praise and an edible following a correct response, or given the correct consequence following an incorrect response. A trial was scored as delivered correctly if all components were presented correctly. The mean percentage of correctly delivered trials across session was 100% for Child 1, 99% (range, 98-100) for Child 2 and 99% (range, 98-100) for Child 3.

## Results

Child 1's baseline correct responses for the 3 tasks in the first comparison were at or near chance levels (33%, 33%, and 44% correct, respectively). Figure 1 shows the frequency of correct responses per session for each training procedure (top graph) and the cumulative number of trials per session including practice trials (bottom graph) for Comparisons 1 and 2. During Comparison 1, Child 1 met the mastery criterion in the Static condition for the first time after 2 training sessions, with 8 errors. He met the mastery criterion in the Varied and Differential Reinforcement conditions for the first time after 3 training sessions each, with 8 and 11 errors, respectively. In Comparison 2, the baseline correct responses for the three tasks were also at or near chance level (33%, 33%, and 44% correct, respectively). He met mastery on all three tasks after 2 training sessions, with 4 errors in the Static condition, 6 errors in the Varied condition, and 13 errors in the differential Reinforcement condition.

The cumulative number of trials across sessions in each training condition, including practice trials for the Static and Varied conditions, is plotted in the bottom graph of Figure 1. In Comparison 1, Child 1 required 76 trials to meet the mastery criterion in the static condition after 2 sessions, 94 trials to meet the mastery criterion in the varied condition after 3 sessions, and 54 trials to meet the mastery criterion in the differential reinforcement condition after 3 sessions. In Comparison 2, he required 66, 56, and 36 trials in the static, varied, and differential reinforcement conditions, respectively, to meet the mastery criterion after 2 sessions. The differential reinforcement procedure averaged 13 min per session (range, 10-19 min), whereas the static procedure averaged 20 min per session (range, 13-35 min) and the varied procedure averaged 21 min per session (range, 11-35 min).

