2009

Analysis of progessive lag reinforcement schedules and environmental cues on verbal response variability

Brian Esteve
Louisiana State University and Agricultural and Mechanical College, brianesteve@cox.net

ANALYSIS OF PROGRESSIVE LAG REINFORCMENT SCHEDULES AND ENVIRONMENTAL CUES ON VERBAL RESPONSE VARIABILITY

A Dissertation

Submitted to the Graduate Faculty of the
Louisiana State University and
Agricultural and Mechanical College
in partial fulfillment of the
requirements for the degree of
Doctor of Philosophy

in

The Department of Psychology

by
Brian Michael Esteve
B.S., Louisiana State University, 2001
M.A., Louisiana State University, 2005
May 2009

Acknowledgements

I would like to thank Dr. George H. Noell for his dedication, support and mentorship throughout this process. Without his guidance, this would not have been possible. I would also like to thank Dr. Kristin Gansle, Dr. Frank Gresham, Dr. Mary Lou Kelley, and Dr. Michelle Livermore for their time and knowledge as members of my dissertation committee. I would like to thank my colleagues for their emotional support throughout this process. I would like to thank my son, Noah Esteve, for always making me smile and continually reminding me of the big picture. Finally, I would like to thank my wife, Claire Sanderson Esteve, for her sacrifice, patience, belief and most importantly, her love which makes anything possible.

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Abstract

This study examined the effectiveness of progressive lag reinforcement schedules to increase novel and appropriate verbal responses to academic skills for three children with language delays. The effect of visual cues on verbal responses was evaluated in conjunction with progressive lag reinforcement schedules using a multiple baseline with an embedded alternating treatments design. Basic research utilizing lag reinforcement schedules have shown to increase variable behavior in both animal and human participants; however, little research has been conducted to evaluate lag reinforcement schedules in applied settings. The results of this study preliminarily indicate that progressive lag reinforcement schedules are an effective and efficient method to increase variable behavior in applied settings. Experimental conditions with visual cues produced a slight overall increase in novel and appropriate verbal responses; however, this effect was not observed across all participants and baselines. The advantages and disadvantages of progressive lag reinforcement schedules and directions for future research are discussed.

Introduction and Review of Literature

The continuous development of age appropriate language skills is an important factor in the favorable long term prognosis of every child (Clegg, Hollis, Mawhood, & Rutter, 2005). Appropriate language development is a critical component for children as they learn to understand and control their environment (Chapman 1981). As children develop language skills they are able to express their physical and emotional needs to the caretakers in their lives. Children who experience delays in language development have a higher incidence of behavioral problems than their same aged peers who do not possess language delays (Tervo, 2007). These behavioral problems are often thought to develop out of frustration due to the child's inability to express his/her wants and needs. In an attempt to stop or prevent these behavioral problems, caretakers often inadvertently reinforce these behaviors which in turn make them likely to occur in the future. Thus, a harmful relationship between the child and caretaker develops early in the child's life: a relationship in which the child learns that the most efficient method to control his/her environment is through using these less adaptive behaviors (Carr & Durand 1985).

The early development of behavioral problems can exacerbate language delays by interfering with treatments/interventions designed to help them. For example, teachers and therapy providers who treat language delays will experience more difficulty treating children who exhibit behavioral problems than those who do not. As a result of these difficulties, teachers and therapy providers may also inadvertently reinforce the child's behavioral problems, begin to avoid the child, and/or deem the child un-teachable. Thus an even more harmful relationship develops in which the child continues to use problem behavior as a form of communication, and as a result attempts to engage the child and remediate the language delay are decreased or discontinued.

The severity of a language delay can vary greatly from one individual to another. Potential causes of language delays can include: (a) developmental disabilities, (b) mental retardation, (c) premature birth, (d) hearing impairments, (e) early childhood illness, (f) neurological problems, and (g) extreme environmental deprivation (Coplan, 1995, pp 195-199). While treatment for language delays can vary depending on the cause of delay, most researchers and treatment providers agree that early detection and intervention leads to better long term outcomes (Sundburg & Michael, 2001). Although treatment recommendations can vary for remediating language delays, there is significant empirical evidence supporting intensive behavioral interventions based on the principles of Applied Behavior Analysis (Ogletree & Oren 2001; Smith 2001). Behavioral interventions have been successful in increasing language development with a variety of populations across a wide range of severities.

Behavioral Interventions

Over the past sixty years there has been significant research applying the principles of behavior analysis to socially significant behaviors. Individuals with language delays have often been targets of behavioral research because of the large negative impact language delays may have on an individual's long term prognosis (Tervo, 2007). Some of the common characteristics of behavioral interventions for language delays are: (a) breaking down instructional tasks into small manageable components, (b) using models and prompts to facilitate correct responding, (c) using a systematic method of reinforcement to promote and maintain learned behaviors, (d) providing immediate feedback regarding responses, and (e) providing many opportunities to respond (Smith, 2001). In addition to these components, behavioral interventions incorporate systematic procedures to address behavioral problems on an individual basis. Systematic reinforcement can be a critical and effective component of behavioral interventions.

Reinforcement and Behavioral Interventions

There is substantial empirical evidence demonstrating that the use of reinforcement-based procedures can aide in the establishment of new/novel behaviors, increase the frequency of occurrence of already established behaviors, and maintain established behaviors over time (Northup, Vollmer, & Serrett, 1993). Traditionally, three methods are used for identifying reinforcers for behavioral interventions. These methods include indirect assessments, preference assessments, and reinforcer assessments. Indirect methods typically involve the use of surveys or interviews to identify potential reinforcers. When a child is the intended target for intervention, parents, teachers, and caregivers are interviewed or administered surveys to identify potential items that will function as reinforcers for the child. These nominated items are then used during interventions as reinforcers. The benefits of indirect assessments are that they are the least time intensive method of reinforcer identification and they are easily administered. However, research aimed at validating indirect assessments as accurate and efficient methods of reinforcer identification has led to mixed results and is in need of further evaluation (Fisher, Piazza, Bowman, & Amari, 1996; Green, Reid, Canipe, and Gardner 1991; Green, Reid, White, Halford, Brittain, & Gardner, 1988). For example, Fisher et al. (1996) compared the effectiveness of two indirect assessment methods to identify effective reinforcers for six individuals. Each of the six participants was diagnosed with mental retardation as well as with other developmental disabilities and/or psychiatric disorders (i.e. Rett's Disorder, ADHD, Down Syndrome). The primary caregivers for each of the participants also participated in the study. In the first phase of the study, the caregivers were provided a standard list of sixteen stimuli and asked to rank them in order of expected preference for their child. This form of indirect assessment for identifying potential reinforcers is a method frequently used in many facilities (i.e. schools, clinics, hospitals) because it is brief and will contain items frequently used or readily available for use. Next, the caregivers were administered a structured interview that allowed them to independently generate a list of preferred items for their child. The caregivers then ranked each generated item in order of expected preference. Phase one concluded with the administration of two paired-choice preference assessments for each of the six participants. Paired-choice assessments were conducted according to Fisher, Piazza, Bowman, Hagoppian, Owens, & Slevin (1992). The sixteen items from the standard list were used in the first assessment, and the top sixteen items from the structured interview were used in the second assessment.

Phase two of this study involved a reinforcer assessment in which the item identified as most preferred from each of the paired-choice assessments was evaluated under a concurrent operants design. In this phase, the two items identified as most preferred were simultaneously available, contingent on the participant engaging in the target behavior to gain access to that item. The target behavior required for access to each item was identical. Phase one results were evaluated by calculating correlation coefficients between caregiver rankings on the standard and structured lists, and their corresponding paired-choice assessment outcomes. There was no significant correlation for the standard list and paired-choice assessment, $r = .19$; however, there was a significant correlation between the structured list and paired-choice assessment, $r = .32$, $p < .005$. These results suggest there is little relationship between caregiver nominations on a standard list of stimuli and what may actually be a preferred stimulus; however, stimuli identified through a structured interview are more likely to be preferred stimuli. These findings were further validated in phase two of the study. The results of phase two demonstrated that each of the six participants consistently engaged in the target behavior to gain access to top item identified from the structured interview list as opposed to the top item from the standard list.

Similar results regarding indirect assessments and reinforcer identification were obtained in a study conducted by Green, Reid, White, Halford, Brittain, and Gardner (1988) and a follow-up study by Green, Reid, Canipe, and Gardner (1991). Participants in both studies (six in the first investigation and seven in the follow-up study) were diagnosed with mental retardation as well as other physical impairments (nonambulatory, blind, deaf). The participants lived in a residential facility and attended school on the facility grounds. Green et al. (1998), first conducted a single stimulus preference assessment with each participant, using twelve different stimuli. Preference was measured in terms of approach and avoidance. Following the preference assessment, an order of preference was established for each participant in relation to the twelve stimuli. Next, direct care and professional personnel who worked with the students completed a survey indicating how preferred they thought each stimulus would be for the student. Rankings were a five point Likert scale with five being most preferred and one being least preferred. An average of five staff members completed a survey for each student. Likert scores for each item were averaged and then ranked to obtain a staff ranking of preference. Correlation coefficients were calculated for each student between rankings obtained through the preference assessments, and rankings obtained through the staff survey. No statistically significant correlations were found for any student preference assessment and staff survey. Individual r values ranged from -.33 to .11.

Green et al. (1988) conducted a second experiment to evaluate the reinforcer effectiveness of the twelve stimuli for five of the participants. The stimuli for each of the students were divided into four groups based on preference assessment rankings and staff rankings: highly preferred by preference assessment and staff, highly preferred by preference assessment/low preferred by staff, low preferred by preference assessment/highly preferred by staff, and low preferred by preference assessment and staff. Reinforcer effectiveness was measured in terms of the mean level of prompts needed to perform a task. Prompt levels ranged from verbal to physical guidance. For all five participants, stimuli categorized as highly preferred by preference assessment and staff resulted in more task engagement at least intrusive/lower prompt levels (verbal prompt). All stimuli that were categorized as low preference, regardless of staff ranking, were associated with more intrusive/higher prompt levels (physical guidance).

Green et al. (1991) conducted a follow-up to this study. For five of the seven participants in this investigation, no significant correlations were found between preference assessment outcomes and staff rankings. Significant correlations were found for two of the participants; however, the authors concluded that the bulk of the findings do not support the use of staff recommended reinforcers. Similar results were found in the reinforcer assessment experiment of the follow-up study. Again, staff rankings of reinforcers did not predict which items would function as reinforcers.

The results Fisher et al. (1996), Green et al. (1988), and Green et al. (1991) indicate that indirect assessments alone are not a valid method to identify reinforcers. The results of Fisher et al. suggest that the validity of indirect assessments can be increased by utilizing a structured interview format. The authors discuss that a structured interview format allows the interviewee to provide information regarding stimuli they have seen the individual interact with, rather than ranking an arbitrary list of items.

Preference assessments offer a direct method to identify items that will potentially function as reinforcers. Four procedures are most frequently used as preference assessments. Those procedures are (a) single-stimulus, (b) paired-choice or forced choice, (c) multiple-stimulus, and (d) multiple-stimulus without replacement (MSWO). Several studies have examined the effectiveness of each procedure in isolation and in comparison to each other to identify effective reinforcers (DeLeon & Iwata, 1996; Fisher et al., 1992; Hagopian, Long, & Rush, 2004; Pace, Ivancic, Edwards, Iwata, & Page, 1985; Paclawskyj & Vollmer, 1995; Piazza, Fisher, Hagopian, Bowman, & Toole, 1996). Each procedure provides a method of ranking potential reinforcers based on an individual's interaction with multiple items. Paired-choice and MSWO methods are potentially the most effective preference assessment procedures in identifying potential reinforcers (DeLeon & Iwata, 1996; Fisher et al., 1992). Of the four preference assessment measures, paired-choice and MSWO are the only two methods that directly evaluate a stimulus against one or more other stimuli for potential preference. Overall, preference assessments are a more effective method of identifying reinforcers than indirect methods;

however, they do require more time to administer and they are limited by only identifying an individual's relative item preferences. Consequently, preference assessments do not explicitly identify items that will function as reinforcers, but only identify preference for an item.

Reinforcer assessments systematically evaluate whether items identified as preferred items actually function as reinforcers for an individual. Typically, reinforcer assessments are used to validate findings outcomes of preference assessments (Fisher and Mazur, 1997). For example, Pace et al. (1985) evaluated the effectiveness of reinforcers identified through a single stimulus preference assessment. In this study, six individuals were presented with sixteen different stimuli across twenty different trials. Preference for these items was measured as approach toward the stimulus. If an approach was made toward the stimulus, then the stimulus was made available to the participant for five seconds. Stimuli approached on 80% or more of the trials were considered to be preferred items. Stimuli approached on 50% or less of the trials were considered as non-preferred items. Following the establishment of preferred and non-preferred items, these items were evaluated for effectiveness using a reversal design. For each of the participants, target behaviors were identified. Target behaviors were adaptive behaviors that the participants did not regularly exhibit (i.e. eye contact, verbal requests). The target behavior was held constant across all experimental conditions. During baseline sessions, a request was made for the participant to engage in the targeted behavior; however, no consequence was available for engagement. During experimental conditions, the same request was made to the participants; however, during these conditions a preferred or non-preferred item was made available as a consequence for engaging in the target behavior. The results showed significantly more task engagement when a preferred item was made available as opposed to baseline and non-preferred conditions. In sum, the reinforcer assessment validated the single stimulus preference assessment as an appropriate method to identify reinforcers.

Reinforcer assessments have been used in similar investigations to validate the use of paired-choice preference assessments. Paclawskyj and Vollmer (1995) conducted a follow-up investigation to further validate the paired-choice preference assessment established by Fisher et al. (1992). Fisher et al. compared the effectiveness of the paired-choice procedure with that of the single stimulus procedure established by Pace et al. (1985). The paired-choice investigation utilized the same sixteen stimuli chosen by Pace et al. (1985). In this method, all possible pairings of the sixteen items were established and then presented to the participants. Approach toward an item served as the dependent variable. Fisher et al. then compared the two preference assessment procedures by utilizing a concurrent operant design. Participants were free to engage in two available activities in order to have access to items identified as preferred through paired-choice and single stimulus procedures or to an item identified as preferred only by the single stimulus method. Items approached on at least 80% of the trials were considered preferred items using the paired-choice method, while items approached on 60% or less of the trial were considered non-preferred. Preference and non-preference criteria for items identified through the multiple stimulus method were the same as those defined in Pace et al., (1985). The results showed that the participants allocated more time to the activity that allowed access to the items identified as preferred through both single stimulus and paired-choice procedures.

Paclawskyj and Vollmer (1995) supported the findings of Fisher et al (1992) and further validated the paired-choice preference assessment by utilizing a multiple-baseline reversal design reinforcer assessment procedure as opposed to a concurrent operants procedure. In addition, stimuli chosen for comparison were those identified as both preferred through paired-choice methods and non-preferred by multiple stimulus methods, to those identified as both non-preferred by paired-choice methods and preferred by multiple stimulus methods. Target behaviors for the reinforcement assessment were skills taken from the participants' curricula. The consequence for engaging in the target behavior was access to the item identified as preferred by one of the preference assessment methods. The results showed that the participants engaged in more target behaviors when the contingency for those behaviors was access to the preferred item identified through the paired-choice method. Again, the reinforcer assessment helped further establish a preference assessment method to identify reinforcers. Overall, reinforcer assessments are the most effective method to identify reinforcers and to validate other preference assessment methods; however, they are the most time-intensive procedure and may not be practical in a clinical setting.

In summary, reinforcers are an important component to behavioral interventions. There are various methods to identify potential reinforcers, but preference assessments offer the most efficient and validated method for reinforcer identification. Once reinforcers are identified, they can be systematically utilized to increase desired outcomes for behavioral interventions. Reinforcer application to behavioral interventions for language delays will be discussed in the next section.

Reinforcement and Language Instruction

The development and acquisition of language in humans is a widely debated topic among theorists and researchers. A review of this area is beyond the scope and purpose of this review; however, the behavioral theory of language development will be briefly presented here. In 1953 B.F. Skinner proposed a behavioral theory to language development in his book *Verbal Behavior*. Skinner proposed that language was a learned behavior and therefore is influenced by the same principles that affect all learned behavior. Skinner proposed that individuals must be taught language, and that those skills are strengthened and/or weakened by the behaviors of the listener. In total, Skinner proposed seven different types of verbal behaviors: (a) mands (commands or requests for specific stimuli); (b) tacts (labeling of specific stimuli); (c) echoic (verbal imitation); (d) intraverbal (conversation/filling in the blank); (e) textual (reading); (f) copying text (copying written material); and (g) transcriptive (taking dictation). Of those seven types of verbal behavior, three types have received the most attention with regard to empirical investigation: mands, tacts, and intraverbals (Sautter & Leblanc, 2006). Some of the possible reasons these behaviors have received disproportionate attention is that they are readily amenable to early interventions and are socially significant behaviors. Second, while the other verbal behaviors may not be investigated under the nomenclature given to them by Skinner, these areas are investigated under different terms by other disciplines. For example, while Skinner refers to reading as the verbal behavior textual, and while there may be little empirical investigation of the textual verbal behavior, the behavior of reading itself has received a substantial amount of empirical attention.

With regard to empirical investigations and verbal behaviors, mands are the most frequently targeted behavior of the three (Sautter & Leblanc 2006). Mands are frequent targets for several reasons. First, because mands frequently are requests for items, when an individual mands it is typically for a preferred item that functions as a reinforcer. Consequently, mands are often directly reinforced by gaining access to preferred stimulus. Second, because mands are often requests for reinforcers, it is likely that the individual will be motivated to engage in the same behavior again. Finally, the use of mands enables a language-delayed individual to learn to exert control over the environment through making requests or commands, and enables the individual to express physical and emotional needs.

The second most targeted verbal behaviors are tacts. Tacts are verbal behaviors that involve labeling or naming in response to a discriminative stimulus (Sautter & Leblanc 2006). Tacts are potentially more difficult to acquire because motivation to engage in this behavior is controlled by reinforcers that are not specific to the behavior itself (i.e. conditioned reinforcers). For example, when learning mands an individual learns that manding leads to the availability of a preferred stimulus. So if an individual says "cookie" they are given a cookie. Tacts differ in that if an individual is learning to label an object, the same response of "cookie" would result in reinforcers not specific to the label object. In this example praise may be used to reward the correct labeling of the cookie.

