

*THE EFFECTS OF DIFFERENTIAL AND
LAG REINFORCEMENT SCHEDULES ON
VARIED VERBAL RESPONDING BY
INDIVIDUALS WITH AUTISM*

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Variability has been shown to be a reinforceable dimension of behavior. One procedure that has been demonstrated to increase variability in basic research is the lag reinforcement schedule. On this type of schedule, a response is reinforced if it differs from a specified number of previous responses. Lag schedules are rarely used, however, for increasing response variability in applied settings. The purpose of the present study was to investigate the effects of a lag schedule of differential reinforcement on varied and appropriate verbal responding to social questions by 3 males with autism. A reversal design with a multiple baseline across subjects was used to evaluate the effects of the lag schedule. During baseline, differential reinforcement of appropriate responding (DRA) resulted in little or no varied responding. During the intervention, a Lag 1 requirement was added to the DRA (Lag 1/DRA) resulting in an increase in the percentage of trials with varied and appropriate verbal responding for 2 of the 3 participants. In addition, an increase in the cumulative number of novel verbal responses was also observed for the same 2 participants. These results are discussed in terms of reinforcement schedules that support variability, generalization, and potential stimulus control over varied responding.

DESCRIPTORS: behavioral variability, lag reinforcement schedules, verbal responding

One common approach to teaching responding to social questions involves the use of differential reinforcement of an appropriate response (DRA) within a discrete-trial format (cf Shabani et al., 2002; Williams, Donley, & Keller, 2000). Specifically, a target verbal response is prompted and reinforced. Consequently, over the course of instruction, one targeted response may be selectively strengthened over other possible appropriate responses. Prompting and reinforcement procedures like those used in discrete-trial for-

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mats may facilitate the development of a dominant response. For instance, although several different responses to a social question would be appropriate and therefore produce reinforcement, over the course of instructional sessions, fewer and fewer of those responses may be emitted until only one or two occur and contact reinforcement. This type of selective strengthening has been demonstrated in the basic literature. For example, Schwartz (1982, Experiment 1) conducted an experiment in which college students were required to emit an eight-response sequence on two available response keys. Any combination of four responses on each key was reinforced, yet a dominant sequence developed for all participants. Specifically, results showed that sequence variability decreased over sessions despite the fact that reinforcement was available for a number of response sequences.

Differential reinforcement can also pro-

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duce and maintain variability in responding. Specifically, when variable responding is reinforced and invariant responding is placed on extinction, response variability increases (Page & Neuringer, 1985). This has been demonstrated most frequently in nonhuman animals. Pryor, Haag, and O'Reilly (1969) showed that when a different response was required for reinforcement in each session, porpoises initially emitted responses that were considered typical of the species' behavioral repertoire. As the sessions progressed and previous responses were extinguished, however, new responses emerged. These results demonstrated that as actions in the porpoises' normal repertoire were exhausted, the probability of actions that were not members of the species' typical behavioral repertoire increased. Similar differential reinforcement procedures have been successful in increasing variability along dimensions other than response topography. For example, Schoenfeld, Harris, and Farmer (1966) demonstrated that when reinforcement was contingent on varying durations of interresponse times, rats' lever pressing occurred with varying interresponse times. Studies such as these have shown that variability is a reinforceable dimension of operant behavior.

One type of reinforcement schedule that has been used to increase response variability has been referred to as a lag x variability schedule, where x represents the number of previous responses the current response must differ from to be reinforced. This reinforcement schedule permits responding to continue to be reinforced as long as successive instances of any single response are separated by other responses to the same discriminative stimulus. The number of other responses is defined by the parameter of the lag schedule. For example, Page and Neuringer (1985) showed that variations of sequences of key pecks with pigeons could be increased

with a variability requirement as stringent as Lag 50.