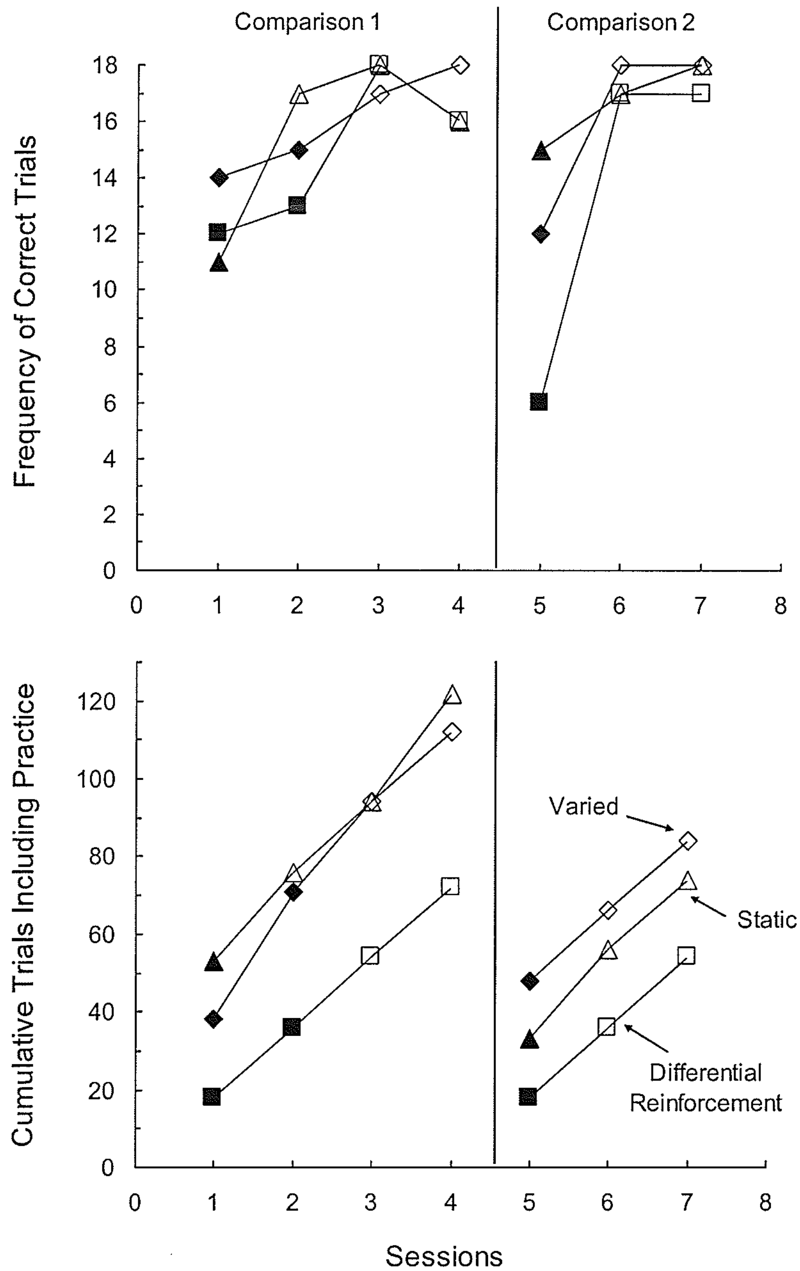



*Figure 1*. Frequency of correct responses per session (top graph) and cumulative trials across session (bottom graph), including practice trials for the static and varied conditions for Child 1. Unfilled data points denote sessions that met the mastery criterion.

Child 2's baseline correct responses for the 3 training tasks in Comparison 1 were below chance levels (11%, 11%, and 22%, respectively). Figure 2 shows the frequency of correct responses per session in each training procedure (top graph) and the cumulative number of trials per session including practice trials (bottom graph). Child 2 met the mastery criterion in the varied antecedent condition for the first time after 4 sessions, with 23 errors. He met mastery in the static and differential reinforcement conditions after 6 sessions each, with 48 and 52 errors, respectively. In the second comparison, his baseline correct responses for the three tasks were below or at chance level (22%, 22%, and 33% correct, respectively). During training, he met the mastery criterion in the static, varied, and differential reinforcement conditions after 7 sessions each, with 57, 53, and 58 errors, respectively.

The cumulative number of trials, including practice trials for the static and varied conditions, across sessions is plotted in the bottom graph of Figure 2. In the first comparison, Child 2 required 348 trials to meet the mastery criterion in the static condition after 6 sessions, 187 trials to meet the mastery criterion in the varied condition for the first time after 4 sessions, and 108 trials to meet the mastery criterion in the differential reinforcement condition after 6 sessions. In the second comparison, he required 411, 391, and 126 trials in the static, varied, and differential reinforcement conditions, respectively, to meet the mastery criterion after 7 sessions each. The differential reinforcement procedure averaged 19 min per session (range, 10-36 min), whereas the static procedure averaged 28 min per session (range, 15-40 min) and the varied procedure averaged 29 min per session (range, 19-40 min).

Child 3's baseline correct responses for the 3 training tasks in the first comparison were at or near chance levels (33%, 44%, and 28%, respectively). Figure 3 shows the