The third and least evaluated verbal behavior of language delay interventions is intraverbal behavior (Sautter & Leblanc 2006). Intraverbal is a behavior in which one verbal stimulus sets the occasion for another verbal response. There is no correspondence between the stimulus and the response. Like tacts, reinforcement for intraverbals is nonspecific. Examples of intraverbals are identifying characteristics of objects, filling in the blank and answering questions. Regardless of the targeted verbal behavior, the use of systematic reinforcement methods has been demonstrated to increase the language repertoire of language-delayed individuals. For example, Warren and Warren (1980) used a prompting and reinforcement procedure to promote the generalization of mands taught in one-to-one sessions for three severely language-delayed children. Throughout the investigation, and for four months prior, the three participants received one-to-one language instruction. Using a multiple baseline design across participants, data were collected during a fifteen minute observation on the number of mands made by the three participants during free-play classroom time. The criterion for a complete mand was dependent on individual language ability of the participant (e.g. one participant was required only to name the requested item, whereas another was required to provide a three to four word phrase). During baseline the participants' teachers were instructed to interact with the children in the manner they typically did. The mean baseline mand rates for the three participants were 11, 13 and 19 respectively. Following baseline, the teachers were taught a prompting procedure that included: (1) when the participant approached an object in the classroom, the teacher prompted the student to request the object (e.g. tell me what you want) or to identify the object (tell me what this is), (2) a model prompt if the participant did not respond to the first prompt or did not give a complete response, and (3) reinforcement with praise and access to the manded object. The free-play classroom activity again served as the experimental setting, and data were collected on the number of mands provided by the participant either spontaneously or on the first prompt during a fifteen minute observation. All three participants increased in the number of mand responses given following the implementation of the prompting and reinforcement training. The mean mand rate for the three participants during this condition increased to 44, 29, and 37 respectively. The intervention also showed a collateral effect of increasing teacher-child verbal interactions, which in turn led to an increase in the percentage of verbal responses provided by the participants.

Similar prompting and reinforcement procedures have been successful in teaching tact behaviors. Petursdottir, Carr, and Michael (2005) examined the theory proposed by Skinner that mands and tacts are functionally independent. Four typically developing preschoolers were taught to complete a four-step construction activity by either manding or tacting for the needed object for each step. The activities were common preschool activities (e.g. putting together a puzzle or putting together a cube); however, the names assigned to the objects were novel nonsense words. The participants were taught to tact for the needed object using a five second constant time delay procedure with reinforcement for correct responding. The procedure included the object first being presented to the participant by the trainer, who prompted the participant with the question "what is this?" If the participant gave the correct response, praise was given along with a conditioned reinforcer (e.g. sticker). If the participant gave and incorrect response or did not respond within five seconds, the trainer provided the correct response which was modeled by the participant. No reinforcement was provided for modeled responses and a new trial was started. Following the training procedure, data were collected on the maintenance of the trained tact objects. The constant time delay plus reinforcement procedure was successful in teaching the participants to acquire and maintain the trained tacts.

Intraverbals have also been successfully trained using prompting and reinforcement procedures. Using a multiple baseline design across stimuli, Luciano (1986) trained intraverbals with three adolescents with intellectual disabilities using a progressive time delay procedure with reinforcement. Intraverbal responses were answers to questions regarding categories for class membership (i.e. Tell me the names of some foods). Prior to baseline, the participants were assigned three of four potential classes that would serve as their target classes for intraverbal training. Those four possible classes were foods, drinks, clothes, and vehicles. During baseline the participants were prompted with the request "Tell me the name of ____," in which one of the target intraverbal classes followed. The baseline dependent measures were the percentage of correct responses to the prompted request, and the different number of correct responses provided during each session. One session consisted of ten presentations/trials of the request. No consequences were provided for correct responding. During baseline, only one of the three participants provided a correct response to the target requests. This participant was able to provide one correct response for each of his assigned classes.

Following baseline a progressive time delay with reinforcement training procedure was implemented. The training began with a zero time delay in which the participants were prompted with the request "Tell me the name of some_____," in which one of the target intraverbal classes followed. Immediately following the prompt, a visual stimulus was presented with a correct response. For example, as the participant was prompted with the request "tell me the name of some foods," the participant was immediately shown a picture of cheese. If the participant responded correctly to the picture, then descriptive verbal praise was provided (i.e. You're right, the cheese is food) on a CRF schedule, along with tokens redeemable for preferred items, on a VR-3 schedule. Incorrect or no participant responses were followed by a five second time-out. Once the participant responded to the visual stimulus at the zero second delay on the three consecutive sessions, the delay was increased to one second. The training process was repeated until the mastery criterion was met at the one second delay. Following mastery at the one second delay, the delay was then increased to two seconds and the training process was repeated. Mastery criteria at the one and two second delay consisted of 80-100% of correct responses without a visual prompt and more than four different responses on three consecutive sessions. A total of five different responses were trained for each class, and each class was trained separately. Training sessions consisted of 30 trials or six presentations of each of the trained stimuli. The result of the training procedure showed an increase in the percentage of correct intraverbals used for each targeted class, and an increase in the total number of different correct intraverbals. Follow-up probes conducted immediately following training and at one month after training showed that the effects of the progressive time delay and reinforcement training were maintained over time.

Despite the many advantages of using systematic reinforcement methods with behavioral interventions, there are potential pitfalls associated with reinforcement methods that may interfere with desired outcomes of behavioral interventions. Balsam and Bondy (1983) compared the use of aversive control methods and positive reinforcement methods with regard to animal and human behavior. They outlined several side effects that may occur with the use of each method, and how the use of positive reinforcement can potentially result in counter-therapeutic behaviors. The side effects of positive reinforcement and how they can interfere with behavioral interventions for language delays are discussed.

Side-Effects of Positive Reinforcement

Balsam and Bondy (1983) first outlined three elicited or emotional side effects of reward that may interfere with behavioral interventions utilizing reinforcement procedures. The first of these emotional side effects was the occurrence of aggressive and ritualistic behaviors in the intervals between reinforcer presentations. Behaviors such as excessive pacing, wheel running, and aggression have been demonstrated with nonhuman subjects (Staddon, 1977; Staddon & Simmelhag, 1971) and excessive motor responses and aggression in human participants (Muller, Crow, & Cheney, 1979). The occurrence of aggressive and ritualistic behaviors potentially interferes with behavioral interventions by interrupting or preventing treatment implementation. For example, interventions that target language delays typically require an individual to emit a communicative response in order to gain access to a preferred reinforcer. Aggressive and ritualistic behaviors often interfere with an individual's ability to emit a communicative response or the ability of an interventionist/therapist to provide an effective prompt that would elicit a communicative response.

The second emotional side effect of reward discussed by Balsam and Bondy was that the presence or the signal of a reinforcer could lead to suppression of the desired target response. In this case, the presence or signal of a reinforcer results in the individual engaging in behaviors that interfere with his/her ability to access the reinforcer. For example, some language delay interventions utilize reinforcers by having individuals provide a communicative response that is a request for the reinforcer (i.e., mands). The presence of the reinforcer may result in the individual engaging in behaviors such as grabbing/reaching for the reinforcer that would interfere with his/her ability to provide an appropriate communicative response or attend to a prompt given by the intervention provider.

The final emotional side effect discussed was the potential for individuals to be near the reinforcing agent. This potential problem is related to the previous example in that the reinforcing agent becomes a discriminative stimulus, and as a result the individual attempts to remain in the vicinity of the reinforcing agent. This may prevent the development of other appropriate behaviors. For example, individuals with autism typically have delays in both language and social development, and are often prescribed interventions to address both deficits. These individuals who attempt to remain exclusively in the vicinity of the reinforcing agents may miss opportunities to further develop needed social skills.

Balsam and Bondy also discuss operant effects that that may occur as result of utilizing reinforcement with behavioral interventions. The first operant effect discussed is rooted in Herrnstein's matching law (Herrnstein, 1961). Herrnstein demonstrated that for time-based schedules of reinforcement, organisms will engage in behaviors at a rate that is matched to the rate of reinforcement for those behaviors in a way that maximizes total contact with reinforcement (Herrnstein, 1961). Behavioral interventions that incorporate reinforcement procedures often target specific behaviors for reinforcement. According to Balsam and Bondy, by altering the rate of reinforcement for a behavior, or a class of behaviors, there is the potential for contrast effects. Contrast effects occur when the schedule of reinforcement for one behavior changes, while an independent schedule of reinforcement for another behavior remains constant (Reynolds, 1961). As a result of the change in the first schedule of reinforcement, the rate of responding for the second behavior changes, despite no change in the reinforcement schedule. For example, a behavioral language delay intervention may target teaching an individual to label different methods of transportation. If the schedule of reinforcement is denser for labeling transportation methods than it is for labeling other objects, it is likely that the individual may begin labeling more transportation items as compared to other items. This effect was experimentally demonstrated by Mace, McCurdy, and Quigley (1990). Baseline levels of performance on two tasks were established for two participants (i.e. completion of multiplication and division problems). Following baseline sessions, a Variable-Ratio 2 (VR-2) schedule of reinforcement was initiated for engaging in both tasks. As expected, performance on both tasks increased compared to baseline levels. In the subsequent experimental sessions, a Continuous Schedule of Reinforcement (CRF) was alternated between the two tasks. The VR-2 schedule remained in place for the alternative task. For both participants, there was an increase in task performance for the task under the CRF reinforcement schedule, and a decrease in the task performance for the task under the VR-2 reinforcement schedule. This effect was maintained across tasks and reinforcers. In sum, when the denser CRF schedule of reinforcement was initiated for engaging in one behavior, there was a decrease in the occurrence of another behavior despite the reinforcement schedule for that behavior remaining constant.

Interventions that utilize reinforcement procedures also face potential problems with generalization of the skills taught during intervention sessions. Generalization of intervention skills involves the use of those skills beyond the intervention environment (Stokes & Baer, 1977). Specifically, the individual receiving the intervention will use the trained skills in other environments, with other persons, and/or transfer the intervention skills to novel situations (i.e., stimulus generalization). Individuals receiving interventions with reinforcement procedures may fail to generalize the taught skills in one or more of these areas. For example, a language delay intervention may target teaching an individual how to request preferred items (mands). The intervention may take place in a controlled environment, focus on one preferred item at a time, and only have one person serving as the interventionist. The ultimate goal of this intervention would result in the individual learning how to request many different preferred items, from a variety of different people, and in a variety of different environments. Individuals who fail to generalize the skill may only learn to request the trained item, only request items from the interventionist, and/or only make requests during intervention sessions.

Balsam and Bondy's last operant side effect of reinforcement is response induction. Response induction refers to the spread of effects of reinforcement across other stimuli (Catania pp 142-143). For example, an intervention may target teaching an individual how to label different methods of transportation. A systematic reinforcement component may be used in order to establish and maintain this new skill. Response induction occurs when the individual begins to label other objects at a higher rate. This phenomenon has positives and negatives. If induction occurs and the result is the individual labeling novel stimuli, the individual is generalizing the skill to other stimuli.

However, the individual may begin labeling other objects with the expectation that labeling objects will always result in reinforcement. This expectation can lead to frustration if the individual does not discriminate the contingencies of the reinforcement schedule (i.e., the individual is only reinforced for labeling novel objects or reinforced only during school time).

Balsam and Bondy's final potential side effect of reinforcement pertains to the transient effects of reinforcement. Interventions that utilize a systematic reinforcement procedure often use conditioned reinforcers and/or use a schedule of reinforcement at a rate denser than would occur naturally in the environment. As a result, the skills that are trained during the intervention fail to maintain once the conditioned reinforcers are removed or the density of the reinforcement schedule is decreased.

Each of these potential side effects can have a serious impact on behavioral interventions that utilize systematic reinforcement procedures as part of the intervention. With regard to behavioral language delay interventions, contrast effects and ritualistic behaviors can potentially be the most negative side effects of reinforcement. Contrast effects may lead to highly repetitive/stereotyped responding. Repetitive and stereotyped responses are counterproductive to language delay interventions since the ultimate goal of all language delay interventions is to increase overall language repertoires. The effect of repetitive/stereotyped responding, and methods to reduce it, will be discussed in more detail.

Behavioral Variability

The goal of much behavioral research is to systematically demonstrate the effects of an independent variable on a dependent variable. This concept is known as experimental control (Cooper, Heron, & Heward, 2007 p. 160). Experimental control is established when a reliable and predictable change in behavior occurs in the dependent variable in the presence or absence of the independent variable. Variability is a factor that researchers attempt to control for and eliminate in behavioral research. High variability is typically an indicator of a lack of experimental control or the presence of confounding variables, both of which violate key concepts necessary to establish internal validity. Without internal validity, conclusions and behavioral relationships cannot be determined from the research (Cooper, Heron, & Heward, 2007 p. 231). The exception to this goal of behavioral research is when the desired outcome is highly variable responding. Variable responding is often the main focus of research that targets behaviors such as creativity, problem solving skills, and language development. These behaviors are characterized by high variability. Predictable, reliable and unchanging responses are often the target behaviors of change in this area of research.

Variability as it is applied to an organism's behavior refers to the predictability of behavior (Cooper, Heron, & Heward, 2007, pp. 160-162). Behavior that is interpreted as highly variable lacks predictability or repetition. Behavior low in variability is predictable, unchanging, and/or repetitious. Variability is best conceptualized as existing on continuum that ranges from complete predictability or repetition on one end, to random or chaos on the other (Neuringer, 2002). The extent to which high and low variability is a desired or undesired characteristic is dependent upon the behaviors under investigation. For example, high variability would not be a desired trait among workers in an assembly line whose pay is contingent on the number of finished products. Typically assembly line workers are assigned specific individual skills that are part of a larger design. The combination of individual skills leads to the creation of a larger product. It is the responsibility of the individual to rapidly and consistently repeat his/her assigned skills. The logic of the assembly line is that final products can be created more efficiently and in greater quantities by having many individuals repeat a small subset of skills rather than having the same individuals attempt to perform all the skills necessary to create the final product. In order for the assembly line to be successful each worker in the line must precisely repeat his/her assigned skill. Variations in their performance will disrupt the performance of subsequent workers, and ultimately decrease the number of finished products. A decrease in the total number products could lead to negative outcomes (i.e., demotion or termination). Simply put, high variability leads to fewer completed products, which leads to undesired outcomes.

Another more applied example of the undesirability of high variability would be in teaching a child his name. The desired outcome of this task would be for the child to answer the question by consistently providing only his/her name when asked. Highly variable responses to this demand would mean the child does not consistently state their own name when asked or they provide additional information that is not related to the question. For this task no variability, or repetition, would be optimal.

As stated earlier in this section, highly variable behavior is desirable when repetitious and predictable behaviors do not benefit an individual/organism and it is most often associated with creative and problem-solving behaviors. For example, the aforementioned assembly line workers benefit the most when variable behavior is low. However, if consumer demand for the product was higher than the supply being generated, a company could earn more money provided it could increase the total amount of products manufactured. Assuming that the cost of adding more workers or working longer hours would out-weight the benefits of the increased sales, the workers would have to develop new techniques in order to maximize profits. In this new example, persisting in the same low variability of behavior does not lead to the most beneficial outcome for workers.

Similarly, the child learning his name may be taught his name by a parent. Consistent behavior is beneficial for this skill; however, variable behavior would be desired regarding who the child provides the response to. Specifically, the desired outcome would be to provide only his name to the question "what is your name," (a low variability response), but provide the same response to all any individual that asks the same question (high variability response) not only to the person that taught the name.

Until relatively recently variable behavior was frequently characterized as problematic and described as evidence of an individual's lack of understanding of contingencies or to an inability on the part of the researchers to demonstrate experimental control (Neuringer, 2004). However, there has been a significant change in the way variable behavior is now defined and examined. Recent reviews of both basic and applied research have demonstrated that behavioral variability is an operant dimension of behavior and as a result can be influenced by reinforcement contingencies and discriminative stimuli (Neuringer, 2002). The operant nature of variability will be discussed in more detail.

The most supportive characteristic that demonstrates the operant nature of variability is that variable behavior is influenced by reinforcement (Neuringer, 2004). One of the first examples of operant variability was demonstrated in 1969 by Pryor, Haag, and O'Reilly. They rewarded porpoises for behaving in novel ways. In each experimental session the porpoise trainer waited for the porpoise to engage in a behavior that had not been previously observed. When a novel behavior was observed, it was reinforced and became the target response for that experimental session. Only the new response was reinforced. The porpoises began to emit highly complex behaviors, many of which had never been observed in this species before. These results of this study were some of the first to demonstrate that variable behavior can be increased as a result of reinforcement.

Goetz and Baer (1973) extended this research to humans by reinforcing novel block-building formations of preschool children. Goetz and Baer differed from Pryor et al. in that all novel block building formations were reinforced during experimental sessions. All the children increased their number of block formations from one another and increased in overall number of formations. The influence of reinforcement on variable behavior was further validated in this study when reinforcers were later contingent on repeating block formations. Ultimately, all the children began to repeat a single block formation.

Following Goetz and Baer (1973) there were several experimental attempts to verify that variability is a reinforceable behavior. The results of these studies lead to conflicting findings regarding variable behavior and reinforcement. For example, Schwartz (1980) examined the effects of contingent reinforcement on the behavior of pigeons. Specifically, Schwartz was investigating the extent to which contingent reinforcement would lead to stereotyped responding when such patterned responding was not programmed. In experiment 1, twelve pigeons were placed in an experimental setting with a 5x5 light matrix mounted on the left side of the chamber. In addition to the light matrix, left and right response keys were present. At the beginning of each experimental session, the top left space in the matrix was illuminated. A response on the left key moved the light one column to the right, and a response on the right key moved the light down a row. Consequently, any sequence of four left responses and four right responses moved the light from the left to the bottom right. If the pigeon responded with any four left and four right sequence, a food pellet was delivered as a reinforcer. In total, there were 70 different possible sequences that would result in reinforcer delivery. Any response sequence that contained five responses on either key terminated the trial and was not reinforced. The dependent measures were the number of reinforced trials and the total number of different response sequences emitted. The results showed that each pigeon's responding became highly stereotyped and for nine of the twelve pigeons their response sequence was either LLLLRRRR or RRRRLLLL. This pattern of responding was replicated for all twelve pigeons in Experiment 3 when the matrix light was removed to test whether the stereotyped responding was a result of the experimental apparatus. In Experiment 4, Schwartz attempted to train variability (prevent stereotyped responding) by implementing a lag 1 response requirement, in which the current response sequence had to differ from the previous response sequence. Subjects for this experiment were eight of the twelve pigeons that served in the previous three experiments. The results for Experiment 4 suggested that the lag 1 response requirement did not increase response variability. For seven of the eight pigeons, the number of different sequences remained constant over 40 sessions, and there was still the emergence of a dominant response for all eight pigeons. Schwartz tentatively concluded that contingent reinforcement led to stereotyped responding (at least in pigeons) and that the results of Experiment 4 indicated that variable behavior could not be reinforced. Schwartz acknowledged two possible reasons for his Experiment 4 conclusions that were contrary to the findings of Pryor et al 1969 and Goetz and Baer 1973. First, he stated that because the subjects in this experiment were not experimentally naïve, these subjects had a reinforced history of stereotyped behavior. Second, since the intertrial interval was ten seconds, Schwartz hypothesized that this interval was too extensive for pigeons to connect the variability and contingency requirement.