The effects of factors that influence response variability, such as interresponse intervals (Neuringer, 1991), reinforcement schedules (Machado, 1989; Neuringer, 1993), the topography of response options (Morgan & Neuringer, 1990), and discriminative control (Denney & Neuringer, 1998) have been examined in basic research. Fewer studies, however, have addressed variability as a reinforceable dimension of responding in applied settings. In an experiment with normally developing children in a preschool setting, Goetz and Baer (1973) reinforced only the first occurrence of forms constructed within block-building sessions. Results demonstrated that differential reinforcement of novel forms resulted in an increase in the number of previously unseen constructions. In another study aimed at increasing response variability, Lalli, Zanolli, and Wohn (1994) trained a single topography of toy play and found that new, untrained topographies were emitted when any topography was briefly reinforced and then placed on extinction. Similarly, Duker and van Lent (1991) increased the use of low-rate communicative gestures of individuals with mental retardation by placing higher rate gestures on extinction. Most recently, Miller and Neuringer (2000) demonstrated that variability in the play behavior of adolescents with autism could be increased using a percentile reinforcement schedule. To date, no research has examined the effects of lag schedules on response variability in applied settings.

The purpose of the present study was to determine whether previous findings on the contingent reinforcement of variability using lag schedules could be extended to the verbal behavior of individuals with autism. Specifically, we examined the effects of a Lag 1 schedule of differential reinforcement on the varied appropriate verbal responding to a so-

cial question of 3 individuals with autism. The present study used a lag schedule of differential reinforcement rather than differentially reinforcing novel responding because extinguishing previous appropriate verbal behavior was undesirable.

METHOD

Participants and Setting

Three individuals who had been diagnosed with autism, David, Charles, and Larry, participated in the study. David and Charles were 7-year-old boys and Larry was a 27-year-old man. All could speak in full sentences. In addition, all produced spontaneous speech (i.e., unprompted by an adult) with occasional prompts to use correct grammar. David typically made spontaneous requests for items or activities, whereas Charles was observed to emit spontaneous requests and greetings as well as descriptive comments about objects in his environment. David and Charles showed some repetitive verbal behavior by repeating the lyrics to songs or television commercials. Larry's spontaneous speech typically consisted of greetings and statements regarding some activity that he engaged in during the day.

The training sessions for David and Charles were conducted in the school cafeteria and kitchen area of an afterschool program for individuals with autism. A wide variety of materials, stimuli, and preferred activities were located in the cafeteria and kitchen areas across all sessions. Generalization probes across settings were conducted with David and Charles in a classroom, a gymnasium, and a staff lounge. A variety of different stimuli were also found in these settings in addition to preferred stimuli that were brought in to be used during programmed consequences. Larry's training sessions were conducted in an office of the day-habilitation program in which he was enrolled. A wide variety of materials and stim-

uli were present in the office across all sessions.

A social question was identified for each of the participants through interviews with the staff. They were asked to identify a question to which the participant always gave the same answer. "What do you like to do?" was used with David and Charles, and "How are you?" was used with Larry.

For all participants, the reinforcement system that was already in place in their program was continued during these sessions. For David and Charles, this consisted of a token economy in which a penny was provided for each correct response emitted during discrete-trial teaching sessions. David and Charles began each session in this study with no tokens. After earning 10 pennies, they exchanged the pennies for 1- to 2-min access to toys or activities or a small portion of edible items (e.g., two cookies or a plate of four to six chips). If David or Charles did not earn 10 pennies by the end of the session, a task from their curriculum was conducted until the remaining pennies were earned. Preferred tangible items were identified prior to the study by staff personnel using paired-choice preference assessments (Fisher et al., 1992). These assessments identified items such as toy cars, coloring books, or edible stimuli (e.g., cookies or potato chips). For Larry, social interaction was identified as a potential reinforcer based on interviews with therapists in his day program and informal observations. Social interaction consisted of praise statements, high fives, pats on the back, and conversations about favored activities (e.g., weekly trips).

Target Behavior, Measurement, and Design

The dependent variable was the percentage of varied appropriate verbal responding to a social question. That is, responses had to be both appropriate and varied. For "What do you like to do?" an appropriate response was defined as a word or gram-

matically correct sentence indicating a socially acceptable activity, for example, "go bowling," "I like to watch TV," and so on. For "How are you?" an appropriate response was defined as a word or grammatically correct sentence indicating affect, for example, "I'm fine," "not bad," or "pretty good." Appropriate responses did not include verbal responses that were unrelated to the question asked, echolalic speech, verbal responses that indicated socially unacceptable responses (e.g., "I like to burp") or responses that occurred more than 5 s following the question.