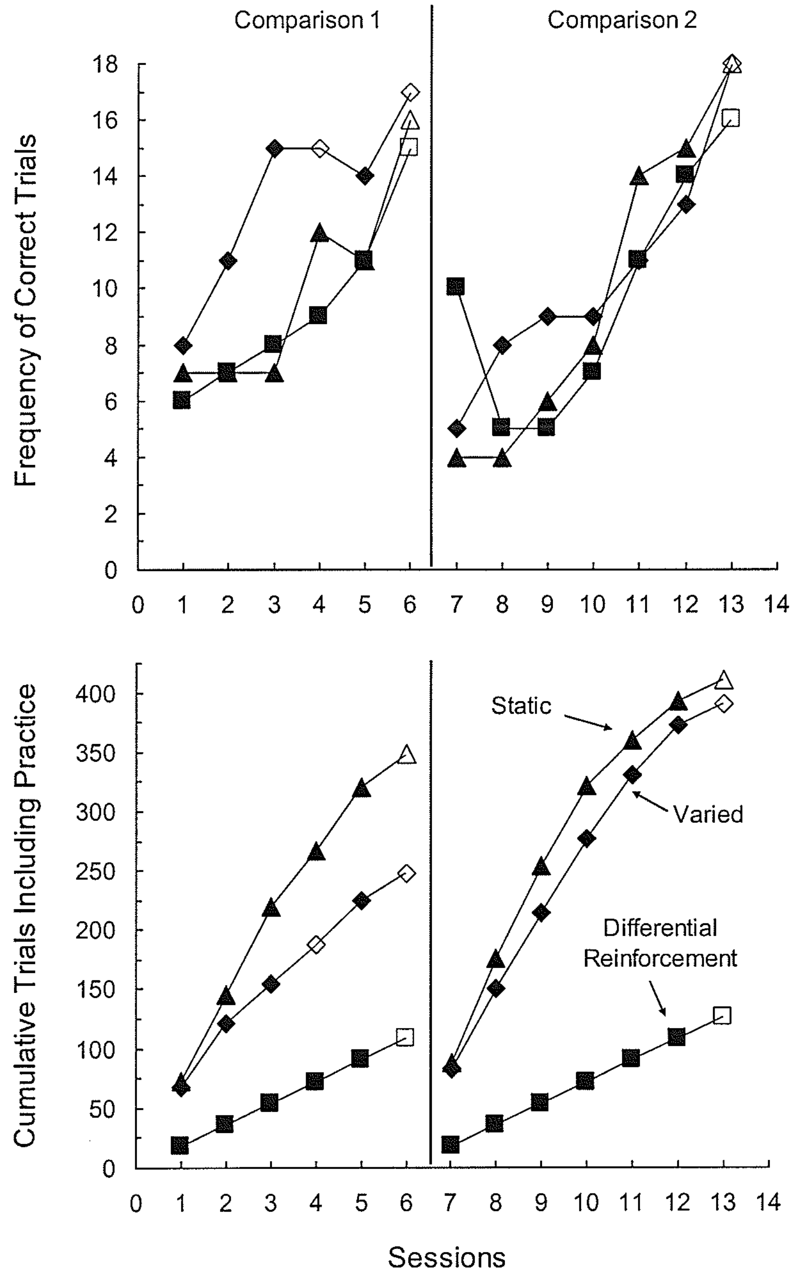



*Figure 2*. Frequency of correct responses per session (top graph) and cumulative trials across sessions (bottom graph), including practice trials for the Static and Varied conditions for Child 2. Unfilled data points denote sessions that met the mastery criterion.

frequency of correct responses per session in each training procedure (top graph) and the cumulative number of trials per session including practice trials (bottom graph). In Comparison 1, Child 3 met the mastery criterion in the differential reinforcement condition after 2 sessions, with 10 errors. He met mastery in the varied condition for the first time after 3 sessions, with 15 errors. However, his frequency of correct responses remained near chance level in all 4 sessions in the static condition.

The cumulative number of trials, including practice trials for the static and varied conditions, across sessions is plotted in the bottom graph of Figure 3. In Comparison 1, Child 3 required 36 trials to meet the mastery criterion in the differential reinforcement condition after 2 sessions and 129 trials to meet the mastery criterion in the varied condition after 3 sessions. He did not meet the mastery criterion in the static condition after 287 trials. Anecdotally, problem behaviours such as spitting, hitting, and out of seat were observed during the static condition, but not in the varied and differential reinforcement conditions. It was not clear whether the problem behaviours were caused by the training procedure or the task stimuli/difficulty. Since the task being trained in the static condition involved matching upper and lower case letters, whereas tasks in the other conditions involved matching animals and fruits, a task effect was a strong possibility. I tested this possibility in Comparison 2.

The second comparison began with matching shapes, letters, and numbers across the three procedures (see Table 1). Baseline correct responses for the 3 tasks were 22%, 11%, and 33% correct, respectively. After 4 training sessions with each procedure, accuracy remained low and problem behaviours were observed in all three conditions. In