To address these issues, Schwartz (1982) replicated Experiment 4 of Schwartz (1980) with the use of six experimentally naïve pigeons and with an intertrial interval of .5 seconds. Again the lag 1 requirement failed to produce variable responding in the pigeons. As in the previous study, pigeons responding became highly repetitive and a dominant sequence emerged for each of the pigeons. In a second experiment, Schwartz trained the pigeons to alternate between the two response keys prior to implementing the lag 1 requirement. The results of the second experiment were similar to the first. The pigeons again failed to vary their responding and a dominant response sequence emerged. Schwartz concluded that variability was not a reinforceable dimension of behavior and that contingent reinforcement lead to stereotyped behaviors. Schwartz explained the previous findings of reinforced variable behavior in terms of artifacts of experimental methods. For example, creative behaviors in Pryor et al. were not due to reinforcement of novel responses, but instead a result of brief exposure to extinction, and the results of Goetz and Baer were a result of unintentional verbal cues.

Ultimately, in 1985, Page and Neuringer were able provide a clearer picture on reinforcement and variability. These authors were able to identify and experimentally demonstrate that the methodological issues lie with the Schwartz investigations, and that variability was, in fact, a reinforceable behavior. Page and Neuringer pointed out that the total number of possible eight sequence responses that could be emitted across the two-key experimental apparatus used in the Schwartz experiments was 256 or 2^8. Because Schwartz required that the pigeons have exactly four responses on each of the two keys, the total possible number of reinforceable responses was reduced to 70 responses. This requirement constrained or limited the number of possible reinforceable sequences; consequently, it would not be beneficial for the pigeons to respond with highly variable responses because to do so would not optimize reinforcement. Page and Neuringer hypothesized that to truly determine if variability or variable behavior could be reinforced, then it would have to be investigated without these constraints.

Using pigeons as subjects, Page and Neuringer (1985, experiments 1 and 2) first demonstrated that variability could be reinforced. Four pigeons were first trained to peck two response keys. Experimental sessions consisted of fifty trials and each trial consisted of eight key pecks. The pigeons could earn reinforcers (food pellets) by varying their eight key response sequence according to a lag 1 or a lag 5 experimental condition requirement. The results indicated that the four pigeons earned a reinforcer on over 90% of trials regardless of the lag requirement (results were averaged across four subjects). Page and Neuringer then compared these findings to Schwartz by conducting an exact replication of Schwartz's 1982 Experiment 1. The results showed that number of reinforced responses decreased from over 90% to 42% or less for the four pigeons. Page and Neuringer concluded that variable behavior could be reinforced and the contrary findings by Schwartz were due to the reinforceable sequence constraints that were created by the requirement to have exactly four responses on both the right and left response keys.

In the following experiment (Experiment 3) Page and Neuringer examined the extent to which reinforcement could increase variable responding. Using four pigeons as subjects, Page and Neuringer repeated the methods utilized in experiments 1 and 2. When the pigeons' responding stabilized for five sessions at the lag 5 requirement (i.e., the pigeons were consistently meeting the variability requirement), the lag reinforcement schedule requirement was increased to 10, 15, 25, and 50 respectively. Progression to the next lag schedule was contingent on five consecutive sessions of stable responding at the current lag schedule. From lags 5 through 25, 85% of the pigeons' responses met the variability requirement and were reinforced. At lag 50 the percentage of reinforced responses decreased to 67%. The decrease in reinforced responses was expected due to high quantity of variable responses needed to earn a reinforcer. Additionally, the findings were validated when compared to the number of reinforced responses of a random response generator that was under the same conditions. A computerized random response generator was programmed to produce eight sequence responses across two response options. This program was designed to be identical to the experimental conditions the pigeons were exposed to, and to provide a percentage comparison at each lag requirement of true random responding (i.e. what percentage responses produced by the random response generator would fulfill the lag 5, 10, 15, etc contingency). While the random generator consistently produced more reinforced responses at each lag requirement, the responding of the pigeons was parallel to that of the random generator. The random response generator produced a higher percentage of reinforced responses at each lag requirement as compared to the responses produced by the pigeons; however, like the pigeons, the percentage of reinforceable responses produced by the random response generator decreased in a similar pattern as the demands of the lag reinforcement schedule increased. To summarize, the result of Experiment 3 not only demonstrated that variable behavior could be reinforced, but that it was possible to produce a response pattern that paralleled random model (Neuringer, 2004).

Page and Neuringer further established the operant nature of variability with Experiment 5. To demonstrate that direct reinforcement of variability was necessary to produce variable responding, Page and Neuringer replicated the lag 50 condition used in Experiment 3 and compared responding in this condition to a yoked-VR condition using a reversal design. The yoked-VR reinforcement schedule was based on individual performances during the last six sessions during the lag 50 condition. Reinforcement during yoked-VR conditions was contingent only on responding and was independent of variable responding. Specifically for Experiment 5, four pigeons were exposed to the lag 50 condition that was implemented at the end of Experiment 3. The initial lag 50 phase continued for 26 to 38 sessions or until responding became stable over five consecutive sessions. Sessions terminated after 100 trials or after 50 reinforcers had been earned. Following the lag 50 phase, the yoked-VR condition was implemented. The yoked-VR reinforcement schedule was derived from the subject’s reinforcement pattern for the last six lag 50 sessions. These reinforcement patterns were then used as the ratio at which reinforcers would be delivered under the yoked-VR condition independent of varied responding. For example, if Subject 2's last six sessions were 55-60, a reinforcement pattern would be established for each of these six sessions. These patterns would serve as the reinforcement schedule for the first six sessions of the yoked-VR condition. Following the sixth session, the pattern would be repeated. Additionally, if the pattern of reinforcement for session 55 was one in which the pigeon earned a reinforcer after every five trials (i.e. trial 5, 10, 15 etc) the reinforcement pattern for the first session of the yoked-VR condition would also be after every fifth trial; however, reinforcement would not be contingent on varied responding. The results showed that variable responding was significantly higher during the lag 50 condition as compared to the yoked-VR condition. The results indicated that direct reinforcement of variability was necessary to produce variable responding, and the use of reinforcement alone does not produce variable responding. Similar results have been found in applied human studies. Eisenberger, Haskins, and Gambleton (1999) examined the effects of divergent thinking training on the creativity of drawings by school children. Following the training the children in the study did produce more creative drawings; however, those children who were promised a reward for more creative (i.e variable) drawings produced more creative pictures than those who were not promised a reward. Additional studies regarding variability and human participants will be presented throughout the remainder of this review.

Page and Neuringer demonstrated that variability can be influenced by discriminative stimuli. In Experiment 6, Page and Neuringer reinforced pigeons for repeating a single response when a blue light was present, and reinforced variable responses, under a lag 5 contingency, when a red light was present. The results showed that the pigeons quickly differentiated between the two conditions and responded accordingly. The pigeons maintained this differentiated responding even when discriminative stimulus pairings were reversed. Cohen, Neuringer, and Rhodes (1990) found similar results regarding discriminative stimuli with rats. Additionally, Neuringer (1998) further extended this research to demonstrate that a repetitive response, as one of the response conditions, was not necessary to demonstrate the effects of discriminative stimuli.

Like most behaviors, variability is also influenced by the choices that are available. Neuringer (1992) manipulated the frequency of reinforcement for variable responding or repetitive responding for four of the pigeons' key pecking responses. The higher rate of reinforcement alternated between the variable and repetitive responses. The pigeons began to match their responding according to the rates of reinforcement for each behavior. Simply, when reinforcer frequency was higher for variable responding than for repetitive responding, the pigeons engaged in more variable responding. When the frequencies switched in favor of repetitive responding, so did the pigeons' responding.

Finally, variable responding is also influenced by the use of extinction procedures. Traditionally, the use of extinction is thought to increase variable responding; however, extinction can have multiple effects on variable behavior and these effects will be discussed here. One of the first examples of extinction induced variability was demonstrated by Antonitis in 1951. Rats were taught to poke their noses through a 10 cm slot in order to gain access to food. Photos were taken of each rat as they poked their noses through the slot. Inevitably, each rat's behavior became highly stereotyped in that they consistently poked their nose in the slot at the same location and held a consistent body position. When reinforcement was withheld, the rats began poking their noses in different locations in the slot, and began altering their body positions. The use of extinction in this experiment resulted in variable responding by the rats in order to gain access to food.

Similar results have been demonstrated in basic experiments with humans. For example, Morgan and Lee (1996) had participants earn points on a computer program by responding on a keyboard. Participants were not provided any instructions other than to try and earn points by pressing the space bar. Points were earned by fulfilling the interresponse (IRT) time requirement between key presses. For example, if the IRT requirement was three seconds, the participant earned points by waiting three seconds after each key press before responding again. Each participant learned the IRT requirement and responding became stable. Once responding was stable, the participants were exposed to a period of extinction in which no points could be earned. Responding for each participant became highly variable. Similar patterns of responding occurred across each participant in that they consistently alternated between short and long IRTs.

Extinction induced variability has also been demonstrated in applied studies. Lalli, Zanolli, and Wohn (1994) attempted to increase appropriate toy play with two individuals with mild developmental delays. Initially, neither participant engaged in appropriate toy play with a doll and airplane. Following baseline sessions, the two participants were trained on appropriate toy play behavior with each of the toys. Appropriate toy play was reinforced with praise. Once the trained toy play behavior was established, reinforcement was withheld for this response. During the extinction phase, reinforcement was available only for novel appropriate toy play. Novel toy play was reinforced for three consecutive occurrences and then placed on extinction as was done with the trained response. Both participants increased their appropriate toy play behaviors with both toys when exposed to extinction.

Similar results have been demonstrated in communication training with autistic individuals. Carr and Kologinsky (1983) attempted to increase spontaneous signing for three nonverbal autistic individuals. Initially, each participant was taught the appropriate sign for ten different preferred items or activities. Following training, a baseline condition was implemented for each participant in which the dependent measures were the total spontaneous occurrence of any the trained signs (i.e., how many of the ten trained signs were given) and the percentage of intervals during a session in which a spontaneous sign occurred. Sessions of fifteen minutes in length were divided into ten second intervals. A continuous time-sampling recording system was used to record the occurrence of a spontaneous sign. No consequences were delivered for the occurrence of any sign. The mean number of spontaneous signs during baseline for the three participants was 0.0, 0.4, and 0.1 respectively. Similarly, the percentage of spontaneous sign occurrence was less than 1% for all sessions.

Following the baseline condition, a reinforcement condition was implemented in which, if the trained sign did not occur then the sign was prompted and reinforced with the corresponding item or activity. This procedure was repeated until all ten trained signs occurred spontaneously or until each sign was emitted following a model prompt. During the reinforcement condition, each sign was reinforced only twice, regardless of whether the sign occurred spontaneously or needed prompting. In other words, following two occurrences of a sign within each session, the consequence for that sign was extinguished. The extinction component was implemented to prevent the participants from perseverating on one sign, and to ensure a history of reinforcement with all the trained signs. Following each reinforcing session, a maintenance session was conducted utilizing the same procedures implemented in the baseline condition. However, during the maintenance condition, if a sign occurred spontaneously it was reinforced with the corresponding item or activity (i.e., cookie, hug). The results showed an increase in the percentage of intervals in which a spontaneous sign occurred (57.9%, 70.4%, and 85.3% respectively), and an increase in the mean total number of signs used by each participant, (5.9, 4.5, and 4.5 respectively). One of the concluding hypotheses regarding the increased spontaneous sign use among the participants was that the extinction procedure utilized during the reinforcing condition resulted in the participants engaging in more variable sign usage in order gain access to the preferred items and activities.

Durker and Van Lent (1991) expanded on this hypothesis of extinction-induced variability by attempting to increase communicative gestures with six severe/profound mentally handicapped individuals utilizing a multiple baseline reversal design. These individuals were selected for this investigation because of low variation in gesture use. In addition, attempts to increase verbal skills with these individuals had failed. For each participant a target group of communicative gestures was identified. These gestures were all requests that the individuals were capable of utilizing spontaneously. Each participant had a fund of at least six spontaneous communicative gesture requests *(Range= 6-14)*. For each participant a baseline condition was implemented in which all spontaneous requests were reinforced with appropriate items or activities (e.g., doll or music). Experimental sessions were thirty minutes in length. The dependent measures during baseline were the percentage of different requests emitted by each participant (percentages were calculated according the number of different requests utilized in the participant's established fund), and the number of different requests emitted in each session. Once baseline responding was established for each participant, the number of spontaneous requests was totaled and ranked according to frequency of occurrence. A treatment condition was now implemented in which the top three most frequently occurring requests were no longer reinforced, but the remaining requests less frequent requests were reinforced. For each participant, the discontinued reinforcement for the most frequent requests resulted in an increase in the percentage of different requests made, and an increase in the total number of different requests made. Interestingly, all six participants continued to make their high frequency requests throughout all experimental conditions.

Overall, studies that have examined the dimensions of variable behavior have demonstrated that variability is an operant dimension of behavior. Variability can be manipulated through systematic reinforcement and will often increase when extinction procedures are utilized. Despite the operant nature of variability, there are potential limitations to using reinforcement procedures or extinction procedures in isolation to increase variable behavior. These limitations will be discussed further.

Limitations

One of the first problems with using reinforcement to increase variable behavior is that variable behavior has to exist before it can be reinforced. For example, Goetz and Baer (1973) were able to increase block formations in children by reinforcing novel block formations. As participants, this study utilized typically developing children who routinely engaged in variable toy play. Thus the probability of exhibiting a novel block formation was high for these children. However, developmental disabilities such as Autism Spectrum Disorders are partially defined by repetitive behaviors and restricted interests. The probability of variable behavior with this population is much lower compared to typically developing peers. This is especially problematic, considering that many individuals with these disorders are likely to receive reinforcement-based behavioral interventions.

As previously stated, the use of reinforcement can have negative or unwanted side effects. One of the unintended side effects of reinforcement is the increase in repetitive or stereotyped responding. This phenomenon has been demonstrated even when variable responding was directly reinforced. Cherot, Jones, and Neuringer (1996) directly examined reinforcement effects on variable behavior as an organism approached reinforcement. Utilizing rats as subjects (and later replicated with pigeons), two groups were assigned to either a repetition group or a variability group. Measured responses were presses on two available levers (left or right levers). A completed trial was defined as any combination of four presses on the left and right levers. The repetition group earned food pellets for fulfilling a lag 3 repetition reinforcement schedule (the fourth trial had to repeat one of the previous three trials). The variability group earned food pellets for completing a lag 3 variability schedule of reinforcement (the fourth trial had to differ from all three previous trials). Once responding for each group was stable, a Fixed Ratio 4 (FR4) reinforcement schedule was implemented in conjunction with lag 3 requirement for both groups. With the FR4 requirement in place, each group had to fulfill the lag 3 requirement on four consecutive trials in order to receive a food pellet. The resulting data were analyzed as the percentage of trials meeting the lag requirement as a function of the location within the FR4 schedule. The results showed that the two groups either repeated or varied their responses dependent on the schedule requirement. However, the percentage of trials meeting the lag 3 schedule for the variability group decreased as the group approached earning the food pellet. In sum, direct reinforcement of variable responding resulted in increased variable responding; however, as the rats approached fulfilling the reinforcement schedule requirements, variable responding decreased.

There are also several factors that must be considered when using extinction as a method to increase behavioral variability. First, it may not always be beneficial or desirable to extinguish the current behavior. For example, in Lalli et al. (1994), an established and appropriate toy play response was extinguished in order to promote a new toy play response. In clinical settings, the elimination of an appropriate response would most likely not be a desired effect. Alternatively, the use of extinction does not necessarily guarantee that a response will no longer be exhibited. Frequently, the extinguished behavior will continue to occur despite no longer being reinforced. This effect is often seen when the newer or the next desired response is topographically similar to the extinguished response (Schwartz, 1981).

Second, the overall effects of extinction procedures on variability may be related to baseline levels of variability. A behavior that requires a high level of variability by nature may be affected differently by extinction than a behavior that requires low variability for repetition (Grunow and Neuringer, 2002; Stokes & Balsam, 2001). For example, a novelist or an artist (professions that require high variability) is likely to exhibit a decrease in variable behavior in response to extinction, whereas a cook or a line worker (professions that benefit from repetition) is likely to increase variable behavior in response to extinction (Neuringer, 2002). Finally, extinction is likely to have only a transient effect on variable behavior without the use of reinforcement to promote and maintain the new behavior.

Purpose and Rationale

The main purpose of this study was to incorporate methods to increase variable behavior to help increase the efficacy of behavioral interventions for individuals with language delays. A second focus of this study was to examine the generalized effects of the increased variable behavior, as well as the potential impact of environmental arrangement on variable behavior. This study added to the emerging literature base examining variable behavior and the use of lag schedules of reinforcement in applied studies. The use of lag schedules of reinforcement and applied studies will be addressed here.

As discussed earlier, lag schedules of reinforcement have been used to increase variable responding. This is accomplished by specifying that a current response has to differ in some way from a specified number of previous responses in order to gain access to a reinforcer. For example, in order to meet the variability requirement of a lag 2 reinforcement schedule, the third response must differ from the previous two responses. As may be seen from previous examples, this method can be very successful in increasing variable behavior; however, the experimental investigations of lag schedules have been utilized almost exclusively with non-human participants and/or in basic studies. Recently, there has been some extension of lag schedules to applied investigations. Cammilleri and Hanley (2005) utilized a differential lag reinforcement contingency to increase engagement in available classroom activities for two participants.

