The Analysis of Verbal Behavior 2009, **25,** 73–78

Increasing Vocal Variability in Children with Autism Using a Lag Schedule of Reinforcement

John W. Esch and Barbara E. Esch, Esch Behavior Consultants, Inc.
Jessa R. Love, Western Michigan University

Variability has been demonstrated to be an operant dimension of behavior (Neuringer, 2002; Page & Neuringer, 1985). Recently, lag schedules have been used to demonstrate operant variability of verbal behavior in persons with a diagnosis of autism (e.g., Lee, McComas, & Jawor, 2002). The current study evaluated the effects of a Lag 1 schedule on the vocal variability of 2 nonverbal children with a diagnosis of autism. Results showed systematic increases in variability during the Lag 1 schedule. Implications of lag schedules for speech and language training are discussed.

Key words: variability, lag schedule, verbal behavior, autism, speech delay, echoic

Children with a diagnosis of autism often have severely delayed speech with few or no echoic skills and infrequent, highly repetitive vocalizations. For these children, acquiring a functional verbal repertoire is difficult. What is needed is a repertoire of highly varied vocal responses that can come under reinforcement contingencies as verbal operants (e.g., mands, tacts). However, without this foundation of varied vocalizations, vocal models such as those used in echoic training (arguably one of the easiest ways to evoke a verbal response) are largely ineffective. There are few therapeutic tools to increase a weak, inconsistent, or invariant vocal repertoire. One promising procedure for nonechoic children with low vocal variability is stimulus–stimulus pairing (SSP), aimed at establishing speech stimuli as conditioned reinforcers by pairing them with already established reinforcers (e.g., Esch, Carr, & Grow, in press; Miguel, Carr, & Michael, 2002). However, SSP effects are equivocal to date. Shaping is another behavioral treatment that may be indicated when echoic skills are absent. One study (Drash, High, & Tudor, 1999) used extinction-induced vocal protests and shaping to differentially reinforce vocalizations as mands. Although the Drash et al. study may inform a potentially useful treatment, procedures that involve extinction may have poor social validity; thus, treatments that circumvent this disadvantage also should be sought.

Lag schedules to induce variability offer another clinical tool that may improve a weak vocal repertoire. These schedules are characterized by reinforcer delivery following a certain number of different responses (Cooper, Heron, & Heward, 2007). For example, reinforcement on a Lag 1 schedule is delivered when a response is different from the response immediately preceding it. Variability has been demonstrated to be an operant dimension of behavior (Neuringer, 2002; Page & Neuringer, 1985); recently, researchers have applied the use of lag schedules to induce vocal variability in persons with a diagnosis of autism (Lee, McComas, & Jawor, 2002; Lee & Sturmey, 2006). Lee et al. used a Lag 1 schedule to teach boys with verbal skills to vary their vocal responses to social questions (e.g., ''What do you like to do?''). Reinforcement was scheduled for any socially appropriate vocal response whose content varied from the preceding response. For example, ''I like to play with toys'' is different from ''I like to play with blocks,'' but it is not different in content from ''play with toys.'' Results indicated that 2 of 3 participants acquired varied vocal-verbal responses. The purpose of the current study was to systematically replicate previous lag sched-

We thank Jim Carr for his helpful suggestions and encouragement. Thanks also to Lindsay Burris and Elizabeth Solliday for their assistance with data collection. Jessa Love is now affiliated with the Thompson Center for Autism and Neurodevelopmental Disorders at the University of Missouri.

Correspondence concerning this article should be addressed to John W. Esch, Esch Behavior Consultants, Inc., P.O. Box 20002, Kalamazoo, Michigan 49019 (e-mail: jesch1@mac.com).

ule applications (Lee et al.; Lee & Sturmey) to evaluate the effects of a Lag 1 schedule on vocal variability in nonverbal children with a diagnosis of autism who emitted infrequent and repetitive speech sounds.