A *varied* verbal response was defined as any verbal response that differed in content from the last response to the same question. For example, if the response emitted on the first trial was "I like to watch TV," programmed consequences were presented on the second trial only if a different (i.e., varied) appropriate response was given. Responses also had to differ in more ways than changes in structure or tense. For example, if the response "I like to play with toys" was given on the preceding trial, "play with toys" would not be considered a different response. However, "I like to play with blocks" would be recorded as a varied response.

Data on appropriateness and variability were collected on an event basis. Sessions consisted of 10 trials and were conducted two to four times per week. All responses were recorded verbatim on a data sheet. This provided a record of the number of novel responses emitted throughout the study. Novel responses consisted of responses that were not emitted in any previous session and included both appropriate and inappropriate verbal responding (only appropriate novel responses are presented here).

Interobserver agreement was collected by a second data collector who was present during the session or who listened to an audiotaped recording of the session. Agreement was collected on 77%, 80%, and 75% of the sessions for David, Charles, and Larry, re-

spectively. Agreement percentages were calculated for appropriate responding, varied responding, and appropriate and varied responding by dividing the number of agreements by the number of agreements plus disagreements and multiplying by 100%. Percentages of agreement on all measures ranged from 90% to 100% for the 3 participants. An AB design (Larry) and ABAB reversal designs (David and Charles) embedded within a multiple baseline across subjects design was used to evaluate the effects of a Lag 1/DRA schedule on the percentage of varied appropriate verbal responding to a social question.

Procedure

The examiner and participant sat on the same side of a table facing each other approximately 1 m apart. For sessions in which interobserver agreement data were obtained during the session, the observer was positioned across the table from the examiner. The examiner presented the question at the beginning of each session and reinforced the first appropriate response. This response was recorded verbatim, but no other data were collected for the initial presentation of the question. The question was then presented for an additional 10 trials during which data were collected, with an intertrial interval of approximately 10 s. Thus, each session consisted of 11 total presentations of the social question, the last 10 of which were scored to give 10 opportunities for varied responding.

During baseline (DRA), appropriate responding to the social question was differentially reinforced. If a socially unacceptable response was emitted (e.g., "I like to burp"), the therapist said "no" and diverted attention away from the participant until the beginning of the next trial. When diverting attention, the therapist turned away to record the data and ignored any initiations made by the participant. The therapist initiated

the next trial at the end of the intertrial interval. If an appropriate but grammatically incorrect response was emitted (e.g., "I play toys"), the therapist corrected the response by providing a verbal prompt (e.g., "Say 'I like to play with toys'"). After the corrected response was imitated, it was reinforced.

The procedures during the intervention (Lag 1/DRA) were identical to baseline except that reinforcement was provided contingent on an appropriate response that fulfilled the Lag 1 requirement. Specifically, all appropriate responses that differed from the immediately preceding response produced reinforcement. If the same response was given on successive trials, the therapist gave no verbal feedback, recorded the data, and presented the next trial. As in baseline, if an inappropriate response was emitted, the therapist said "no" and diverted attention (as described above) until the beginning of the next trial. Finally, if a grammatically incorrect but appropriate and varied sentence was emitted, the therapist provided corrective verbal prompts and reinforced appropriate imitation of the prompt.

If Lag 1/DRA failed to increase varied and appropriate verbal responding to the social question after six sessions, a different therapist implemented a brief training procedure. During this training procedure, the social question was presented at the beginning of the trial and a verbal response was immediately modeled. Social praise was provided following correct imitation of the modeled response. A different verbal response to the social question was modeled on each of 10 trials during the session, and the order of the modeled responses was randomized across training sessions. After three consecutive sessions of 100% correct imitation of the modeled verbal responses, a delay was inserted between the presentation of the social question and the model. The delay was increased in increments of 2 s, up to a maximum of 6 s, if independent and appropriate respond-

ing occurred on at least 80% of the trials. This training procedure was necessary only for Larry.