Experimental sessions were sixty minutes in length, and there were a total of twelve possible classroom activities. The dependent measure was the number of novel activities the participant engaged in during each session. A novel activity engagement was defined as engaging in an activity not previously engaged in during that session. An activity could be counted as novel more than once per session, if the participant engaged in all other available activities prior engaging the same activity again. For example, if block play was an available activity, the first occurrence of block play was counted as novel activity engagement. Once the participant engaged in the remaining eleven classroom activities, block play was again a reinforceable response and counted as novel activity engagement. During baseline sessions both participants allocated all available time between three of the twelve available classroom activities. There were no consequences for changing activities during baseline sessions and the participants were free to engage in any activity for any duration. Following baseline sessions, a differential lag condition was implemented, in which the students could earn tokens redeemable for teacher attention by engaging in novel classroom activities. During this condition, the student earned a token for engaging in any available classroom activity. Following reinforcement for the initial activity selection, reinforcement was now contingent on the participant engaging in any available activity other than the initial activity. Subsequent novel activity selection resulted in participant reinforcement and removal of the selected activity from available reinforceable activities. This procedure continued until all activities were selected, in which the lag contingency reset and/or the session terminated. The results showed that both students increased their engagement with novel classroom activities and the time engaged with each activity. The students increased their task engagement from an average of one activity per session to an average of eight per session. Also, the students increased the number of tasks completed at each activity. For example, during baseline sessions neither student engaged in the free reading activity; however, during the experimental conditions, both students allocated more time to this activity and increasingly completed more tasks during this activity (number of pages read).

Lee, McComas, and Jawor (2002) compared the use of differential reinforcement to a lag 1 reinforcement schedule to increase variable responding to a social question (What do you like to do?) by three autistic participants. The dependent measures were the percentage of trials per session in which a varied and appropriate response was emitted, and the cumulative number of varied and appropriate responses. Sessions consisted of ten presentations of the target question. A varied response was defined as a response that differed from the previous response. An appropriate response was defined as a socially appropriate answer to the target question (i.e. the response “I like to burp” was not considered an appropriate response the question “What do you like to do?”). For each participant, the differential reinforcement condition served as the baseline condition in a multiple baseline across participants reversal design. During this condition, all appropriate responses to the question “What do you like to do?” or “How are you?” were reinforced with preferred items identified through a MSWO assessment. Data were only recorded for varied and appropriate responses; however, the varied criterion did not have to be met during baseline to gain access to the reinforcer. Following baseline, a lag 1 reinforcement condition was implemented. During this condition, the response to the target question had to meet the criteria of varied and appropriate in order earn access to the reinforcer. Two of the three participants increased from zero levels of varied and appropriate responding in the differential reinforcement condition to 50-70% varied and appropriate responding during the lag 1 condition.

Similar results were found in a follow-up study conducted by Lee and Sturmey (2006). Again, the authors examined the effects of a lag 1 reinforcement schedule to increase varied responding to social questions ("What do you like to do?") by three autistic participants. Also under investigation was the effect of cued environmental stimuli on varied responding. Procedures and dependent measures for Lee and Sturmey (2006) were identical to Lee et al. (2002) with the following exceptions. The authors utilized an ABAB reversal design to compare the differential reinforcement condition to the lag 1 condition as opposed to the multiple baseline design used by Lee et al. Also, a multielement design was used to evaluate the effects of cued environmental stimuli on varied responding. The effects of cued environmental stimuli were evaluated across three conditions that incorporated different levels of environmental stimuli that could potentially prompt a varied and appropriate response to the questions "What do you like to do?" The three conditions were a 0% condition, a 50% condition, and a 100% condition. The items and activities that were chosen as potential cues were based on the results of MSWO preference assessments conducted prior to each session. The appropriate items were then placed in the view of the participant depending on each condition. For example, a 0% condition did not display any items from the preference assessment, and 50% condition displayed half the items from the preference assessment, and a 100% condition displayed all the items from the preference assessment. Similar results were found in that for two of the participants, varied and appropriate responding increased from zero levels during baseline to 10-90% varied responding during the lag 1 condition. There was no effect found for using cued environmental stimuli.

While these three studies support the use of lag schedules to increase variable behavior in applied settings, they are not without limitations. First, Lee et al. (2002) and Lee and Sturmey (2006) only looked at lag 1 reinforcement schedules. In order to meet the lag requirement, the current response had to differ only from the previous response. This arrangement allowed the participant to alternate between only a few different responses and still meet the lag schedule requirement. This phenomenon did occur for three of the four participants who showed an increase in their percentage of variable responding. The cumulative number of varied responses ranged between two and five responses for these participants. Potential explanations for this effect could be that the participants in both studies all had a diagnosis of autism, which by definition is characterized by repetitive behavior. Alternatively the participants discovered that they could maximize their overall reinforcement by alternating between responses. This would be an artifact of the schedule requirement.

A second consideration with all three studies is the overall effectiveness of lag schedules to increase variable behavior with humans. By comparison, the participants in the Cammilleri and Hanley (2005) study demonstrated a more variable behavior than the participants in the two Lee studies. This discrepancy may be due to participant characteristics (typically developing participants versus participants with autism), task effects (independent class work versus providing verbal responses to questions), variation of the lag contingency (differential lag reinforcement contingency versus lag 1) and/or potential variability limitations of the task (social questions such as "What do you like to do?" have natural variability limitations).

These considerations warrant more investigation in the use of lag reinforcement schedules to increase behavioral variability with humans. This study attempted to overcome the first limitation by utilizing a progressive lag reinforcement schedule as opposed to the lag 1 reinforcement schedule used in the previous studies (this schedule will be described more fully in the Methodology Section). A progressive lag schedule has the potential to eliminate the ability of participants to alternate between responses. It was hypothesized that the progressive lag schedule will result in higher cumulative totals of unique responses.

Secondly, this study expanded upon the use of verbal responses as the dependent variable. Previous studies that have used verbal responses as the dependent variable have focused solely on responses to social questions. These questions can have a limited number of responses depending on the individual. This study attempted to overcome this potential limitation/problem by focusing on academic skills. The use of academic skills potentially increases the overall domain of possible responses.

Third, behavioral interventions are often criticized for their lack of generalization (Steege, Mace, Perry, & Longenecker, 2007), meaning that individuals who are trained or taught using these methods often fail to demonstrate these skills with others besides the trainer and/or in other environment. This study evaluated generalization of variable behavior by conducting assessments in environments other than the experimental environment, with persons other than the primary investigator, and by assessing/using alternate forms of the primary target prompt.

Finally, the effects of environmental stimuli on variable behavior were investigated. The potential for various environmental stimuli to affect variable behavior was first proposed by Lee et al. (2002) when they observed one participant incorporating objects from the physical environment into his responses. This effect was later experimentally investigated in a follow-up study by Lee and Sturmey (2006). The results from Lee and Sturmey did not show an effect for environmental stimuli on variable behavior. A potential explanation for the lack of effect may again be due to all participants having a diagnosis of Autism. It is common for individuals with Autism to have impaired social awareness. At this point the potential effect of environmental stimuli on variable behavior is still uncertain and warranted further investigation.

Method

Participants and Setting

Three children with expressive language delays participated in the study. Participants were selected based on teacher referral as being in need of increased novel or varied responding to age appropriate academic skill. Parent consent for participation was obtained for each child. Each child's primary teacher and parent were interviewed to determine the academic skill in need of increased varied or novel responding, and to determine each child's verbal response requirement. The verbal response requirement to the academic questions was individualized to the abilities of each participant for all phases of the study. Parents and teachers were asked to identify a minimum five academic skills in which the child consistently provided a repetitive verbal response. Repetitive responses were defined as any response that is identical to the previous response or a response that is equivalent in content from the previous response. For example, if the participant was asked to describe a dog, the responses "a dog has four paws" and "a dog has four feet" was considered a repetitive response because it did not differ in content from the previous response. Also, responses that differed only in grammatical structure were considered repetitive responses. Parents and teachers were asked to rank the identified skills in order of most important or in most need of assistance. The identified skills were used in a screening process (described below) to determine if the child was eligible for participation in the study.

Eric and Vincent were enrolled in clinic for preschool aged children with speech and language delays. Both received group language instruction twice a week, and individual speech therapy once a week at the clinic. Eric was a four year old male diagnosed with Autism. Eric was not prescribed any medication at the time of the study. No physical limitations were reported or observed. Eric primarily spoke in two-to-three-word utterances. Vincent was a four year old male diagnosed with an expressive language delay. Vincent was not prescribed any medication at the time of the study. No physical limitations were reported or observed. Vincent primarily spoke in two-to-four word utterances. All experimental sessions were conducted by the lead investigator in a small room located in the clinic. Ari was a seven year old male diagnosed with Autism, Attention Deficit/Hyperactivity Disorder, and Obsessive/Compulsive Disorder. No physical limitations were reported or observed. Ari spoke primarily in three-to-five word utterances; however, he would use complete sentences when instructed to do so. Ari attended public school in a small rural town in Central Louisiana and was in the first grade. Ari spent 80% of the school day in a regular education first grade class, and 20% of the school day in a resource class where he received individual assistance for academic assignments, and participated in social skills activities. At the start of the study, Ari was prescribed 25 mg of Concerta once a day. After the tenth experimental session, Ari's medication was changed from Concerta to 50 mg of Risperdal once a day. Ari's experimental sessions were conducted by the lead investigator during resource class time. Sessions were conducted in a small partitioned area of the resource classroom.

<u>Screening</u>

Once target skills were identified through parent and teacher interview, a screening session was conducted in order to determine the target academic skills for each participant. The screening order of each target skill was based on parent/teacher ranking of importance. Each participant was presented with the first ranked referred skill ten times. Each participant's response was recorded, and all sessions were audio-taped. The referred skills were eligible for a target skill if the participant provided an identical, grammatically similar, or content equivalent response on seven out of ten trials. Grammatically similar responses were defined as any response that were identical in content, but differed in sentence/phrase structure. For example if a participant was asked to describe a dog, the responses "dogs bark" and "a dog barks" were considered grammatically similar. If a participant did not meet the seven out of ten criteria, the next ranked skill was screened. Screening continued until three target skills were established or until all referred skills were screened. If the participant did not meet the seven out of ten criteria for three of the referred academic skills, he was excluded from the study. Additionally, if the participant engaged in excessive inappropriate behavior (i.e. self injury, tantrums, aggression) he was excluded from the study. All three participants met the necessary criteria for inclusion in the study (See Table 1).

Materials

Each experimental session area was equipped with a table and two chairs. All sessions were conducted with the child seated in one chair on one side of the table, and the investigator seated directly across from or adjacent to the participant. A mini audio tape recorder was used to record each session. Sessions were recorded for the purposes of calculating inter-observer agreement. All participants' verbal responses were recorded on data sheets.

Other environmental stimuli during sessions were dependent on two procedural considerations.

Table 1

Screening Results-Number of Unique Responses to teacher/parent referred target questions.

Participant		Teacher/Parent Referred Questions	Number of Unique Responses
Eric			
	Classes		
		Colors	6
		Shapes	2
		Animals	2
	Functions		
		Toys	5
		Food	2
Vincent			
	Classes		
		Colors	5
		Shapes	4
		Animals	2
	Functions		
		Transportation	4
		Clothes	2
		Food	2
Ari			
	Classes		
		Colors	7
		Shapes	4
		Animals	4
	Functions		
		Toys	4
		Transportation	4
		Food	2
		Clothes	2
	Features/Characteristics		
		Dog	1

First, during experimental phases that examined the effects of environmental stimuli on verbal responding, the session area contained pictures and/or objects relevant to the target skill. For example, if a participant's target skill was to name an animal, the area contained pictures of animals as well as animal toys. Second, during generalization probes (described below), environmental stimuli consisted of any stimuli present in the participant's primary classroom. Any stimuli in the participant's primary classroom that influenced responding were removed or covered. Remaining environmental stimuli consisted of reinforcers identified during preference assessments. Reinforcers were kept out of reach of the participant, and delivered to the participant based on the experimental procedure.

Dependent Measures: Definition, Measurement, and Interobserver Agreement.

The dependent measures were the number of unique appropriate verbal responses to the academic skill per session, the cumulative number of unique appropriate verbal responses throughout the study, and the percentage of baseline and first five experimental session unique appropriate responses that occurred throughout the study (maintenance). Maintenance data allowed for the examination of an individual's response repertoire. Specifically, did responses that occurred during baseline and initial progressive lag sessions maintain throughout the study and become predictable members of a larger response repertoire, did initial responses become variable as new responses are established, or was there a significant decrease in response frequency of established responses as new responses were established?

An appropriate verbal response was defined as any word, phrase, or sentence that correctly answered the target academic skill. Any response that was appropriate but grammatically incorrect was counted as an appropriate response. Inappropriate responses were any response that did not correctly answer the target skill, was unrelated to the skill (e.g. echoic speech or off topic responses), or responses that occurred more than ten seconds following the instructional prompt.

A unique response was defined as any appropriate response that differed in content from any previous response to the same target skill. Content was defined as appropriate statements provided in response to the target academic skill. Therefore, for a response to be considered unique, the response must differ in regard to the information provided in any previous response. For example, if the participant was asked to describe a dog, the responses “a dog has four paws” and “a dog has four feet” would not differ in content because both statements provided the same information regarding a dog’s physical characteristics. However, the statements “a dog has four paws” and “a dog has four legs” were considered unique because they provided different information regarding a dog’s physical characteristics.

During baseline and progressive lag sessions, a verbal response was considered unique and appropriate if it differed in content from any previous response within that session. Investigator response was contingent on the participant’s response to the target academic skill, and the participant reinforcement was dependent upon fulfilling the reinforcement contingency established for either baseline or progressive lag sessions (see Experimental Design).

All verbal responses were recorded on a data sheets as well as audio taped. This provided a record of all responses and provided a record of all unique responses emitted throughout the study. Unique and appropriate responses and the maintenance of responses were evaluated on an event basis. Maintenance of verbal responses were evaluated at the end of each session and totaled at the end of the study. Maintenance was calculated as the percentage of sessions a unique appropriate verbal response occurred during baseline and the first five experimental sessions.

Interobserver agreement data (IOA) was collected for approximately 50% of the total sessions for each participant. A second observer listened to the audio recording of the session and recorded each participant's verbal response. IOA was calculated by dividing the number of agreements by the total number of agreements plus disagreements (see Table 2)

Table 2

Interobserver Agreement for Ari, Vincent, and Eric

Participant	Number & Percent of Sessions Analyzed	Percent IOA	Range
Ari	54 sessions (51.43%)	94.43%	72.72-100%
Vincent	46 Sessions (50.0%)	89.13%	54.54-100%
Eric	49 Session (48.5%)	94.81%	63.63-100%

Experimental Design

Design. A within-subject multiple baseline design across target academic skills, embedded within an ABAB reversal design, was used to evaluate the use of progressive lag schedules of reinforcement to increase unique and appropriate responses and maintenance of these responses to academic skills. The effect of relevant environmental stimuli on maintenance and unique appropriate verbal responding was evaluated using an alternating treatments design.

Baseline. During baseline, the target academic skill was presented eleven times. All appropriate verbal responses to the target skill were reinforced (lag 0 schedule of reinforcement). If the participant responded incorrectly or with an inappropriate response, the investigator responded with a “no” and diverted his attention from the participant until the beginning of the next trial. Any attempts to interact with the investigator were ignored.

Progressive Lag Phase (PLP). During the Progressive Lag Phase (PLP) the sessions began with a presentation of the target skill in order to establish a starter response. Any appropriate verbal response to the skill was reinforced. The target skill was presented until a starter response was established. Following the starter response, a lag 1 schedule of reinforcement for verbal responding was implemented. Reinforcement for verbal responding was contingent upon the participant fulfilling the current lag 1 requirement. Once the participant fulfilled the lag 1 criteria for reinforcement, the progressive lag reinforcement schedule was increased by one. For example, after the presentation of the first skill and a response was emitted (the starter response), the target skill was presented again. In order for the participant to receive a reinforcer, their next response had to be appropriate and varied from the starter response. If the response was varied and appropriate, the progressive lag reinforcement schedule was increased by one. The next progressive lag reinforcement schedule was a lag 2, and the participant was presented with the target skill again. In order to fulfill the criteria of the lag 2 schedule, the participant’s response had to be appropriate and varied from the previous two responses. The schedule continued to increase by one until the end of the session. Each session was terminated once the target skill was presented ten times following the establishment of the starter response. For any given schedule of reinforcement, if the participant did not provide a response that met the criteria of the current lag schedule, the current lag schedule remained in effect until either the participant met the requirement of the lag schedule and progressed to the next schedule, or the session terminated. Responses to inappropriate or incorrect responses were identical to those in baseline. No feedback was provided to appropriate answers that did not meet the criteria for reinforcement.

Stimuli Present/ Stimuli Absent. The effect of environmental stimuli on unique appropriate verbal responding and maintenance was evaluated using an alternating treatments design. During stimuli present conditions, five items relevant to the target skill were present in the room (see Table 3). During stimuli absent conditions, only relevant experimental materials were present in the room. The only noted exception was for Eric and Vincent's experimental sessions. An office desk, computer, and file cabinet were present during experimental sessions; however, these items were not related to either participant's target skills.

Table 3.

Items utilized during Stimulus Present Conditions

Animals	Clothes/Apparel	Food	Shapes
Lion	Pants	Hotdog	Circle
Cat	Jacket	Pizza	Triangle
Dog	Ring	Cheese	Square
Horse	Glasses	Burger	Rectangle
Cow	Hat	Sandwich	Star

Generalization Probes. Generalization probes were conducted following every fourth experimental session. Generalization probes were conducted a general education setting. Procedures for generalization probes were identical to procedures used during baseline sessions. Dependent measures for generalization probes were identical to other experimental phases.

Generalization was assessed in three areas. First, generalization was assessed across environments by conducting probes in a typical classroom setting. Second, generalization across persons was assessed by having the participant's teacher or classroom aide administer probes for each target skill. Finally, generalization across instructional prompts was assessed by using an alternate prompt of the academic skill.

Procedure

Prior to the beginning of the study two, paired-choice preference (Fisher et al, 1992) assessments for edibles and tangibles were conducted with each participant. Preference assessment items were derived from parent and teacher recommendations. The top five items from both assessments were used as reinforcers for the study. Prior to each session, a multiple stimulus without replacement preference assessment (DeLeon & Iwata, 1996) was conducted to assess current participant preferences. Any item considered to have a confounding impact on verbal responding was excluded. For example, Animal Crackers were not used during sessions that targeted animals or food.

For each session the investigator and the participant were seated across from or adjacent to each other at a small table. The investigator presented the target academic skill eleven times for each session. For all sessions, the first appropriate verbal response to the target skill resulted in participant reinforcement. Following the first response, reinforcement schedules were contingent upon the experimental phases. All verbal responses were recorded on data sheets.

During baseline, every appropriate verbal response to the target skill was reinforced (lag 0). If the participant provided an incorrect verbal response or an inappropriate response, the investigator responded with a "no" and diverted his attention away from the participant. Investigator attention was diverted until the start of the next trial. Inter-trial intervals were approximately ten seconds.