METHOD

Participants, Setting, and Materials

Two children with a diagnosis of autism participated in the study. At the beginning of the experiment, Randall was 7 years 1 month old and Chandler was 2 years 6 months old. Neither child emitted functional speech. Their vocal topographies were assessed for the frequency of each of the 44 English phonemes during a 30-min preexperimental observation of solitary play and play with a familiar teacher. Target phonemes were selected from those that occurred in the lower half of ranked frequencies. Echoic accuracy was assessed with the Kaufman Speech Praxis Test for Children (Kaufman, 1995). Neither participant passed any part of the test; that is, they emitted no echoics and no recognizable words. The study was conducted in a small conference room at the children's preschool. The room was equipped with a table, chairs, video camera, and a variety of toys that had been previously identified as preferred during the stimulus preference assessment. These items remained in the room throughout each session, although preferred items were available and visible only during appropriate experimental conditions.

Stimulus Preference Assessment

Prior to the experiment, items reported by caregivers as preferred were presented three times in a separate multiple-stimulus preference assessment as described by Carr, Nicolson, and Higbee (2000). The three highest ranked items were used as putative reinforcers for the Lag 1 condition of the experiment. Randall preferred edible items and bubbles, and Chandler preferred puzzles, bubbles, and drawing on the dry-erase board.

Response Definition and Data Collection

Sessions were videotaped, and participants' vocal responses were recorded and subsequently phonetically transcribed by a speech pathologist. Vocal behavior was defined as responses that produced speech sounds. Nonspeech vocal responses such as grunts or cries were not counted.

Vocal response variability was the primary variable of interest. (Data collected on secondary variables, i.e., echoics, all vocalizations, and new phonemes, are not included in this report.) Variability was coded according to the correspondence (or lack thereof) of a response to the response topography emitted in the preceding trial. (See *Sample session* below for an example of a coded session.) A varied vocal response (VAR) was defined as a speech vocalization that was different (coded D) from the response topography of the preceding trial and that occurred within 5 s of the experimenter's model. For instance, the therapist's model *buh* on Trial 1 might evoke the child's response *ah*. Regardless of the next model, any Trial 2 response other than the previous trial's *ah* (such as *uh, ahp, buh*) would be different (thus, VAR and coded D) and would be reinforced. Responses that were not coded D were coded as either repeated (R), no vocal response (N), or base vocal response (B). A response was coded R if its topography matched the topography of the response emitted in the preceding trial. For example, *buh buh* would be a repeat of the previous response *buh-buh*, but not of responses such as *bub* or *ub ub* (i.e., although the same two speech sounds comprise these responses, the sound sequences are different). A trial in which no speech response was emitted was coded N. N trials precluded reinforcement in the subsequent trial because they contained no emitted topography from which the subsequent trial's response could vary. Thus, a vocal response on the trial following an N trial was coded B as a base vocal response. This base response then served as a comparison to determine the code for the vocal response in the trial following the base trial. In addition to comparing responses to each other and coding them accordingly (D, R, or B), responses also were compared to the antecedent model and coded E (for echoic) if they contained a phoneme that matched a phoneme in the therapist's model. For instance, the response *buh* following the model *bubba* would be

coded E. Thus, any particular response was compared twice, first to the previous response (and coded D, R, or B) and then to the therapist's model (and coded E if any phoneme matched the model).

Interobserver Agreement

Two independent observers collected data on at least 50% of randomly selected sessions in each condition. Data were collected during sessions or from session videotapes. Point-by-point agreement was calculated on each 10-trial block by dividing the number of code agreements by the sum of agreements and disagreements and converting this ratio to a percentage. Mean agreement of VAR was 99.6% for Randall (range, 80% to 100%) and 94.5% for Chandler (range, 80% to 100%).

Procedural Integrity

A trained observer assessed treatment integrity from videotapes or during sessions for at least 50% of sessions, randomly selected from each condition. Integrity was defined as the presentation of the programmed vocal model, reinforcement delivery within 5 s, and presentation of an intertrial motor task. Trials were scored as completely correct or incorrect. A procedural integrity score was calculated for each 10-trial block by dividing the number of correct trials by the sum of correct and incorrect trials and converting this ratio to a percentage. Mean procedural integrity was 94.4% and 92.8% for Randall and Chandler, respectively.