Generalization probes across all conditions were conducted with procedures identical to those used in the baseline (DRA) condition. That is, reinforcement was provided contingent on appropriate responding without a variability requirement. Generalization probes were interspersed throughout both DRA and Lag 1/DRA conditions for David and Charles. Generalization probes across settings were conducted by the primary therapist in any of three settings other than the training setting. Generalization probes across people were conducted by any of three instructors other than the primary therapist in the training setting. These instructors were therapists from other classrooms and had minimal interaction with the participants prior to the study. Probes varying both the setting and the instructor were not conducted.

RESULTS

Figure 1 shows the percentage of varied appropriate verbal responding for David, Charles, and Larry. During the first DRA condition, David gave the same response on each trial during each session. With the addition of the Lag 1 requirement, the percentage of trials in which responses varied increased within two sessions from 0% to 50%, and following a brief decrease to 0% on the fourth and fifth sessions, remained stable between 40% and 70% for 11 sessions. During the reversal to DRA, the level of varied appropriate verbal responding immediately decreased, reaching 0% within three sessions. Conversely, the level of varied responding immediately increased with the return to the Lag 1/DRA schedule.

Similarly, Charles did not show any variation in the content of his verbal responses during the first DRA condition. With the

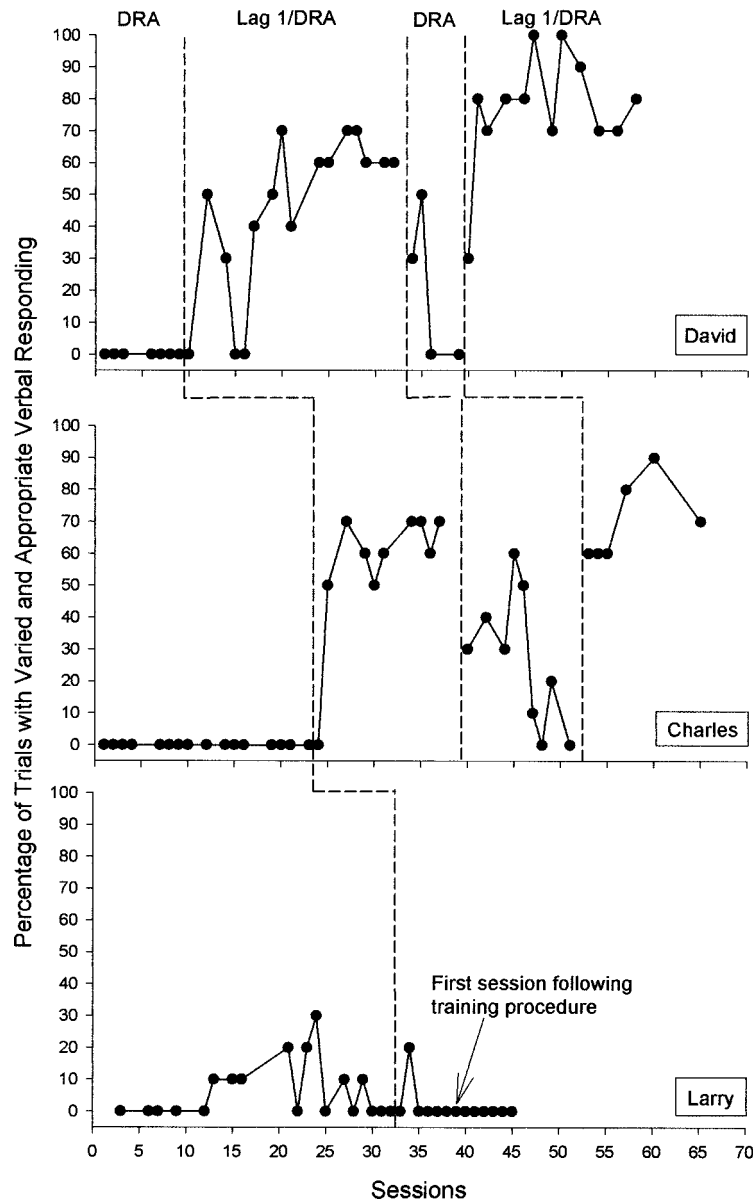


Figure 1. Percentage of trials with varied and appropriate verbal responding during Differential reinforcement of appropriate responding (DRA) and DRA plus a Lag 1 variability requirement (Lag 1/DRA) for David, Charles, and Larry.

onset of the Lag 1/DRA condition, the percentage of responses that varied from previous responses increased by the second session to 50% and remained between 50% and 70% for nine sessions. During the reversal, some varied responding was observed, but the trend decreased across sessions. The

reintroduction of the Lag 1/DRA produced an immediate increase in the level of varied responding.