During the Progressive Lag Phase (PLP), participant reinforcement for verbal responses to the target skill was contingent on meeting the criteria of the current progressive lag reinforcement schedule. As in baseline sessions, the participant's first appropriate verbal response was reinforced. The first verbal response served as the starter response. Following the starter response, a lag 1 reinforcement schedule was implemented. As the participant met the criteria for each lag schedule, the lag reinforcement schedule was increased by one. For example, if the participant's target academic skill was to provide characteristics/features of a dog, a response of "a dog has fur" was reinforced and constituted the starter response. This response is an appropriate feature of dog. Following the starter response a lag 1 reinforcement schedule was implemented. The target question was presented again to the participant. In order for the participant to receive a reinforcer the next response had to be appropriate and varied from the previous response. The response "a dog has a tail" fulfilled the lag 1 criteria and the participant received a reinforcer. "A dog has a tail" is an appropriate feature of a dog and is varied from the previous response. Next, a lag 2 schedule of reinforcement was implemented. In order for the participant to receive a reinforcer the next response had to be appropriate and varied from the previous two responses. The response "a dog barks" fulfilled the lag 2 criteria and the participant received a reinforcer. "A dog barks" is an appropriate characteristic/feature of a dog and is varied from the previous two responses. The lag schedule continued to be increased by one until the end of the session, and as long as the participant continued to meet the criteria for the current lag schedule. If the participant did not meet the criteria for any given lag schedule, participant reinforcement remained contingent the current lag schedule until the criterion was met or the session terminated. Using the previous example, if reinforcement was contingent on fulfilling the lag 2 criteria and the participant response was "dogs have fur or a dog has a tail" the participant did not receive a reinforcer and the participant did not receive feedback regarding their response. These characteristics are appropriate but not varied from the previous two responses. Subsequently, participant reinforcement was again contingent the participant meeting the lag 2 criteria. The participant's reinforcement continued to be contingent on the lag 2 schedule until the participant fulfilled the schedule criteria and progress to the lag schedule or the session terminated. Investigator responses for inappropriate and incorrect verbal responses were the same as in baseline. No feedback was provided for verbal responses that were appropriate but did not meet the criteria of the current lag schedule for reinforcement. PLP sessions were terminated after ten presentations of the target academic skill following the establishment of the starter response. New sessions began with a lag 1 schedule of reinforcement following the starter response.

The effect of relevant environmental stimuli on unique appropriate responding was evaluated in conjunction with progressive lag reinforcement schedules using an alternating treatments design. During the Stimuli Absent Condition, only experimentally relevant materials were present in each session. During the Stimuli Present Condition, stimuli relevant to the target question were present in the room. For example, if the target academic question was to provide different characteristics of a dog, pictures of different dogs as well as toy representations of dogs were present in the room. Preferred items that may influence verbal responding were excluded as reinforcers.

Results

A within-subject multiple baseline design across target academic skills, embedded within an ABAB reversal design, was used to evaluate the use of progressive lag reinforcement schedules to increase unique and appropriate responses and maintenance of these responses to academic skills. The effect of relevant environmental stimuli on maintenance and unique appropriate verbal responding was evaluated using an alternating treatments design. Ari's three academic skills included naming items by their function (food and clothes) and indentifying features or characteristics of a dog. As seen in Figure 1, Ari's unique and appropriate responses to all three academic skills were low and stable during initial baseline sessions (*M*= 3.0, 1.86, and 1.16 respectively). During initial Progressive Lag Phases (PLP) Ari showed an increasing trend in the number of unique and appropriate responses for each academic skill. With respect to the effects of relevant environmental stimuli on unique and appropriate responses, the inclusion of relevant stimuli increased unique and appropriate responses for two of Ari's three academic instructions as compared to conditions without relevant stimuli (see Table 4). During initial PLP sessions for features, Ari emitted more unique and appropriate responses during Stimuli Absent Conditions (*M*=7.0) than Stimuli Present Conditions (*M*=5.8). This trend reversed during subsequent PLP sessions when Ari emitted more unique and appropriate responses during Stimuli Present Conditions (*M*=10.67) as compared to Stimuli Absent Conditions (*M*=10.00). During a reversal phases, Ari showed a decreasing trend in unique verbal responses for two of the three target domains. For features, Ari's responding decreased slightly as compared to PLP phases; however, his responding did not return to baseline levels.

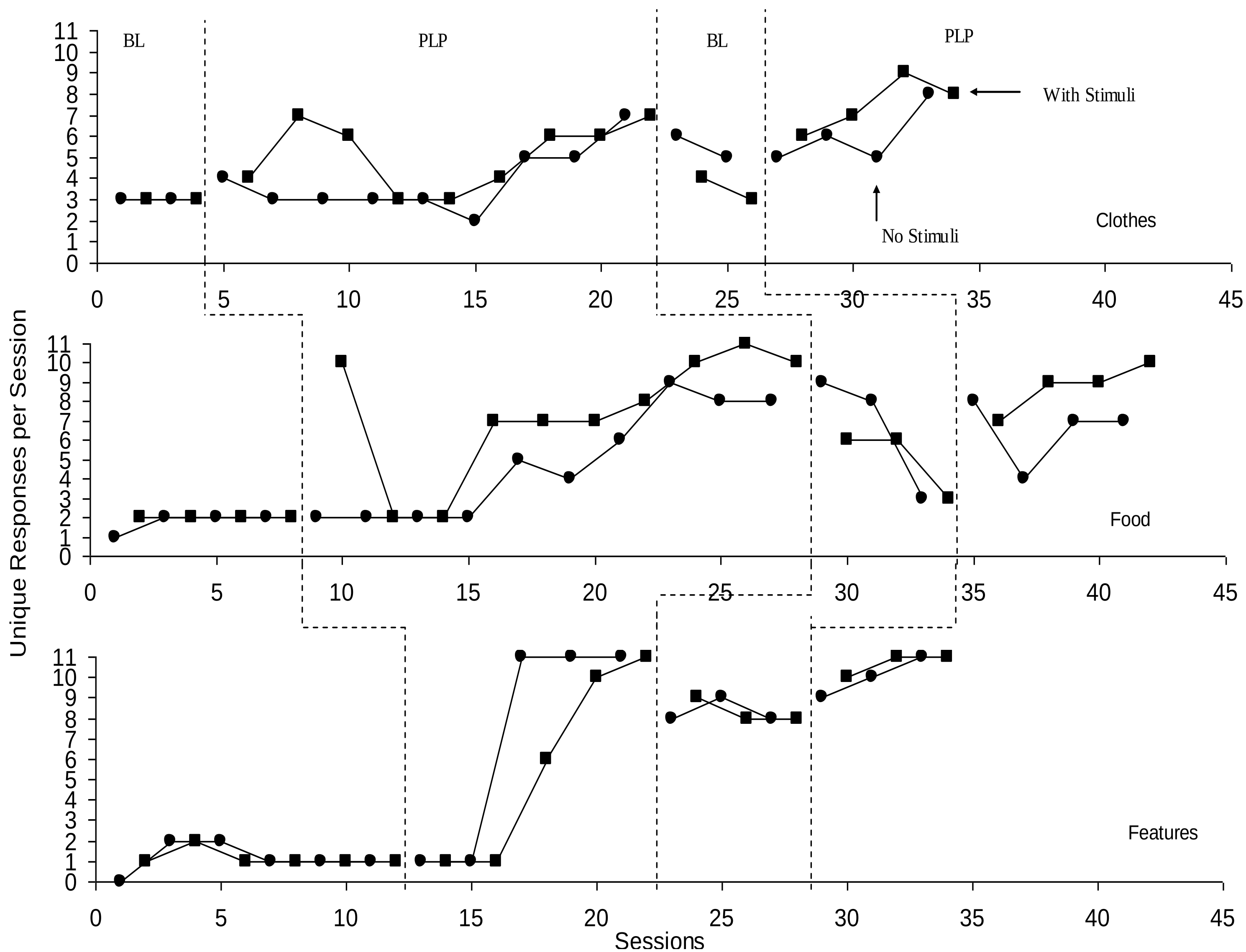

Figure 1. Number of unique and appropriate responses per session for Ari. BL equals baseline. PLP equals progressive lag sessions. Circles represent Stimuli Absent Conditions. Squares equal Stimuli Present Conditions

Table 4

Ari's mean responses during baseline and PLP conditions

Domain	BL1	PLP1	BL2	PLP2	Total PLP Sessions
Clothes					
	3.00		4.50		
No Stimuli		3.88		6.00	4.54
With Stimuli		5.11		7.50	5.85
Combined		4.50		6.75	5.19
Food					
	1.86		5.83		
No Stimuli		4.80		6.50	5.29
With Stimuli		7.40		8.75	7.79
Combined		6.10		7.63	6.54
Features of Dog					
	1.16		8.33		
No Stimuli		7.00		10.00	8.13
With Stimuli		5.80		10.67	7.63
Combined		6.40		10.33	7.88

Ari's responding trended toward similar levels as compared to initial PLP sessions during a return to PLP conditions for all three academic skills.

Eric's three academic skills included naming items by their class association (animals and shape) and naming items by their function (food). As seen in Figure 2 , Eric's unique and appropriate responses to all three academic skills were low and stable during initial baseline sessions (*M*= 3.25, 2.60, and 2.62 respectively). During initial Progressive Lag Phases (PLP) Eric showed an increasing trend in the number of unique and appropriate responses for each academic skill. With respect to the effects of relevant environmental stimuli on unique and appropriate responses, the inclusion of relevant stimuli increased unique and appropriate responses for all three academic skills as compared to conditions without relevant stimuli (see Table 5). Similar to Ari, Eric's response levels did not return baseline levels for one academic skill following a reversal phase. For animals, Eric's unique and appropriate responses decreased during a reversal phase, but did not return to levels obtained during initial baseline sessions. Eric's responding trended toward similar levels as compared to initial PLP sessions during a return to PLP conditions for all three academic skills.

Vincent's three academic skills included naming items by their class association (animals) and naming items by their function (food and clothes). As seen in Figure 3, Vincent's unique and appropriate responses to all three academic skills were low and stable during initial baseline sessions (*M*= 2.16, 1.88, and 2.60 respectively). During initial Progressive Lag Phases (PLP) Vincent showed a modest increasing trend in the number of unique and appropriate responses for each academic skill. With respect to the effects of relevant environmental stimuli on unique and appropriate responses, the inclusion of relevant stimuli increased unique and appropriate responses for all three academic skills as compared to conditions without relevant stimuli (see Table 6). During reversal sessions, Vincent's number of unique and appropriate responses returned to levels observed during initial baseline sessions. Vincent's responding trended toward similar levels as compared to initial PLP sessions during a return to PLP conditions for all three academic skills.

Generalization effects across Setting, Person, and Instructional Prompts for Ari can be seen in Figure 4 and Table 7. Ari demonstrated a transfer of experimental effects for all three generalization conditions across each target academic skill as compared to each skill's respective baseline levels. As seen in Figure 4, there was little differentiation among the three generalization conditions for each skill suggesting an overall equal transfer of experimental effects across all generalization conditions.

Generalization effects across Setting, Person, and Instructional Prompts for Eric can be seen in Figure 5 and Table 8. Eric demonstrated a transfer of experimental effects for all three generalization conditions across each target academic skill as compared to each skill's respective baseline levels. Similar to Ari's generalization results, there was little differentiation among the three generalization conditions for each skill suggesting an overall equal transfer of experimental effects across all generalization conditions (see Figure 5).

Generalization effects across Setting, Person, and Instructional Prompts for Vincent can be seen in Figure 6 and Table 9. Vincent demonstrated a transfer of experimental effects for all three generalization conditions across each target academic skill as compared to each skill's respective baseline level.

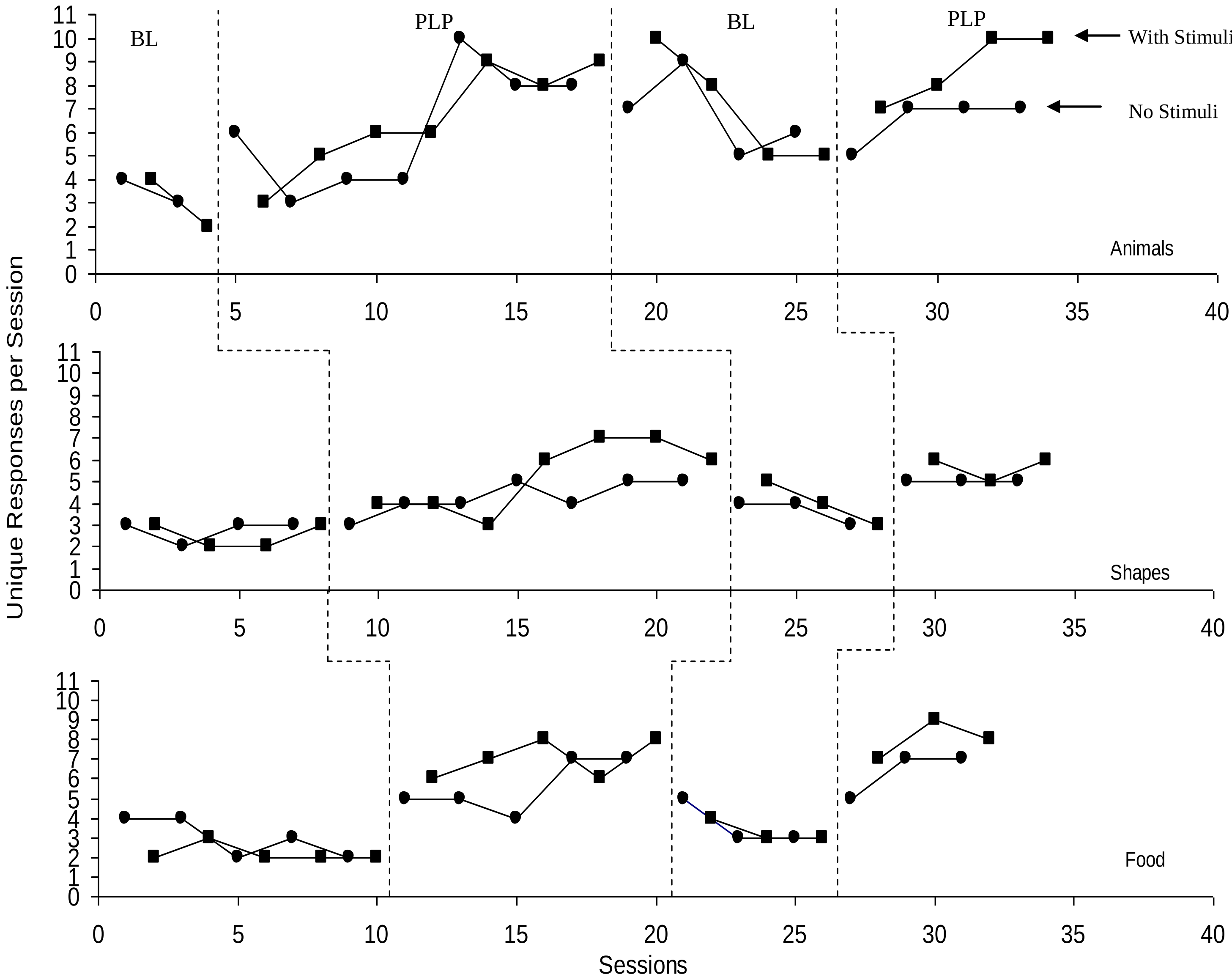

Figure 2. Number of unique and appropriate responses per session for Eric. BL equals baseline . PLP equals progressive lag sessions. Circles represent Stimuli Absent Conditions. Squares equal Stimuli Present Conditions

Table 5.

Eric's mean responses during baseline and PLP conditions

Domain	BL1	PLP1	BL2	PLP2	Total PLP Sessions
Animals					
	3.25		7.20		
No Stimuli		6.14		6.50	6.72
With Stimuli		6.57		8.75	7.36
Combined		6.36		7.63	6.82
Shapes					
	2.62		4.16		
No Stimuli		4.16		5.00	4.44
With Stimuli		5.16		5.66	5.33
Combined		4.66		5.33	4.83
Food					
	2.60		3.50		
No Stimuli		5.60		6.33	5.83
With Stimuli		7.00		8.00	7.38
Combined		6.30		7.16	6.63

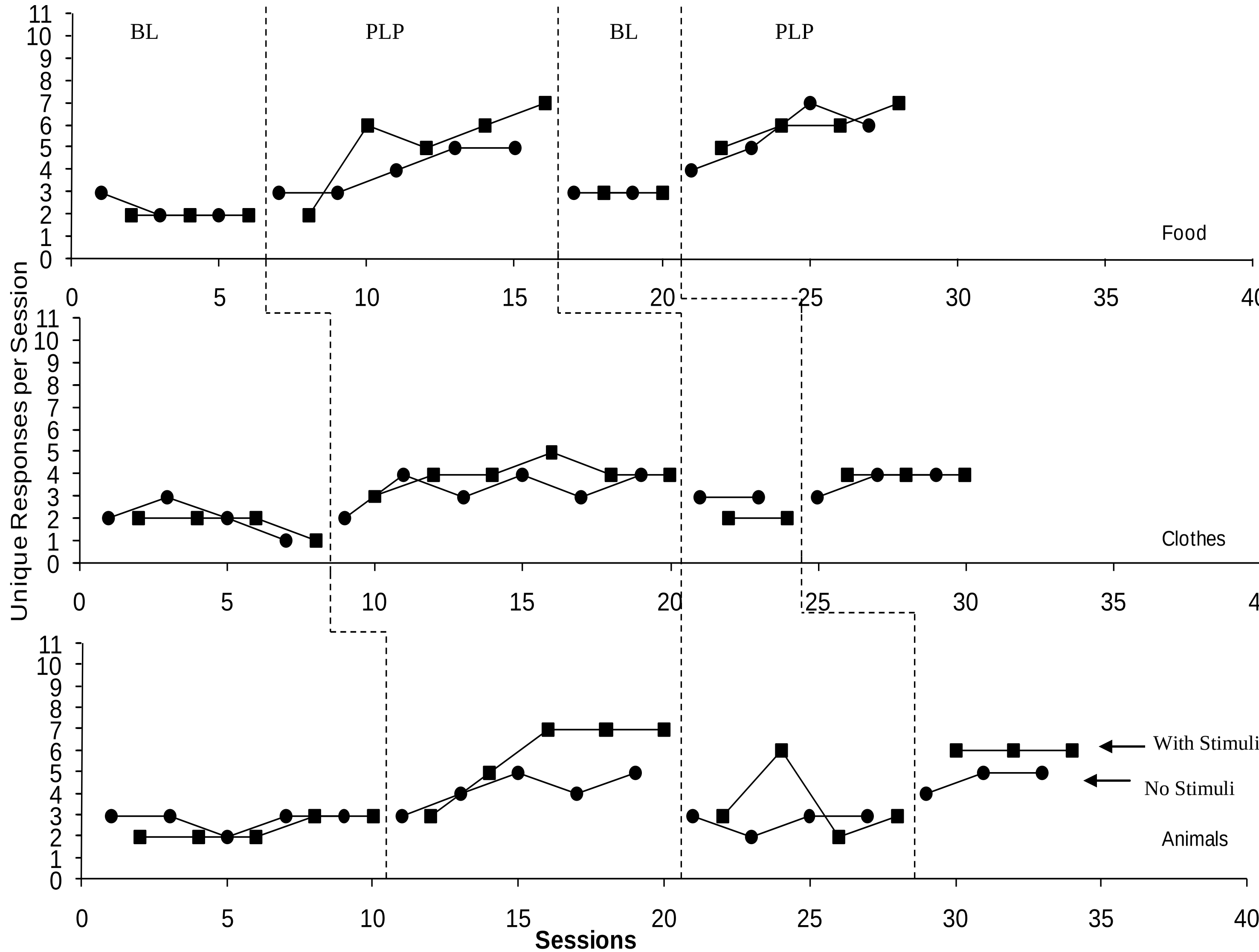

Figure 3. Number of unique and appropriate responses per session for Vincent. BL equals baseline. PLP equals progressive lag sessions. Circles represent Stimuli Absent Conditions. Squares equal Stimuli Present Conditions

Table 6.