Experimental Design and Procedures

A nonconcurrent multiple baseline design (Watson & Workman, 1981) across participants was combined with a reversal design to evaluate the effects of a Lag 1 schedule on variable vocal responding.

Vocal models. Antecedent vocal models initiated each trial and were included to maximize the likelihood of a vocal response and to inform echoic responding as a secondary dependent measure. Each session consisted of a 10-trial block in which five vocal models were presented twice each, one model per trial. The most frequently occurring phoneme from the preexperimental observation was presented immediately prior to each 10-trial block; this functioned as a base for determining variability on Trial 1 of each session. The sequence of vocal models for Randall was (base trial: *bah*), *dip*, ***wow***, ***wow***, *dip*, ***my***, ***my***, *mop*, *oh*, *mop*, *oh*. Chandler's vocal models were (base trial: *m*), *oh*, ***ae***, ***ae***, *ay*, ***fawfaw***, ***fawfaw***, *ay*, *bubba*, *oh*, *bubba*. Sequentially repeated phonemes (in boldface) controlled for echoic responding. That is, if each vocal model differed from the preceding model, there would be no way to determine whether responding was controlled by the effects of the immediately antecedent vocal model (i.e., echoic control) or by the lag schedule. Thus, contiguously repeated models permitted the identification of responses controlled solely by echoic variables (i.e., immediately antecedent vocal models). Therefore, a session in which all 10 responses were echoic would yield a D score of eight because an echoic response on any trial with a contiguously repeated model would be scored as a repeat of the previous response. In contrast, completely varied vocal responses, absent echoic control, would yield a D score of 10.

Baseline. The experimenter initiated each trial by saying the child's name and then presenting the designated vocal model for that trial. If the child did not respond within 5 s, the experimenter re-presented the model. Any vocal response within 5 s of the model was praised and was followed by an intertrial motor task (e.g., put an object in a container). Task completion signaled initiation of the next trial.

Lag 1 schedule. At the beginning of each Lag 1 schedule session, the child was given a choice of previously identified preferred items and was allowed to interact with them briefly. Then the items were put out of reach. Vocal models were presented sequentially as in baseline. A response that was different (D) from the previous trial was praised and preferred items were delivered. If no vocal response (N) occurred after two presentations of the model or the previous vocal response was repeated (R), the child was instructed to complete an intertrial motor task. If the child vocalized a new base response (B) following a trial with no vocal response, the new response was praised, followed by completion of the intertrial motor task. Echoic responses