For Larry, Lag 1/DRA did not increase the percentage of varied verbal responding. Percentages ranged from 0% to 30% throughout both phases of the study. The

training procedure was implemented following the sixth session of the Lag 1/DRA condition. Although accurate imitation of the modeled responses was obtained in four sessions (data not shown), no subsequent increases in varied verbal responding were observed upon the return to the Lag1/DRA condition.

Figure 2 shows the cumulative number of appropriate novel verbal responses for David, Charles, and Larry. David emitted one novel response during the first DRA condition. With the introduction of Lag 1/DRA, appropriate novel verbal responding increased and continued to do so throughout the study, reaching a total of 19 appropriate novel verbal responses by the last session. Charles did not emit a novel response until the lag requirement was introduced, and he emitted a total of four appropriate novel verbal responses throughout the study. In addition, the emission of appropriate novel responses occurred exclusively during Lag 1/DRA phases. The cumulative record for Larry showed that only one appropriate novel response was emitted throughout the study.

Figure 3 shows the results of the generalization probes across settings and people for David (top panel) and Charles (bottom panel), respectively. No varied verbal responding was observed when the first DRA was in effect during the experimental sessions. A systematic increase in the percentage of varied and appropriate verbal responding was observed during generalization probes for both David and Charles when Lag 1/DRA was introduced (indicated by the dark shading). During the reversal to DRA, a systematic decrease in the percentage of varied and appropriate verbal responding was observed during the generalization probes for both David and Charles, followed by another increase in varied and appropriate responding during the generalization probes when Lag 1/DRA was reintroduced.

DISCUSSION

The present study demonstrated that a lag schedule of differential reinforcement of varied and appropriate verbal responding (Lag 1/DRA) was effective at increasing the percentage of varied appropriate verbal responding to a social question for 2 of the 3 participants. Systematic increases in the percentage of varied and appropriate verbal responding were observed when Lag 1/DRA was introduced, and a systematic decrease was observed during the return to baseline (DRA), demonstrating control by the schedule of reinforcement. These results extend previous findings on the use of lag schedules for increasing varied responding to instances of verbal behavior. This and previous findings by Miller and Neuringer (2000) suggest that the extent of invariant and varied behavior exhibited by individuals with autism may be influenced by reinforcement contingencies. Of particular interest is the fact that prompts for varied or novel verbal responses were not necessary to produce varied, appropriate, and novel verbal responses. These results provide a preliminary demonstration of the effectiveness of a reinforcement schedule that requires varied verbal responding to a social question in the absence of any prompting.

It should be noted that the effects observed with David and Charles may have been influenced by the nature of the social question in combination with the Lag 1/DRA schedule and the type of stimuli available in the room. A closer examination of the cumulative record of verbal responses emitted by David and Charles suggested that stimuli in the environment may have signaled or prompted novel responses. Specifically, the content of novel responses tended to be influenced by items found in the environment. For example, when edible items were present in the training room, the content of David's responses occasionally reflect-