Vincent's mean responses during baseline and PLP conditions

Domain	BL1	PLP1	BL2	PLP2	Total PLP Sessions
Food					
	2.16		3.00		
No Stimuli		4.00		5.50	4.67
With Stimuli		5.20		6.00	5.56
Combined		4.60		5.75	5.11
Clothes					
	1.88		1.75		
No Stimuli		3.33		3.67	3.44
With Stimuli		4.00		4.00	4.00
Combined		3.67		3.83	3.72
Animals					
	2.60		3.13		
No Stimuli		4.20		4.66	4.38
With Stimuli		5.80		6.00	5.88
Combined		5.00		5.33	5.13

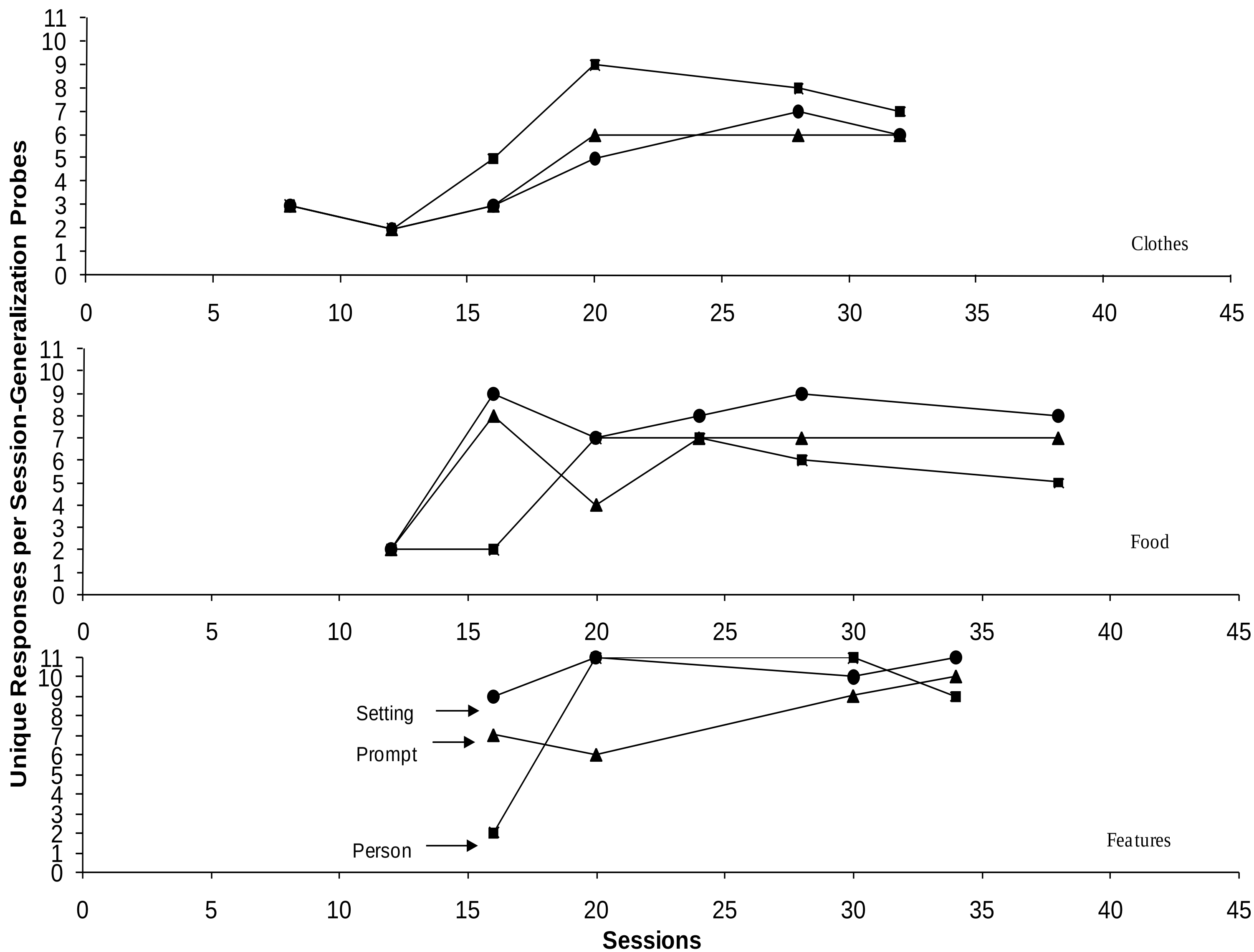

Figure 4. Unique responses per session for Ari-Generalization probes. Circles represent generalization probes across settings. Squares represent generalization probes across persons. Triangles represent generalization probes across instructional prompts.

Table 7

Number of Unique Responses for Generalization Probes (Ari).

Probe	Setting	Person	Prompt
Clothes			
1	3	3	3
2	2	2	2
3	3	5	3
4	5	9	6
5	7	8	6
6	6	7	6
Mean	4.33	5.67	4.33
Food			
1	2	2	2
2	9	2	8
3	7	7	4
4	8	7	7
5	9	6	7
6	8	5	7
Mean	7.17	4.83	5.83
Features			
1	9	2	7
2	11	11	6
3	10	11	9
4	11	9	10
Mean	10.25	8.25	8.00

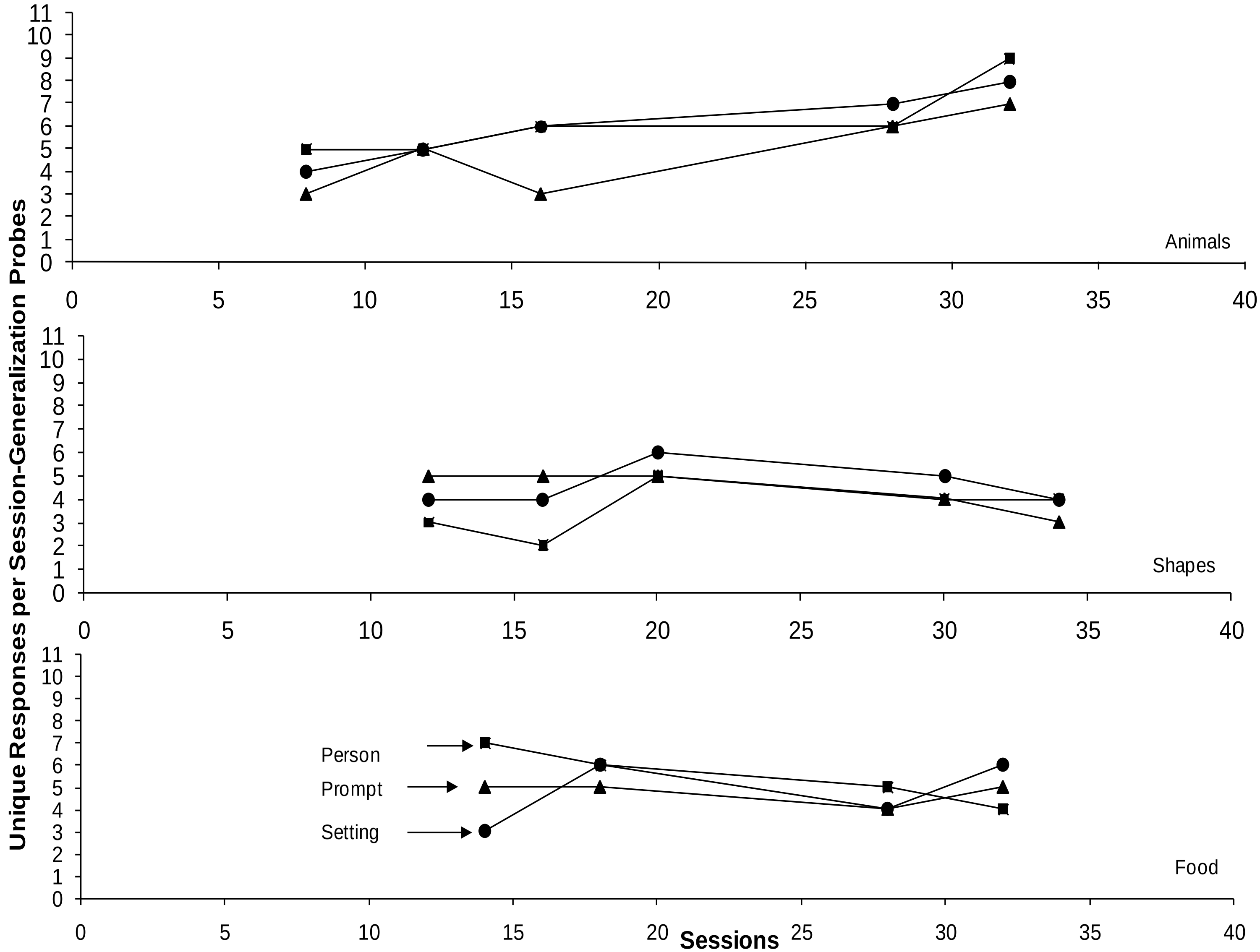

Figure 5. Unique responses per session for Eric-Generalization probes. Circles represent generalization probes across settings. Squares represent generalization probes across persons. Triangles represent generalization probes across instructional prompts.

Table 8

Number of Unique Responses for Generalization Probes (Eric).

Probe	Setting	Person	Prompt
Animals			
1	4	5	3
2	5	5	5
3	6	6	3
4	7	6	6
5	8	9	7
Mean	6.00	6.20	4.80
Shapes			
1	4	3	5
2	4	2	5
3	6	5	5
4	5	4	4
5	4	4	3
Mean	4.60	3.60	4.40
Food			
1	3	7	5
2	6	6	5
3	4	5	4
4	6	4	5
Mean	4.75	5.50	4.75

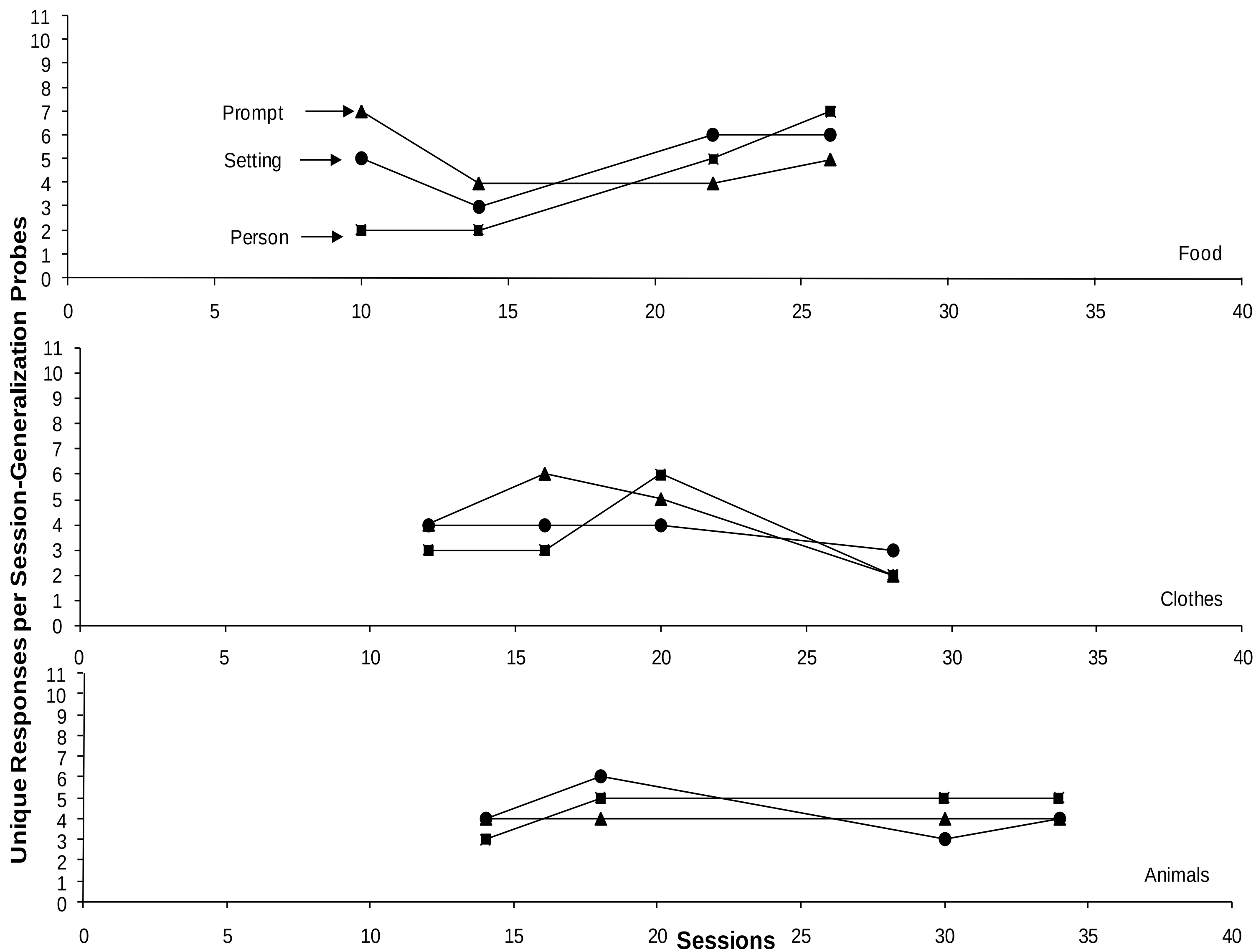

Figure 6. Unique responses per session for Vincent-Generalization probes. Circles represent generalization probes across settings. Squares represent generalization probes across persons. Triangles represent generalization probes across instructional prompts

Table 9

Number of Unique Responses for Generalization Probes (Vincent).

	Probe	Setting	Person	Prompt
Food				
	1	5	2	7
	2	3	2	4
	3	6	5	4
	4	6	7	5
	Mean	5.00	4.00	5.00
Clothes				
	1	4	3	4
	2	4	3	6
	3	4	6	5
	4	3	2	2
	Mean	3.75	3.5	4.25
Animals				
	1	4	3	4
	2	6	5	4
	3	3	4	5
	4	4	5	4
	Mean	4.25	4.25	4.25

Consistent with the generalization results seen for Ari and Eric, there was little differentiation among the three generalization conditions for each skill suggesting an overall equal transfer of experimental effects across all generalization conditions (see Figure 6).

Ari's cumulative unique responses are presented in Figure 7. During baseline sessions, Ari provided few unique responses for all three target domains. For clothes, Ari provided a total of three unique responses over four baseline sessions, for food, Ari provided two unique responses over eight baseline sessions, and for features of a dog, Ari provided four unique responses over twelve baseline sessions. Following the initial PLP phases, Ari showed an increase in the cumulative number of unique and appropriate responses across all three target skills (increase of 7, 27, and 13 responses respectively). Cumulative responding became stable (i.e. little growth) during a return to baseline conditions (increase of 0, 3, and 1 responses respectively), and again showed an increasing trend during a return to PLP phases (increase of 6, 1, and 4 responses respectively). Overall, Ari demonstrated a cumulative growth of 13, 31, and 18 unique and appropriate responses, following initial baseline sessions, for clothes, food and features.

Eric's cumulative unique responses are presented in Figure 8. During baseline sessions, Eric provided few unique responses for all three target domains. For animals, Eric provided a total of six unique responses over four baseline sessions, for shapes, Eric provided three unique responses over eight baseline sessions, and for food, Eric provided seven unique responses over ten baseline sessions.

