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Using a Lag Reinforcement Schedule to Increase Response Variability in Children with Autism Spectrum Disorders

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Abstract

Deficits in generating varied responding across repertoires is often observed in individuals with Autism Spectrum Disorders (ASD). Existing research explored the use of lag reinforcement schedule in promoting both verbal and non-verbal response variability in individuals with developmental disabilities. However, current research in this area is deemed minimal and with limitations. In this study, the effectiveness of an alternative lag reinforcement schedule, which incorporates both within response and between response lag criteria in promoting response variability was investigated with 5 participants in ASD using a block-building activity. The study also extended the investigation to a social game, I Spy game. Results of the study showed that the proposed lag reinforcement schedule was effective in promoting response variability in 2 participants in the block-building task. Furthermore, possible generalization effect of the intervention to promote varied responding in I Spy game was found in 1 of the participants. The study demonstrated that the proposed lag reinforcement schedule is feasible in promoting response variability in individuals with ASD, which hopefully can support future research in exploring possibilities to alleviate the problem of stereotyped responding.

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CHAPTER I: INTRODUCTION AND LITERATURE REVIEW

In our day-to-day lives, behavioral variability is deemed essential for effective social integration. Undeniably, the display of rote and invariant responses may affect one's quality of life and social interaction to a certain extent in a number of aspects. For instance, opportunities to converse with others may be greatly reduced if one often uses repetitive language with little or no variation. Likewise, a peer may not be interested to make friends or being close with one whose play is restricted and repetitive.

Impairments in language acquisition and deficits in social and communicative skills are apparent symptoms of individuals who are diagnosed with Autism Spectrum Disorders (ASD; American Psychiatric Association, 2013). Because of such challenges in language, acquisition of varied responses in individuals with ASD may require teaching with more specific techniques such as discrete-trial training and motivational techniques such as the use of reinforcement and stimulus control (Goldstein, 2002; Koegel, Koegel, & Surratt, 1992). Without systematic training, individuals with ASD may possess repetitive verbal repertoires and this may interfere with one's quality of life. For instance, Jones (1990) suggested that unvaried responding to social questions might not only reduce opportunities of social interactions but also stigmatize the individual in the social community. Further, the absence of varied responding may interfere with acquisition of novel responses (Jones, 1990) and influence problem-solving and creativity (Neuringer, 2004).

Targeting response variability enhancement, behavioral interventions such as differential reinforcement, extinction, and lag schedules have been developed and investigated. For example, in Lalli, Zanolli, and Wohn (1994), previously acquired toy play responses were put on extinction while reinforcement was delivered for production of novel toy play responses. Results of the study found that novel and varied toy play responses were successfully induced with extinction. In another study, reinforcement was differentially

provided contingent on generation of varied sequences of responses in a computer game (Miller and Neuringer, 2000). Results of the study revealed that levels of variability were increased during implementation of differential reinforcement compared to baseline when reinforcement was delivered independent of variability. In addition, lag schedules of reinforcement have been examined. Under lag schedules of reinforcement, a response is reinforced if it differs from a specific number of preceding responses. In Napolitano, Smith, Zarcone, Goodkin, and McAdam (2010) for instance, variability in toy play responses was effectively promoted with the intervention of lag schedules of reinforcement.

In recent decades, more concerted effort has been made in applied behavioral analysis research to enhance language acquisition of individuals with developmental disabilities (Landa, 2007). Although training language skills with the technique of discrete trial training has been criticized for promoting robotic learning and exhibition of rote responses in individuals (Tarbox & Najdowski, 2008), a review of previous studies revealed that language acquisition and verbal response variability could in fact be effectively promoted using discrete trial teaching. Focusing on enhancing verbal response variability, existing research was observed to focus largely on the use of lag schedules.

Page and Neuringer (1985) were the first to use lag schedules of reinforcement to increase response variability in animal subjects. In a Lag N schedule, reinforcement is provided when the response is different from N previous responses. For instance, in a Lag 1 schedule, reinforcement is delivered contingent on a response produced that is varied from one preceding response. Similarly in a Lag 3 schedule, the response is reinforced if it differs from three previous responses. While past research recruited animals as subjects, researchers have recently extended the use of lag schedules to human subjects.