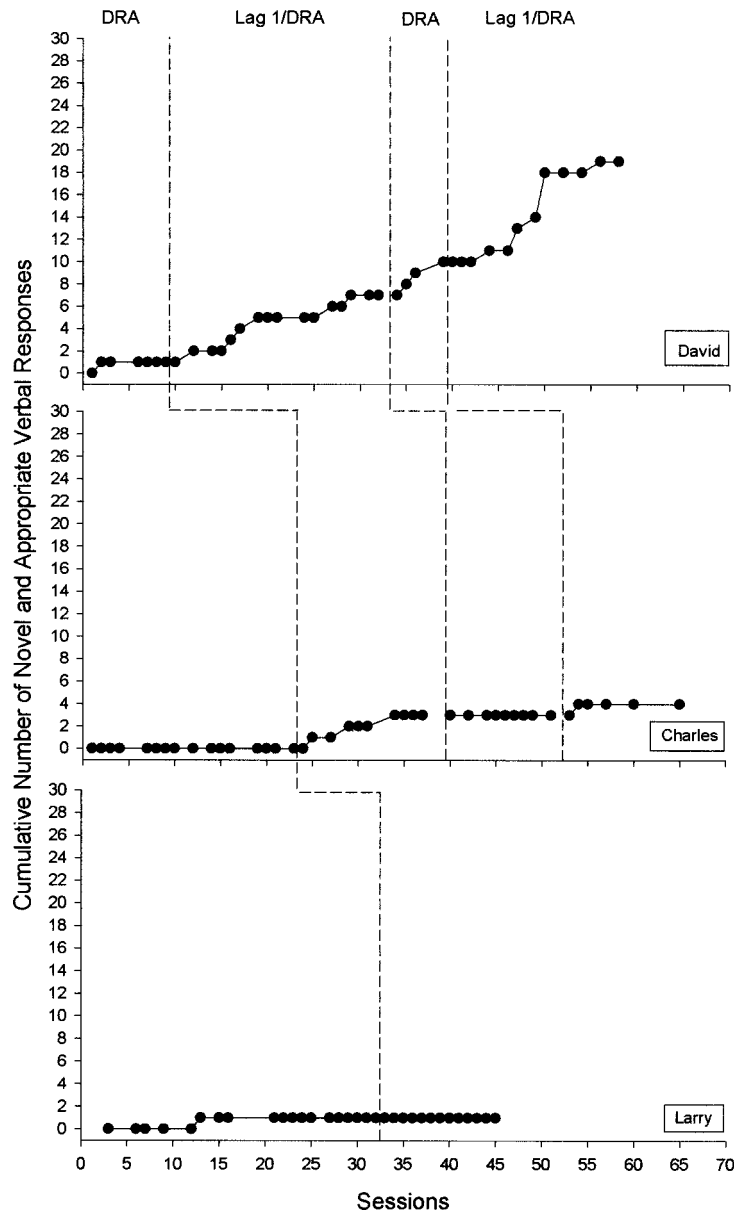


Figure 2. Cumulative number of novel appropriate verbal statements for David, Charles, and Larry. A novel verbal statement was any statement that had not been observed in any previous session. The shaded areas indicate when the Lag 1/DRA schedule was in effect during the experimental sessions.

ed those items, such as, “I like to drink juice” and “I like to eat pretzels.” Responses such as, “I like to color” and “I like to read” occasionally occurred when items such as books and toys were present. Beginning with the 26th session, David’s sessions were conducted in a kitchen area in an office build-

ing. The content of his responses then changed to reflect the presence of various items in the new environment. With the presence of different objects, David emitted responses such as “I like to drink Coke,” “I like to go to the soda shack,” and “I like to ride the exercise bike.” This also accounts for