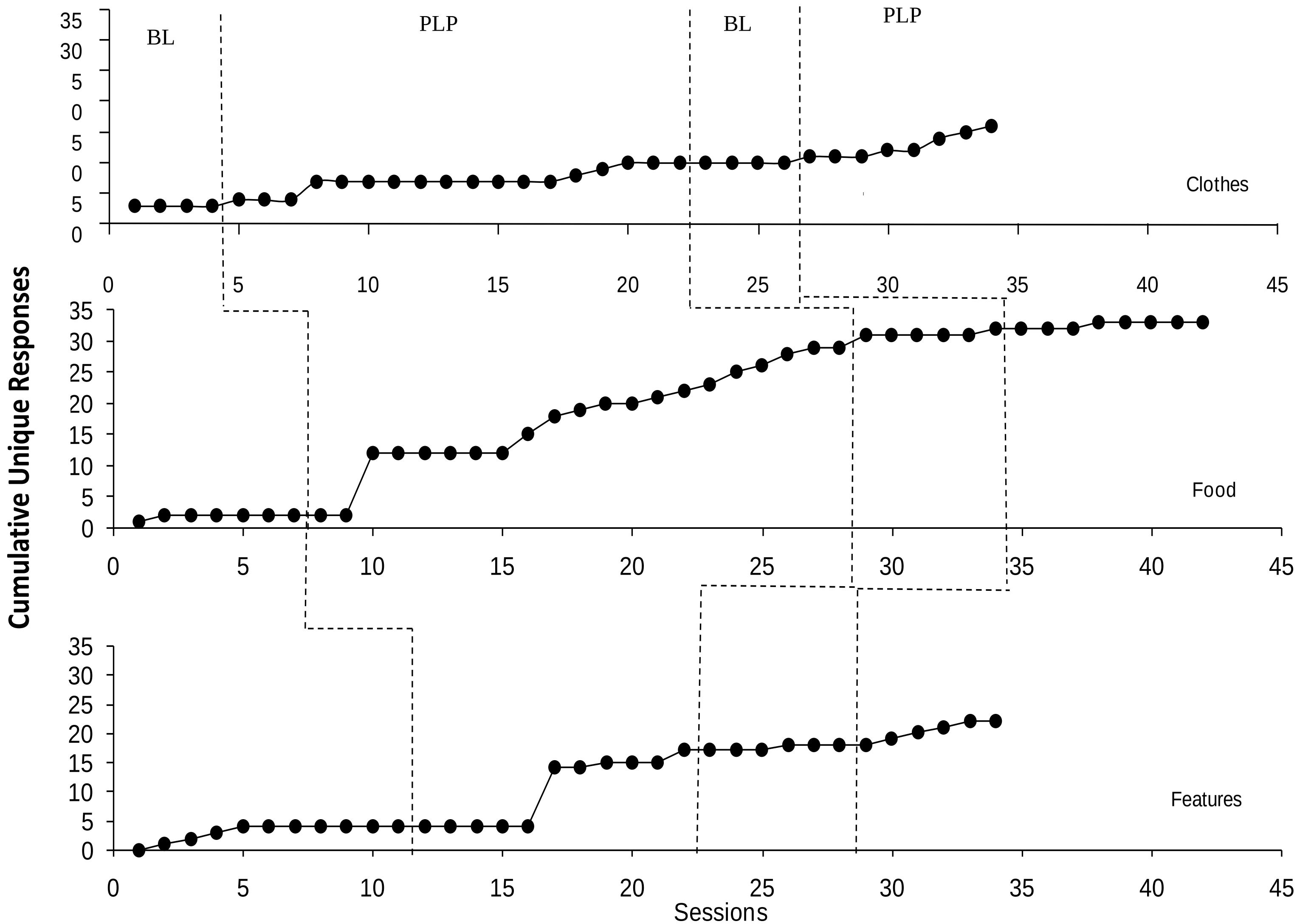

Figure 7. Cumulative number of unique responses for Ari

Following the initial PLP phases, Eric showed an increasing trend in the cumulative number of unique and appropriate responses across all three target skills (increase of 24, 7, and 13 responses respectively). Cumulative responding became stable during a return to baseline conditions for two academic skills. For shapes and food, Eric showed no cumulative growth during a reversal sessions. For animals, Eric emitted six unique and appropriate responses, across eight reversal sessions, which were not emitted during any previous session. A subsequent return to PLP resulted in minimal change for each of Eric's academic skills with respect to cumulative responses. Eric emitted three new responses for animals across eight PLP sessions, and two new responses for food across six PLP sessions. Eric did not emit any new response for shapes across six PLP sessions. Overall, Eric demonstrated a cumulative growth of 33, 7, and 15 unique and appropriate responses, following initial baseline sessions, for animals, shapes and food.

Vincent's cumulative unique responses are presented in Figure 9. During baseline sessions, Vincent provided few unique responses for all three target domains. For food, Vincent provided a total of five unique responses over six baseline sessions, for clothes, Vincent provided three unique responses over eight baseline sessions, and for animals, Vincent provided eight unique responses over ten baseline sessions. Following the initial PLP phases, Vincent showed an increasing trend in the cumulative number of unique and appropriate responses across all three target skills (increase of 13, 5, and 9 responses respectively). Cumulative responding became stable during a return to baseline conditions for two academic skills. For the clothes and animals, Vincent showed no cumulative growth during reversal sessions.

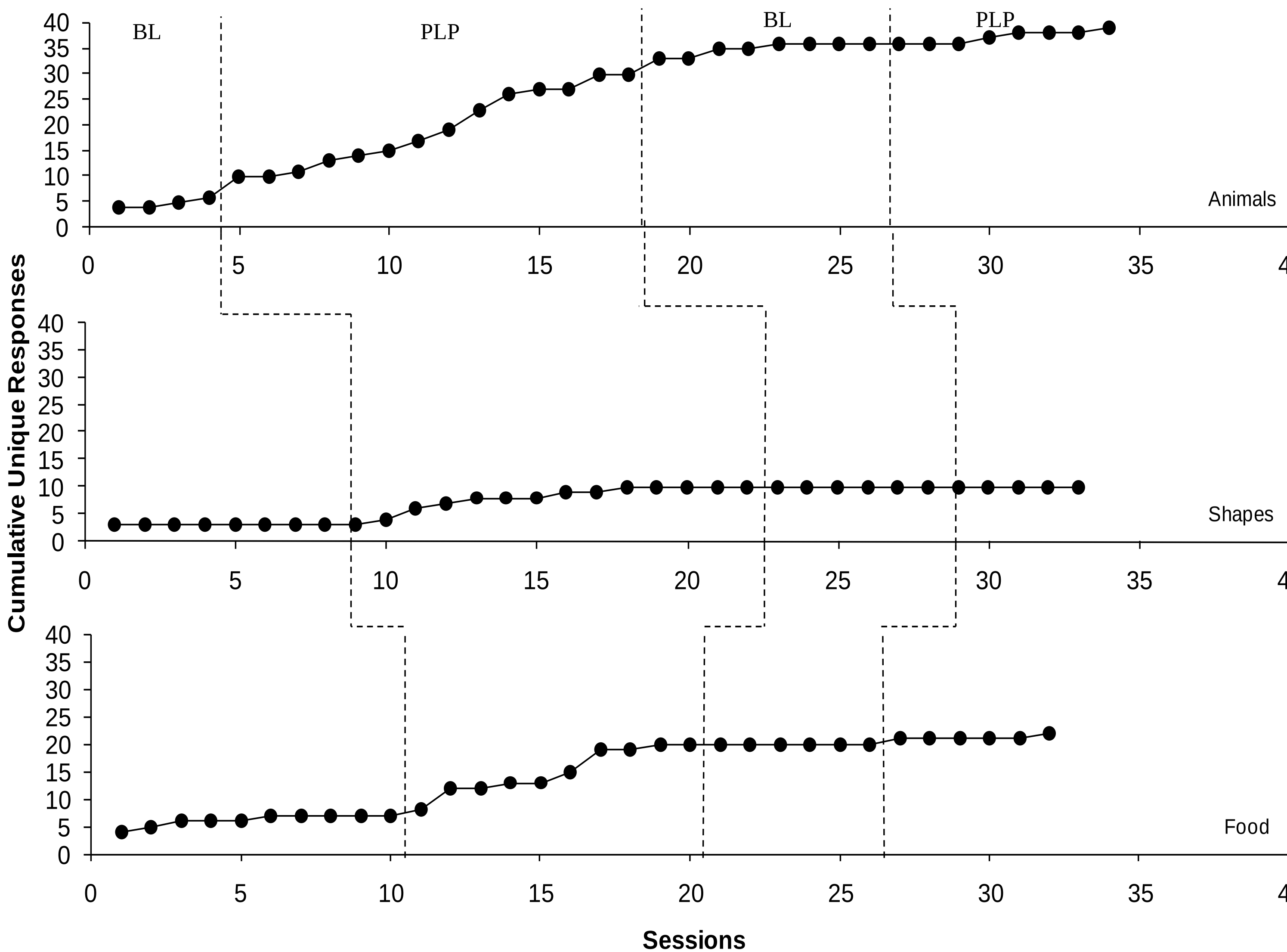

Figure 8. Cumulative number of unique responses for Eric

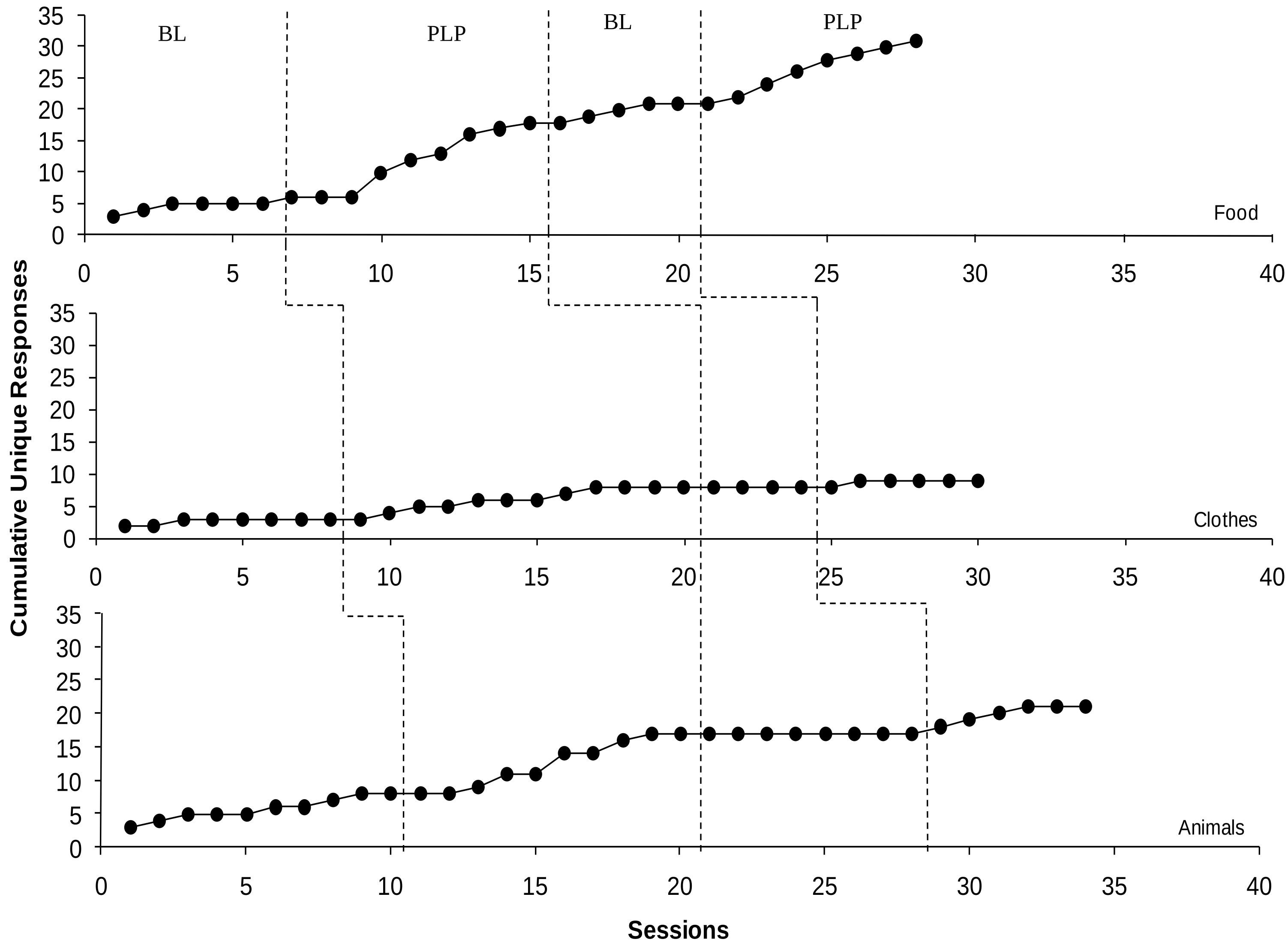

Figure 9. Cumulative number of unique responses for Vincent

For food, Vincent emitted three unique and appropriate responses, across six reversal sessions, which were not emitted during any previous session. A subsequent return to PLP resulted in continued cumulative growth for two of the academic skills. For food, Vincent emitted ten new responses across eight PLP sessions and four new responses for animals across six PLP sessions. Vincent emitted one new response for clothes across six PLP sessions. Overall, Vincent demonstrated a cumulative growth of 26, 6, and 13 unique and appropriate responses, following initial baseline sessions, for food, clothes and animals.

Maintenance of responses for each participant are presented in Table 10, Table 11, and Table 12. Maintenance was analyzed by calculating the percentage of sessions an individual response occurred across all possible sessions. Percentages were calculated for all unique and appropriate responses that occurred during baseline and the first five experimental sessions. For clothes and food skills (Table 10), Ari's continued to emit all baseline responses following the applications of a progressive lag reinforcement schedule, suggesting these responses maintained and became a part of an increasing repertoire of responses. For features skill, Ari continued to emit only one of the four baseline responses during PLP sessions, indicating that the remaining three responses did not maintain following the implementation of a progressive lag reinforcement schedule. Eric's Maintenance of responses can be seen in Table 11. For animals, Eric continued to emit four of his six baseline responses, all three of his baseline responses for shapes, and five of his seven baseline responses for food following the application of a progressive lag reinforcement schedule. Similar to Ari, this response pattern suggests that these responses maintained and became a part of an increasing repertoire of responses.

Vincent's Maintenance of responses can be seen in Table 12. For food, Vincent continued to emit two of his five baseline responses, all three baseline responses for clothes, and three of his eight baseline responses for animals following the application of a progressive lag reinforcement schedule. Again, this response pattern suggests that these responses maintained and became a part of an increasing repertoire of responses. Maintenance of responses was more variable for responses emitted during the first five experimental sessions as compared to those that occurred during baseline sessions. For clothes, Ari continued to emit all responses that occurred during baseline and the first five experimental sessions. However, maintenance of these responses may be more related to the cumulative number of responses for this particular academic skill. Ari showed the smallest cumulative growth for clothes suggesting that maintenance was a result of Ari using a small repertoire of responses. In addition, Ari's responses that occurred during the first five experimental sessions were all items used in Stimulus Present Conditions. Similarly, Vincent showed very little cumulative growth for clothes. Vincent emitted a total of nine unique and appropriate responses throughout the investigation for clothes. Six of the nine responses occurred during baseline and the first five experimental sessions. The remaining three responses occurred only once during the investigation. Like Ari, Vincent's responses for clothes are likely not a result of these responses maintaining as they became a part of a larger repertoire of responses, rather a result of Vincent using a small a small repertoire of responses. This same effect can be seen for Eric with respect to shapes in which eight of his ten cumulative responses occurred during baseline and the first five experimental sessions.

Table 10

Maintenance of Baseline and initial experimental session responses (Ari)

Response	Percentage	Response	Percentage
	Clothes (34 sessions)		
Shirt*	94.4	*Ring*	41.2(46.7)
*Pants**	100	*Glasses*	38.2(43.3)
Shoes*	67.6	*Hat*	35.3 (40.0)
Jacket	41.2(46.7)		
	Food (42 sessions)		
Cookie*	47.6	*Cheese*	28.8(35.3)
Chip*	61.9	Berry	2.4(2.9)
Banana	2.4(2.9)	Orange	14.3(17.6)
Grape	9.5(11.8)	Popcorn	9.5(11.8)
Apple	4.8(5.9)	Carrots	2.4(2.9)
Chicken	11.9(14.7)	*Burger*	45.2(55.9)
	Features (34 session)		
Fur*	73.5	Tail	50.0(77.3)
Walk*	2.9	Eyes	41.2(63.6)
Run*	2.9	Nose	55.9(86.4)
Bark*	2.9	Head	14.7(22.7)
Legs	47.1(72.7)	Neck	47.1(72.7)
Ear	44.1(68.2)	Penis	29.4(45.5)
Mouth	47.1(72.7)	Face	2.90(4.5)
Body	47.1(72.7)		

*** denotes responses emitted during baseline sessions. Italicized items were used in Stimuli present conditions. Responses are reported in the chronological order in which they were emitted. Percentages within parentheses are percentages minus baseline sessions.**

Table 11

Maintenance of Baseline and initial experimental session responses (Eric)

Response	Percentage	Response	Percentage
	Animals (34 sessions)		
Giraffe*	82.4	*Cow*	11.8(13.3)
*Dog**	41.2	Penguin	8.8(10.0)
Bear*	14.7	*Horse*	23.5(26.6)
Elephant*	70.6	Snake	5.9(6.7)
Walrus*	8.8	Zebra	14.7(16.7)
*Cat**	29.4	*Lion*	35.3(40.0)
Pig	17.6(20.0)		
	Shape (34 sessions)		
*Triangle**	94.1	Octagon	8.8(11.5)
*Circle**	100	*Rectangle*	32.4(42.3)
*Square**	79.4	Cross	2.9(3.8)
Crescent	23.5(30.8)	Oval	55.9(73.1)
	Food (33 session)		
Grapefruit*	3.03	Turkey	3.03(4.40)
Fish*	39.4	*Pizza*	30.3(43.5)
Chicken*	66.7	*Cheese*	27.3(39.1)
Chip*	33.3	*Burger*	33.3(47.8)
Popcorn*	9.1	*Sandwich*	9.1(13.0)
Rice*	51.5	*Hotdog*	27.1(43.5)
Fry*	69.7		

*** denotes responses emitted during baseline sessions. Italicized items were used in Stimuli present conditions. Responses are reported in the chronological order in which they were emitted. Percentages within parentheses are percentages minus baseline sessions.**

Table 12

Maintenance of Baseline and initial experimental session responses (Vincent)

Response	Percentage	Response	Percentage
	Food (28 sessions)		
Peaches*	3.6	Chip	3.6(4.5)
Noodle*	28.6	*Burger*	17.9(22.7)
Bean*	3.6	Cereal	7.1(9.1)
Rice*	3.6	Corndog	7.1(9.1)
*Cheese**	92.9	*Sandwich*	10.7(13.6)
Macaroni	78.6(100)	Rice & Gravy	21.4(27.3)
	Clothes (30 sessions)		
Shirt*	100	*Jacket*	6.7(9.1)
*Pants**	90.0	Costume	13.3(18.1)
Shoes*	46.7	Shorts	36.6(50.0)
	Animal (34_session)		
*Lion**	94.1	*Cow**	14.7
Tiger*	97.1	Giraffe*	50.0
Elephant*	20.6	Kangaroo*	2.9
Crocodile*	17.6	Bear	5.9(8.3)
Rabbit*	8.8	*Cat*	20.6(29.2)

*** denotes responses emitted during baseline sessions. Italicized items were used in Stimuli present conditions. Responses are reported in the chronological order in which they were emitted. Percentages within parentheses are percentages minus baseline sessions.**

For food, Ari continued to regularly emit only two of the ten responses (Cheese and Burger) that occurred during the first five experimental sessions. These two responses were the only responses of the ten that were physically present during Stimuli Present Conditions. In addition, other items that were used during Stimulus Present Conditions, while they were not emitted during baseline and the first five experimental sessions, were frequently emitted throughout the study. Specifically, Ari emitted the response Pizza during twenty-one sessions and Hotdog during nineteen sessions. Interestingly, Ari demonstrated the most cumulative growth for food indicating he emitted several responses that were not items used in Stimulus Present Conditions; however, for this academic skill response maintenance for responses occurring during the first five experimental sessions was greater for items used during Stimulus Present Conditions. This same effect was demonstrated by Eric for food. While Eric continued to emit five of seven baseline responses throughout the study, five of the six responses that occurred during the first five experimental sessions were all items used in Stimulus Present Conditions. Again, response maintenance was greater for items used during Stimulus Present Conditions for unique and appropriate responses that occurred following baseline sessions.