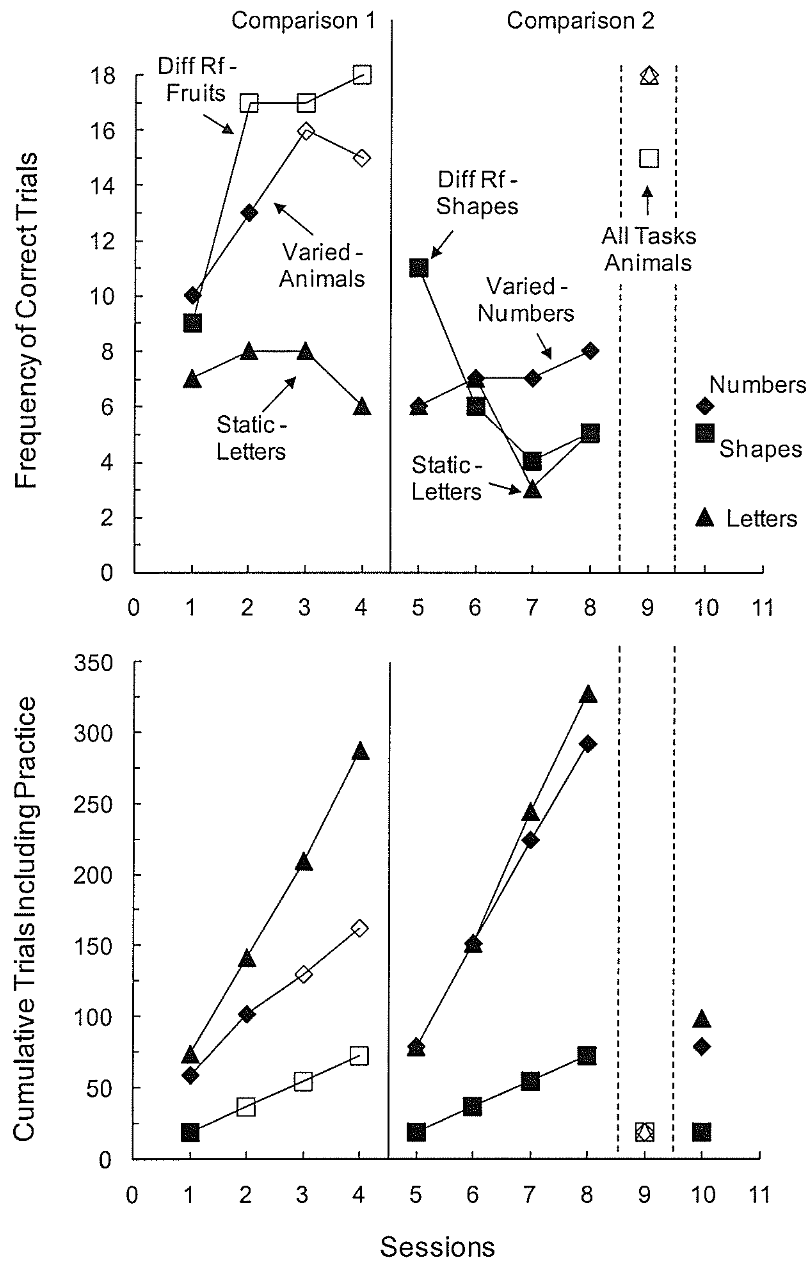



*Figure 3*. Frequency of correct responses per session (top graph) and cumulative trials across sessions (bottom graph), including practice trials for the Static and Varied conditions for Child 3. Unfilled data points denote sessions that met the mastery criterion.

the fifth session, the task stimuli were replaced with animals in all three conditions (see Table 1). Child 3 met the mastery criterion in 1 session and without any problem behaviours in all three conditions. A reversal to the shapes, letters and numbers tasks was conducted in the last session and his performance reverted back to a low level and problem behaviours occurred in all three conditions.

For Child 3, the differential reinforcement procedure averaged 13 min per session (range, 5-18 min). The static and varied procedure averaged 22 min per session (range, 17-30 min) and 21 min per session (range, 13-28 min), respectively.

## Discussion

There was little difference in the number of training sessions required to master the 12 tasks for Children 1 and 2. In total, the Static procedure required 17 sessions, the Varied procedure 16 sessions, and the Differential Reinforcement procedure 18 sessions. Child 3's results were influenced by a task effect, which was verified in the replication. In the first comparison, the stimuli used in the differential Reinforcement and Varied procedures were fruits and animals, respectively, and the stimuli used in the Static procedure were letters, which were likely more difficult to discriminate. In the second comparison, after the stimuli in the Differential Reinforcement and Varied procedures were replaced with more abstract stimuli (shapes and numbers), Child 3's performance was similar in all three conditions and remained near chance level after 4 sessions. When the stimuli in all procedures were replaced with animals, he mastered the discriminations in 1 session in all three procedures. A reversal to the more abstract stimuli again resulted in chance performance and problem behaviours. Based on the results involving only the fruits and animal stimuli, Child 3's results appeared to be consistent with those observed for the other two children, showing little difference between the procedures in sessions to criterion.