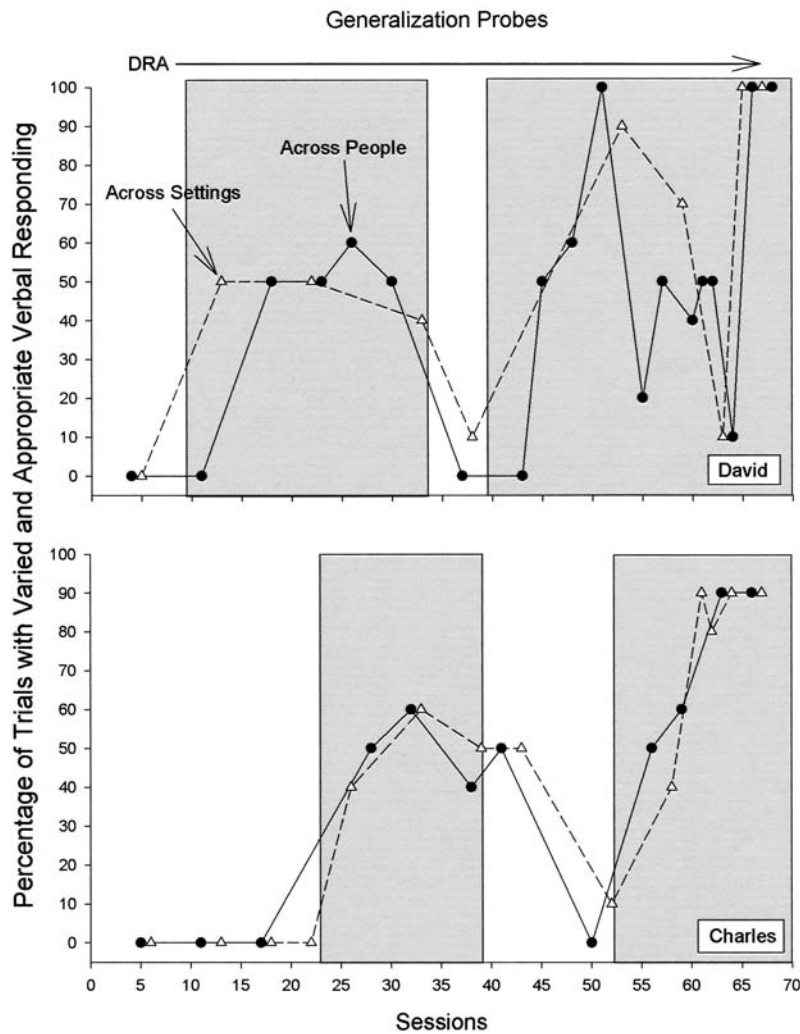


Figure 3. Percentage of trials with varied and appropriate verbal responding during generalization probes across different people and settings for David (top panel) and Charles (bottom panel). The shaded areas indicate when the Lag 1/DRA schedule was in effect during the experimental sessions.

the occurrence of a novel response on each of the last three sessions in the reversal to DRA despite 0% varied responding throughout the session. Thus, on each of these sessions, David emitted a response that had not been observed in any previous session but did not emit a different response within those sessions.

The effect of environmental stimuli on the content of the verbal responses was also observed with Charles. He emitted responses such as “I like to play with toys” and “I like

to play with my animals and dinosaurs,” which were highly preferred items and were also located in the area where the sessions were conducted. Similar observations were made during generalization probes. When probes were conducted in the gym, David emitted responses such as, “I like to ride the bicycle” and “I like to roller skate in the gym.” Upon exchanging their tokens, David and Charles frequently requested items that were indicated in their responses to the social question. These observations suggest

that the participants' responses may have been mands for available reinforcers. The fact that these stimuli were present across all conditions suggests that the lag schedule was responsible for varied responding but that environmental stimuli may have occasioned novel responses. It is possible that in the absence of the variety of stimuli that were present during these sessions, Lag 1/DRA would have been insufficient to increase varied verbal responding. Future studies may attempt to identify the effects of the presence of antecedent stimuli and the properties of stimuli (e.g., salience, preference) that occasion specific responses when varied responding produces reinforcement.

A limitation of the Lag 1 schedule used in this study is that it was possible for the participants to obtain 100% of the reinforcers (i.e., on each of the 10 trials) by consistently alternating between two responses. Typically, the minimum amount of variability will occur to fulfill the reinforcement requirement. This has been observed in previous research, and has been referred to as higher order stereotypy (Schwartz, 1982). An examination of the cumulative record of novel appropriate responses, however, revealed that David emitted responses that had not occurred in any previous session following exposure to the Lag 1/DRA schedule, and continued to do so throughout the study, for a total of 19 different appropriate responses. This was observed to a lesser extent for Charles, who emitted a total of four different appropriate responses. It is not clear why David did not consistently alternate between two responses, whereas Charles' responding was more efficient. Future studies may investigate different parameters of lag schedules, including variable lag schedules, and their effects on higher order stereotypies.