For the remaining academic skills, response maintenance was more variable for each participant. Ari emitted eleven unique and appropriate responses for features during the first five experimental sessions. These responses, and all remaining responses, pertained to physical characteristics of a dog. For animals, Eric emitted seven unique and appropriate responses during the first five experimental sessions. Eric demonstrated the greatest cumulative growth for animals, and Eric's response maintenance was less affected by items used in Stimulus Present Conditions as compared to food. For animals, Eric demonstrated a steady growth of unique and appropriate responses which integrated responses that occurred during baseline and the first five experimental sessions. Vincent showed a similar response maintenance pattern for food and animals. Vincent demonstrated a steady growth of cumulative unique and appropriate for food and animals which integrated baseline and first five experimental responses. Overall, Vincent's emitted fewer responses that were also items used in Stimulus Present Conditions as compared to Ari and Eric. Maintenance of responses for all participants will be addressed in more detail in the Discussion section.

Discussion

The purpose of this investigation was to expand an emerging literature base on the use of lag reinforcement schedules to increase variable behavior in humans. This investigation replicates previous research indicating that lag reinforcement schedules can be used to increase the variability of socially significant behaviors in applied settings (Cammilleri & Hanley 2005; Lee et al, 2002; & Lee & Sturmey 2006). This study extends previous research by utilizing a progressive lag reinforcement schedule and by targeting academic skills as the dependent variable. For all three participants, the introduction of a progressive lag schedule of reinforcement lead to an increase in the number of unique and appropriate verbal responses to at least two of the three targeted academic skills without the need for additional prompts or training. The presence of stimuli relevant to the target skill resulted in an increase in the number of unique and appropriate responses per session as compared to sessions without relevant stimuli that was equivocal at most. This study also replicates and extends the use of lag reinforcement schedules with regard to increasing the cumulative number of desired behaviors. Lee et al. (2002) demonstrated an increase one participant's varied and appropriate responses to the question "what do you like to do?" from one cumulative response during baseline sessions to nineteen cumulative responses following the introduction of a fixed lag 1 reinforcement schedule. Cumulative responses for the remaining two participants were minimal (less than five cumulative responses for both participants). The current investigation replicates Lee et al. (2002) by demonstrating that lag reinforcement schedules can produce significant increases in cumulative responses. The current investigation extends previous research by demonstrating, at least for these three individuals, that a progressive lag reinforcement schedule was a more effective and efficient method to increase cumulative responses.

Both Eric and Vincent showed only slight increases in one of their targeted academic skills (shapes and clothes respectively). This can be seen in both participants' Multiple Baseline and Cumulative graphs. One potential explanation for the minimal response in these academic skills as compared to other academic skills is the more limited response options that children would be familiar with. Shapes and clothing classes have a smaller range of commonly used potential responses as compared to animals and food. There were fewer options to choose from in the shapes and clothing classes than in the animals and food classes. To a degree, this effect was seen in previous studies that focused on increasing verbal responses to social questions (Lee, McComas, & Jawor, 2002; Lee & Sturmey, 2006). The combination of these finding suggests that the effectiveness of lag reinforcement schedules (both fixed and progressive) may be directly related to the number of behavioral choices available within an individual's repertoire. Interestingly, Ari and Vincent both had clothes as one of their target academic skills. While Ari demonstrated the least amount of cumulative growth for this skill, with respect to his other two target skills, he emitted seven more unique and appropriate responses than Vincent for the same skill.

In reversal experimental designs, the independent variable is systemically applied and removed based on changes in the trend, level or stability of the dependent variable. Experimental control is established when the application of the independent variable results in a predicted change in the trend, level, or stability of the dependent variable, and the subsequent removal of the independent variable results in the dependent variable returning to or trending towards levels obtained prior to the application of the independent variable (Cooper, Heron, & Heward, 2007 p 177). ABAB reversal designs further establishes experimental control by reapplying the independent variable following withdrawal. Experimental control is further validated if the change in the dependent variable returns to or trends towards levels obtained following the initial application of the independent variable. In this investigation, the removal of the progressive lag contingency resulted in a decrease in the number of unique and appropriate responses emitted per session for each participant and generally exhibited a negative trend; however, all participant's responding did not return baseline levels of responding. During a return to baseline for features, Ari's unique and appropriate responses decreased slightly, but did not trend towards or return to baseline levels of responding. This same pattern of responding can be seen in Eric's reversal sessions for animals. His unique and appropriate responses for this academic skill decreased, but did not reach initial baseline levels. This leaves the possibility that Ari's and Eric's initial increase in the number of unique and appropriate responses were in part a result of an extraneous variable and not the use of a progressive lag reinforcement schedule. However, Ari and Eric's unique and appropriate responses did trend toward baseline measures for the remaining academic skills. In addition, baseline response levels for each of Ari's and Eric's skills were low and stable, and subsequently increased following the application of the progressive lag reinforcement schedule. If an extraneous variable was responsible for the change in unique and appropriate responses, the extraneous variable impacted only one targeted skill for each participant. Alternatively, the fact that Ari's and Eric's unique and appropriate responses did not return to baseline levels, following the removal of the progressive lag reinforcement schedule, may indicate that the effects of the independent variable maintained for some time despite no longer being applied.

Examining response maintenance for each participant's baseline and first five experimental responses lead to interesting findings. Overall, responses that occurred during baseline sessions tended to maintain more than those responses that occurred during the first five experimental sessions. This effect held true even when percentages for first five experimental session response were adjusted for by total number of sessions. One possibility for this occurrence is the rich schedule of reinforcement used in baseline sessions. During these sessions, every appropriate response was reinforced regardless of how many times it was previously emitted. Therefore baseline responses had a longer history of reinforcement as compared to responses occurring during the first five experimental sessions. In addition, a progressive lag reinforcement schedule was in place during experimental sessions in which maximum reinforcement opportunities were contingent upon varying responses. In other words, repeating a response during baseline sessions resulted in continuous reinforcement; however, during PLP sessions repeating responses lead to a significant decrease in participant reinforcement. These findings are somewhat similar to those reported by Cammilleri and Hanley (2005). In their investigation, the authors utilized a differential lag reinforcement schedule to increase selection of available classroom activities and the time engaged in those activities for two typically developing children. For all phases, sessions consisted of 60 minute observation periods in which an audible stimulus (i.e. timer) signaled the availability to change activities; however, the participants were free to change activities at any time. Unlike the current investigation, there were no programmed consequences during baseline sessions for activity selection (i.e. participants were free to engage in any of the 12 available activities for any desired duration). During lag phases the participant was provided a token redeemable for two minutes of teacher attention following engagement in a novel activity. The inclusion of the differential lag contingency resulted increased activity selection as well as an increase in the time engaged in those activities. A close inspection of time engaged data showed that while both participants increased activity selection and time engaged in those activities, both participants continued to allocate more overall time to activities that occurred during baseline sessions than those that occurred following lag phases. For the Cammilleri and Hanley (2005) study, limited response allocation during baseline sessions was likely due to preferences for the individual activities (i.e. these activities possessed a higher quality of reinforcement). In the current study, baseline responses had a longer and denser history of reinforcement as compared to initial experimental sessions. A comparison can between the two studies in terms of response maintenance in that the responses with the more favorable reinforcement history occurred more frequently during experimental sessions despite reinforcement contingencies that supported variable responding.

Response maintenance may also be at least partially related to the presence of relevant stimuli. For example, both Ari and Eric had one academic skill in which the unique and appropriate responses that occurred during the first five experimental sessions were predominately items used in Stimuli Present Conditions. Both participants continued to emit these responses throughout the study independent of the stimulus condition. Meaning that both Ari and Eric emitted responses that were items used in Stimuli Present Conditions during both Stimulus Present Conditions and Stimulus Absent

Conditions. The maintenance of these responses may have been affected if the items used in Stimuli Present Conditions were alternated. Similar results were demonstrated in Lee et al, (2006). In this investigation, the authors examined the use of a fixed lag 1 reinforcement schedule and environmental cues to increase varied responding to the prompt “tell me something you like to do” for three individuals with autism. Environmental cues consisted of ten items identified as preferred items through a MSWO preference assessment conducted with each participant. The effect of environmental cues on responding to the target prompt was tested across three conditions in a multielement design: 0% condition in which no preferred items were present, a 50% condition in which five preferred items were present, and a 100% condition in which all preferred items were present. Overall, the results indicated there was no effect for environmental cues on varied responding to the target prompt. Specifically, there was an increase in varied responding following the implementation of the lag 1 reinforcement schedule; however, there was no differentiation between environmental cue conditions. However, the authors noted that when individual participant responses were analyzed, they found that for two of the participants their responses consistently included the preferred items regardless of the environmental cue condition (i.e. participant responses included preferred items during 0% conditions). These results are similar to Ari and Eric’s in that responses emitted during Stimuli Absent Conditions included items used during Stimuli Present Conditions. Taken together, these results indicate that the presence of relevant stimuli may impact the degree to which verbal responses maintain over time.

It is also possible that the presence of relevant stimuli may have hindered overall cumulative growth. During the study, all three participants became aware that the presence of the items changed (sometimes pictures and toys were present, some times they were not), which may have had a negative influence on unique and appropriate responses. For example, Ari and Eric emitted more novel responses during Stimuli Absent Conditions for food and animals respectively. These are also the two academic skills in which Ari and Eric demonstrated the most cumulative growth. It is possible that the presence of relevant stimuli for these particular academic skills decreased overall cumulative potential.

Overall this investigation preliminarily indicates that progressive lag reinforcement schedules are an efficient and effective method to increase variable behavior in humans. In addition, progressive lag reinforcement schedules may be a superior alternative means of increasing variable behavior than more traditional methods. As previously discussed, behavioral variability can be positively influenced or increased by extinction (Carr & Kologinsky, 1983; Durker & Van Lent, 1991; Lalli, Zanolli, & Whon, 1994) and reinforcement (Goetz & Baer, 1973; Morgan & Lee, 1996; Neuringer, 1992; Page & Neuringer, 1985). Progressive lag reinforcement schedules promote behavioral variability without the need to extinguish previously established responses. This is especially important for verbal, social, and adaptive behaviors where extinguishing established behaviors may not be desirable. Also, the effectiveness reinforcement methods can be dependent on baseline levels or probability of behavioral variability (Goetz & Baer, 1973) and repetitive/stereotyped responding can occur even when variable behavior is directly reinforced (Cherot, James, & Neuringer, 1996). Lee, Sturmey, and Fields (2007) discuss this as higher-order stereotypy which occurs with fixed lag reinforcement schedules. For example, an individual exposed to a fixed lag 1 reinforcement contingency (the current response has to vary from the previous response) could maximize reinforcement by alternating between two responses. Ultimately for any lag X schedule of reinforcement, there is the potential for a lag X+1 pattern of responding to emerge where an individual learns to vary the current response by a predetermined number of previous responses. Progressive lag reinforcement schedules guard against higher-order stereotypy by continuously increasing variability requirement in order to meet the reinforcer contingency.

The differential lag contingency utilized by Cammilleri and Hanley (2005), while not explicitly referred to as a progressive lag reinforcement schedule, can be conceptualized as such. In their investigation, novel classroom activity selection was reinforced with teacher attention. Once an activity was selected, engagement in that activity was not reinforced until all remaining unselected activities were selected. In other words, the participants had to continuously engage in novel activities in order to earn teacher attention. The lag contingency reset following engagement in all twelve activities. This procedure differs from the current investigation in that there were a set number of possible responses available and the contingency for variable behavior was more stringent. For example, the first activity selected by the participants had to be followed by eleven novel activity selections prior to again being a reinforceable response. In this investigation, it was theoretically possible for the one response to be reinforced three times within a session. The procedure used by Cammilleri and Hanley also has the potential to guard against higher-order stereotypy in that a predetermined number of novel responses must occur before a previously emitted response could result in reinforcement. However, this procedure may only be useful for behaviors that have a limited number of response options. For example, their procedure included twelve possible activities representative of a typical classroom environment as response options. This same procedure many not be appropriate for verbal behaviors that frequently have many more appropriate response options. Specifically, a high differential lag contingency may inadvertently extinguish some responses, or even overall responding, due to minimal opportunities for responses to be paired with a reinforcer delivery. Conversely, a low differential lag contingency has the potential to result in the previously discussed higher-order stereotypy, in which an individual learns to vary among small subset of potential responses as opposed to varying their current response by a predetermined number of responses.

The results of this investigation also have implications for treatments for individuals with Autism Spectrum Disorders. ASD is partially defined by repetitive behaviors and restricted interests and these areas are often area targeted for treatment/intervention. Two of the participants in this study were diagnosed with Autism and in need of varied or novel responding to academic skills. The use of the progressive lag reinforcement schedule increased the cumulative number of responses for both participants as well as increased the number of unique responses emitted within each session. Thus progressive lag reinforcement schedules may be useful in increasing behavioral variability in a variety of behaviors for individuals with Autism. In addition, many interventions that are frequently used in autism treatment utilize a rich schedule of reinforcement during acquisition/training phases. For example, Discrete Trial Training (DTT) is an instructional method frequently used with individuals with Autism to teach a variety of behaviors. In DTT when a new behavior is taught, an individual may receive a reinforcer (i.e. candy, toy, praise) every time they demonstrate that new behavior. Gradually, as the new behavior is learned and mastered, the frequency of reinforcement is faded (decreased). Progressive lag reinforcement schedules may be useful as a systematic method to fade reinforcement frequency while promoting new behaviors. For example, when teaching class membership, every response provided that is a correct member of the class may be positively reinforced. As previously discussed, this rich schedule of positive reinforcement may lead to the unwanted side effect of repetitive or restricted behaviors. Utilizing a progressive lag reinforcement schedule may be an efficient procedure to maintain the established responses while promoting new responses.

Limitations and Directions for Future Research

The method in which generalization effects were analyzed can be improved upon in future studies. While each participant did show a transfer of skills for all three generalization conditions, this investigation did not examine whether skills generalized to more naturalistic environments. Each participant's teacher referred them for participation in this study based on their behavior in the primary educational environment. While this study examined generalization effects across setting and persons, it did not examine whether or not these skills transferred to instructional situations more representative of the primary instructional environment.

Both Ari and Eric did not demonstrate a reversal to baseline levels for one academic skill during a withdrawal phase (animals and features respectively). While more investigations on progressive lag schedules and variable behavior are certainly needed, this preliminary finding suggests that the effects of progressive lag schedules may persist for some time after being terminated. Future studies should conduct long term follow-ups to determine if the desired effects of progressive lag reinforcement schedules remain following an extended withdrawal period. In addition, both Ari and Eric showed substantial cumulative growth for each skill that did not return baseline levels. Future studies should also examine whether long term maintenance effects are related to the number of choices available within the response repertoire.

This investigation also has preliminary implications for teaching verbal behavior, specifically intraverbals. Skinner (1957) proposed that all verbal behaviors are functionally independent. Meaning antecedent stimuli that evoke a verbal behavior and the consequences that maintain that behavior all serve different functions. For example, a child may be able to say the word “mama” when he wants to be held by his mother (i.e. a mand) but may not emit the same response when shown a picture of his mother (i.e. a tact). The failure to generalize a verbal response across multiple verbal behaviors is frequently seen with individuals with language delays, Autism Spectrum Disorders, and developmental disabilities (Sundburg & Partington, 1998). As previously discussed, Luciano (1986) examined generalization of known tacts (labels) to intraverbals (class membership) for three individuals with intellectual disabilities. The results showed that all three individuals required extensive training in order to generalize known tacts to intraverbals. For example, each participant could identify many food items when provided a physical example of that item (tact); however, none of the participants could provide a correct verbal response when asked to name food items without a physical example (intraverbal). It was only after training that the individuals were able to generalize known tacts to intraverbals. The verbal responses provided by the participants in this investigation all fall under the verbal behavior category of intraverbal. As a part of the interview and screening process, parents and teachers were asked to generate at least five academic areas/questions in need of novel or varied responding. For each academic area, parents and teacher were asked if the participant could name multiple items in each area when provided a physical example. This was to help insure that the lack of varied or novel responding to the referred questions was not due to a limited response repertoire. For example, Eric could name many different shapes when shown a picture (tact) but would frequently reply with triangle when asked to name a shape in the absence of a visual stimulus (intraverbal). While a formal assessment of tacts and intraverbals was not conducted in this investigation, it is possible that each participant generalized verbal behaviors previously acquired as tacts to intraverbals. Future studies should examine the effects of progressive lag reinforcement schedules to promote generalization of established verbal behaviors to untrained verbal behaviors.

Finally, while this investigation focused on increasing socially significant variable behavior in applied studies, the experimental procedures used to examine the effects of progressive lag reinforcement schedules were not representative of a natural environment. For example, it is unlikely that a teacher/therapist would ask an individual the same question repeatedly in an effort to elicit multiple responses to that question without the use of feedback and/or prompts. Future studies should examine the effectiveness of progressive lag reinforcement schedules in more naturalistic environments. Cammilleri and Hanley (2005) demonstrated that a differential lag contingency increased the number of activities selected and time engaged in those activities for two typically developing children in a typical classroom setting. Future studies should examine progressive lag reinforcement in similar environments, and with non-typically developing individuals.

Overall this investigation supports previous research on lag reinforcement schedules as an effective method to increase variable or novel behavior. This investigation extends previous by utilizing a progressive lag reinforcement schedule to increase variable behavior and by selecting academic skills as the targeted behavior. In addition, there are preliminary implications for use of progressive lag reinforcement contingencies to increase the efficacy of established behavior analytic treatments/interventions and to promote the generalization of established behaviors. The effect of relevant environmental stimuli was less clear and warrants further investigation. Based on the current results, it appears the effect of relevant environmental stimuli may be influenced by idiosyncratic variables.

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Vita

Brian Esteve is currently a graduate student in the school psychology program in the Department of Psychology at Louisiana State University. Brian works under the direction and mentorship of Dr. George H. Noell. Brian received both his Bachelor of Science degree (2001) and Master of Arts degree (2005) from Louisiana State University in the area of psychology. Brian is a candidate for the Doctor of Philosophy degree to be awarded in May of 2009. Upon graduating Brian intends to remain in Louisiana to serve children and families in the state.