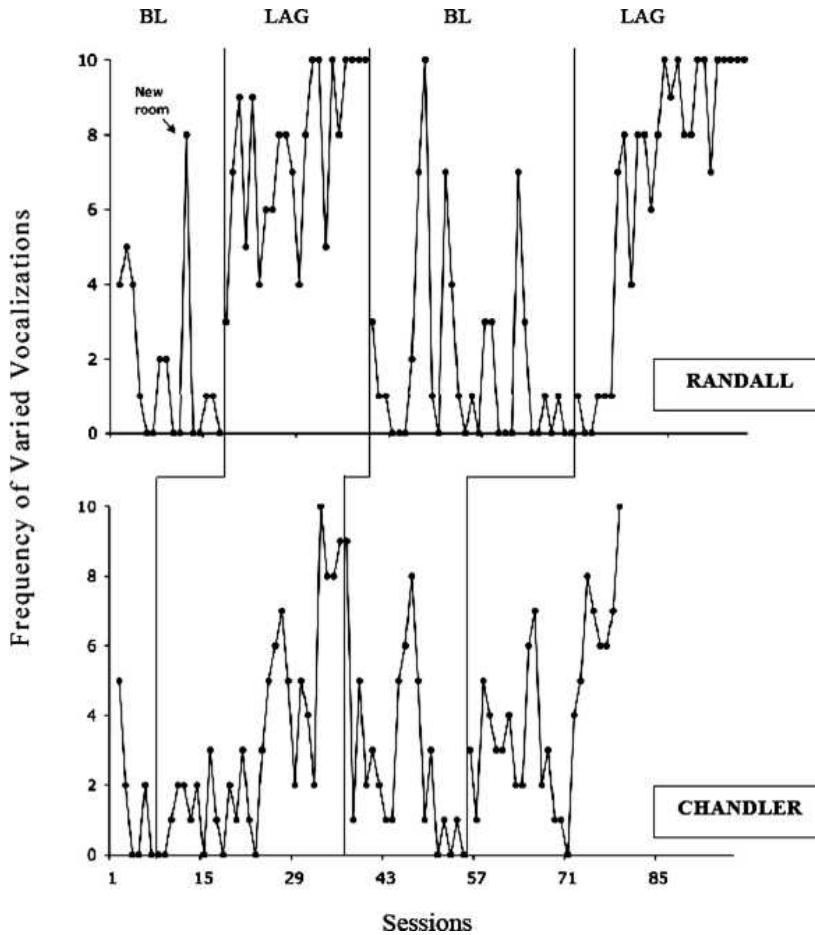

Figure 1. Frequency of trials in which a vocalization was different from the vocalization of the previous trial across baseline and Lag 1 schedules for Randall and Chandler.

(E) were recorded but received consequences only according to the score code D, R, or B. The next trial was initiated after 30 s of reinforcer contact or after completion of the intertrial motor task.

Sample session. The following illustrates score codes for a typical lag session with Chandler. Lag 1 consequences were delivered for trials in boldface. Other trials received consequences as described above. Session base model: *mmm*; response: *ah* (no code); Trial 1 model: *oh*; response: *ah* (R); Trial 2 model: *ae*; no response: (N); Trial 3 model: *ae*; response: *ah* (B); **Trial 4** model: *ay*; response: *bah* (D); **Trial 5** model: *fawfaw*; response: *baba* (D); **Trial 6** model: *fawfaw*; response: *ah* (D); Trial 7 model: *ay*; no response: (N); Trial 8 model: *bubba*; response: *bubba* (B, E); **Trial 9** model: *oh*; response: *ah* (D); **Trial 10** model: *bubba*; response: *buh* (D, E).

RESULTS

Figure 1 displays results for Randall and Chandler on the frequency within 10-trial blocks in which a vocalization varied (VAR, coded D) from the previous trial. VAR levels were low (<5) during Baseline 1, with the exception of Randall's Session 11, which required an unexpected room change. Baseline mean VAR was 1.8 (range, 0 to 8) for Randall and 1.5 (range, 0 to 5) for Chandler. During the first Lag 1, response levels were

variable, but there was a strong upward trend in both data paths. Randall's mean VAR was 7.6 (range, 0 to 10) and Chandler's was 3.2 (range, 0 to 10). After return to baseline, a similar pattern of unstable responding was evident, but Baseline 1 levels were reestablished. Mean VAR levels were 1.8 (range, 0 to 10) for Randall and 2.8 (range, 0 to 8) for Chandler. With reinstatement of the Lag 1 schedule, an upward trend was seen for both participants, although Chandler's highly variable responding continued. Randall's mean VAR was 6.7 (range, 0 to 10), and Chandler's mean VAR was 3.5 (range, 0 to 10).