An interesting effect observed in this study was the occurrence of varied responding during the generalization probes, despite

the fact that reinforcement was not contingent on varied responding. An increase in the percentage of varied and appropriate verbal responding was observed in the generalization probes each time the Lag 1/DRA was introduced in the experimental sessions. A corresponding decrease was observed in the generalization probes when the variability requirement was withdrawn in the experimental sessions. One plausible explanation is that the social question may have been discriminative for the schedule that was in effect during the experimental sessions. That is, when the social question was correlated with DRA, performance during the generalization probes was similar to that seen during DRA sessions. When the social question was paired with Lag 1/DRA, performance during the generalization probes was similar to that seen during Lag 1/DRA sessions. These results, combined with the tight schedule control demonstrated in the ABAB reversal design, suggest that varied responding is highly sensitive to lag schedules. Future studies may attempt to identify the training situations and environmental conditions that are necessary and sufficient for varied responding to occur and to be maintained under natural conditions that do not explicitly require varied responding but in which varied responding may be more socially appropriate or adaptive.

Finally, Lag 1/DRA was shown to be ineffective at increasing the percentage of varied appropriate verbal responding for Larry. Some varied responding was observed during the DRA phase, but this may have been due to prior social interaction training in which he was taught to reciprocate social questions. For example, Larry typically emitted the response, "Fine. How are you?" to the social question. Occasionally, Larry did not reciprocate the social question. This accounted for all instances of varied responding throughout the study. The reason for the lack of the desired effect with Larry is un-

clear, but there are several plausible hypotheses. First, the stimuli used as consequences with David and Charles were different from those used with Larry. The lack of an effect observed with Larry may be due to the possibility that verbal praise did not function as a reinforcer. Second, the specific question asked of Larry may have not evoked varied responding. As discussed with David and Charles, responding to "What do you like to do?" may have been occasioned by the presence of objects in the environment that are associated with specific activities. Responding to "How are you?" is less likely to be occasioned in this manner because objects in the environment are generally not associated with statements of how an individual feels. Third, Larry was 27 years old, whereas David and Charles were both 7 years old. Although it is not known what role this age difference may have had, it may represent a longer reinforcement history for Larry's invariant responding. Furthermore, other sources of stimulus control may also have interfered with the Lag 1/DRA contingency. Following the training procedure, Larry's varied and appropriate verbal responding occurred in the presence of the therapist who provided the training. However, the level of varied and appropriate verbal responding remained at 0% with the therapist who conducted the Lag 1/DRA sessions. The failure for varied responding to generalize to the primary therapist may have been due to unidentified sources of control over invariant responding in the presence of the primary therapist. When invariant responding persists in the presence of lag schedules, prompting and fading procedures may be necessary to occasion varied responding. This was not evaluated for the primary therapist for Larry.

Future research should investigate the role of prompts in either facilitating or restricting variability. In the education and treatment of individuals with developmental disabili-

ties and particularly autism, gains have been achieved with behavior-analytic techniques, yet our training procedures are often criticized for teaching people with autism to behave robotically. Further systematic investigations in the area of variability might begin to address those issues. If variability in interresponse times is subject to reinforcement (Schoenfeld et al., 1966), then perhaps characteristics of speech are as well. If the content of verbal statements is subject to reinforcement, then perhaps daily routines are also. Future applied research in this area should be designed to determine further the behavioral processes that are responsible for varied responding in training and generalization sessions and the conditions that are necessary and sufficient to produce and maintain a desirable level of varied responding of socially meaningful behavior in natural settings.

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STUDY QUESTIONS

1. What are some conditions under which response variability would be desirable and undesirable?
2. Describe the response options that would result in reinforcement on the first six trials of a Lag 3 schedule of reinforcement.
3. Why did the authors choose to implement a lag schedule of differential reinforcement rather than to simply reinforce novel responses?
4. Describe the consequences provided for appropriate, inappropriate, and grammatically incorrect responses during DRA, Lag 1/DRA, and generalization sessions.
5. Briefly describe the training procedure and the conditions under which it was implemented.
6. Summarize the results obtained during the DRA, lag reinforcement, and generalization conditions.
7. What aspect of participants' performance suggested that context influenced their behavior?
8. What procedure seems to be a common component of all behavioral interventions aimed at increasing response variability?

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