For the 12 tasks mastered by Children 1 and 2 (excluding Child 3 due to the task effect) in both comparisons, fewer total errors occurred with the static and varied procedures (117 and 90 errors respectively) than with differential reinforcement (134 errors). However, since the differential reinforcement procedure required fewer trials to criterion than the varied and static antecedent procedures after practice trials were taken into consideration, it produced a higher rate of reinforcement per trial despite its higher error rate. For Children 1 and 2, edible reinforcement occurred on 80% and 77% of the trials, respectively, during differential reinforcement, whereas edible reinforcement occurred on 49% and 57%, respectively, during the varied antecedent procedure and on 37% and 23%, respectively, during the static antecedent procedure.

In addition, the advantage of the static and varied procedures for having fewer errors was off-set by the practice trials. Children 1 and 2 required a combined 324 trials in the differential reinforcement procedure, 738 trials (including practice) in the Varied procedure, and 891 (including practice) in the Static procedure. As a result, the differential reinforcement procedure required approximately 30% to 35% less time per session than the other procedures. Fewer practice trials (e.g., 1 instead of 5) would have taken less time although it is not clear whether that would yield error rates similar to 5 practice trials. Future research is needed to address this question.

A potential limitation of this study could be that we did not evaluate the quality of the reinforcing consequence for correct responses between procedures. Since the edible provided for correct responses was chosen by the child at the beginning of each session and procedural fidelity checks indicated that the edibles were delivered consistently, it was unlikely that the edibles had biased the results. However, we did not evaluate the quality of praise that accompanied the edibles. It could be argued that systematically praising a child more enthusiastically in one condition than another could have affected the results. However, this was also unlikely since the findings contradicted the hypothesis. Nonetheless, the quality of praise should be assessed systematically in future research.

The results of the present study contradict previous research that generally showed multiple-practice to be more effective than single- or no-practice (Barbetta et al., 1993, 1994; Worsdell et al., 2005). However, all of these studies had taught sight-word reading as the target behaviour. Smith et al. (2006) conducted one of the few error-correction studies that taught word-to-picture matching tasks to 6 children with autism. However, they compared a no-feedback condition, an error statement condition, and a modeling condition, and they did not require a practice response in any of the procedures. Results were mixed and did not favour any one procedure. Rodgers and Iwata (1991) compared a no-practice (differential reinforcement) condition to a multiple-practice condition to teach picture-to-picture matching to 7 adults with intellectual disabilities. Although 5 of the participants performed better in the practice condition, all participants showed improvement in the no-practice condition. The Smith et al. and Rodgers et al. studies, in conjunction with the present results, may suggest an interaction between the error correction procedures and the target responses being taught. A discussion of Michael's (1985) selection-based and topography-based responding may be relevant to this interaction.

Michael (1985) described selection-based responding as a more simplistic response where, under appropriate conditions, a person may emit a pointing, touching or selecting response in order to behave verbally, whereas topography-based responding requires the response itself to vary. For example, pointing to a symbol or picture from an array of symbols or pictures to communicate would be a selection-based response. In contrast, communicating by speaking or signing manually would be a topography-based response as each response would sound or appear different. To date, research that has found multiple practice to be more effective than differential reinforcement has all taught sight-word reading using topography-based responses in Michael's terms (Barbetta et al., 1993; Barbetta et al., 1994; Fabrizio & Pahl, 2007; Graff & Green, 2004; Worsdell et al., 2005) whereas research that has found mixed results has taught matching-to-sample discrimination tasks using selection-based responses (Rodgers & Iwata, 1991; Smith et al., 2006). It is possible that the primary benefit of multiple-practice is on improving response topography rather than strengthening stimulus control. With selection-based responses where the individual is already capable of pointing, practice following an error may be unnecessary and it reduces efficiency. Future research is needed to examine the impact of practice as an error correction procedure on topography-based versus selection-based responses.

In summary, the present results showed that for teaching selection-based matching-to-sample discriminations to children with ASDs, differential reinforcement produced more errors than the practice procedures. However, it required fewer trials and less time, and consequently it produced higher reinforcement density than the varied and static antecedent practice procedures. In addition, differential reinforcement has the added advantage of being a simpler procedure to use.

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