DISCUSSION

In this study, a Lag 1 reinforcement schedule resulted in systematic increases in varied vocalizations of 2 nonverbal children with autism and low vocal variability. This investigation extends previous research (Lee et al., 2002; Lee & Sturmey, 2006) with verbal participants to nonverbal children with severely limited vocal skills. Although the study presents a small data set, it suggests that lag schedules may be a useful tool to help severely speech-impaired children learn to talk by first strengthening the variability of their vocal repertoires. This is a necessary first step for children who lack verbal behavior because, without a large class of highly variable vocalizations, there is insufficient raw material to develop verbal operants. In other words, an available pool of varied vocalizations permits the clinician to selectively reinforce those varied sounds as echoics, mands, tacts, and so forth. In an unreported data set from this study, we found that lag schedules may induce, or otherwise make available, echoic responses, even though variability rather than echoic responding is targeted through lag schedules. Data indicated that echoic responses covaried with VAR responses during Lag 1 for 1 participant. Future researchers might consider the benefits of such covariance. That is, it could be useful to target vocal variability while strengthening relevant antecedent and consequent control to produce verbal behavior. Concurrent schedules offer a mechanism to reinforce variable responding on one schedule while reinforcing nonvariable (e.g., echoic) responding on another schedule. For instance, a lag schedule could arrange differential reinforcement for variable vocal responding while responses that approximate the antecedent vocal model are differentially reinforced according to another schedule. Various lags could be investigated to determine optimal performance. In this study, the immediate return to baseline levels following withdrawal of Lag 1 suggests that thinner lag schedules (e.g., Lag 2, Lag 3) may be beneficial to provide more resistance to extinction. Once the effects of a lag schedule are established, they might be enhanced by multiple and perhaps more frequent alternation between baseline and lag conditions.

One caveat suggested by this study is the importance of developing a socially significant definition of vocal variability. We defined vocal variability as any vocalization whose phonemes differed in topography (*lee, mop*) or in sequence (*ub, buh*) from those uttered in the previous trial. For both children, vocal responses tended to vary within a phonemic class whose response members required little tongue repositioning (e.g., *uh, ah, buh, muh*). Hence, defining and reinforcing variability solely on the basis of phonemic sequence may have inadvertently constrained other aspects of variability that are needed for further speech learning. That is, although speech variations were strengthened, they were atypical of those required for fluent speech in which rapid tongue, lip, jaw, and laryngeal movements must necessarily occur to produce a variety of different phonemes in coordinated sequences.

REFERENCES

Carr, J. E., Nicolson, A. C., & Higbee, T. S. (2000). Evaluation of a brief multiple-stimulus preference assessment in a naturalistic context. *Journal of Applied Behavior Analysis, 33,* 353–357.

Cooper, J. O., Heron, T. E., & Heward, W. L. (2007). *Applied behavior analysis (2nd ed.).* Upper Saddle River, NJ: Pearson Education.

Drash, P. W., High, R. L., & Tudor, R. M. (1999). Using mand training to establish an echoic repertoire in young children with autism. *The Analysis of Verbal Behavior, 16,* 29–44.

Esch, B. E., Carr, J. E., & Grow, L. L. (in press). Evaluation of an enhanced stimulus–stimulus pairing procedure to increase early vocalizations of children with autism. *Journal of Applied Behavior Analysis.*

Kaufman, N. R. (1995). *Kaufman speech-praxis test for children.* Detroit: Wayne State University Press.

Lee, R., McComas, J. J., & Jawor, J. (2002). The effects of differential and lag reinforcement schedules on varied verbal responding by individuals with autism. *Journal of Applied Behavior Analysis, 35,* 391–402.

Lee, R., & Sturmey, P. (2006). The effects of lag schedules and preferred materials on variable responding in students with autism. *Journal of Autism and Developmental Disorders, 36,* 421–428.

Miguel, C. F., Carr, J. E., & Michael, J. (2002). The effects of a stimulus-stimulus pairing procedure on the vocal behavior of children diagnosed with autism. *The Analysis of Verbal Behavior, 18,* 3–13.

Neuringer, A. (2002). Operant variability: Evidence, functions, and theory. *Psychonomic Bulletin & Review, 9,* 672–705.

Page, S., & Neuringer, A. (1985). Variability is an operant. *Journal of Experimental Psychology: Animal Behavior Processes, 11,* 429–452.

Watson, P. J., & Workman, E. A. (1981). The non-concurrent multiple baseline across individuals design: An extension of the traditional multiple baseline design. *Journal of Behavior Therapy and Experimental Psychiatry, 12,* 257–259.