In this literature review, eleven studies which employed lag schedules of reinforcement to increase response variability will be presented. A study involving animal

subjects will first be mentioned briefly. Afterwards, ten applied researches with human subjects will be reviewed. Among these, six of the studies focused on promoting verbal response variability while the others targeted nonverbal response variability such as toy play and selections of classroom activities. After presenting a review of existing studies, the paper will discuss several common limitations and potential modifications to be made in the current studies.

The Use of Lag Schedules in an Animal Research

Lag schedules were commonly used to promote response variability in animal research since their first use by Page and Neuringer (1985). The study by Neuringer (1993) explored the functional control of target response difficulty in relation to the efficacy of lag schedules in promoting variability and the effect of reinforcement fading.

In baseline, Lag 3 or Lag 5 schedules of reinforcement were in effect (Neuringer, 1993). Behavioral variability was measured by four-press sequences generated on the left (L) or right (R) lever in the experimental apparatus. Food pellets were delivered to the animals contingent on generating a number of varied sequences from three or five preceding responses depending on the lag criterion in place. Conversely, a time-out period would be delivered contingent on absence of varied sequences.

An ‘always-reinforced’ contingency, which referred to the concurrent delivery of reinforcement contingent on the occurrence of the selected response, was superimposed on lag schedules of reinforcement to evaluate its effect on the selected sequence (Neuringer, 1993). For instance, if a Lag 3 schedule was in effect and the ‘always-reinforced’ sequence of lever pressing selected is LLLR, reinforcement was delivered when a response that differed from three previous responses was produced and whenever the selected sequence, LLLR, was produced. In one of the experiments, Neuringer (1993) explored if variations in difficulties of the selected response would influence the effect of the ‘always-reinforced’

contingency superimposed. Further, another experiment examined the possibility of strengthening a difficult response with fading of reinforcement. Specifically, this involved the use of a variable-interval (VI) schedule instead of a fixed-interval schedule of reinforcement.

Results found that the superimposition of 'always-reinforced' contingency for a selected response increased the occurrence of that response (Neuringer, 1993). It was also revealed that the difficulty of the selected response influenced its frequency of occurrence such that an easy response was produced in higher frequency than a difficult response with the same contingency in effect. In addition, the study found that a difficult response could be effectively strengthened even when reinforcement was faded. Across the five experiments conducted, lag schedules of reinforcement were found to be effective in promoting and maintaining behavioral variability (Neuringer, 1993). The demonstration of the effective use of a superimposed 'always-reinforced' contingency and fading procedure yielded insights for applied research in teaching difficult selected responses and skills to individuals with behavioral challenges or developmental disabilities.

The Use of Lag Schedules in Human Research

It was not until recent decades that experimenters started to examine the use of lag schedules in increasing response variability in human subjects. In order to ensure meaningful social integration and adaptation of individuals with developmental disabilities, variability across a variety of skills is essential. The studies reviewed below explored the use of lag schedules in promoting response variability for both verbal and nonverbal responses. A summary of the literature review on applied research is shown in Table 1.

Studies on nonverbal response variability. The use of lag schedules in increasing variability in selecting activities in typical classrooms was evaluated by Cammilleri and Hanley (2005). Two typically-developing individuals participated and were selected because

both were reported to often repeatedly select the same activities in the classroom. Three dependent variables, activity selection, activity engagement, and the number of academic units completed were measured using a reversal design. The activities presented were either academic-related with specific target skills or non-academically-related such as play activities. During baseline condition, no consequences were provided on activity selections. When a lag schedule of reinforcement was in place, provision of teacher attention was delivered contingent on selection of novel activities.

Cammilleri and Hanley (2005) found that variability in activity selection increased during intervention when compared to baseline and reversal to baseline conditions. The authors suggested that the use of lag schedules was significant to the participants because varied responding led to more varied selection of academic-related activities, which resulted in increased units of academic activities completed.

In another study, Napolitano et al. (2010) extended and modified a previous study by Goetz and Baer (1973) to investigate the use of lag schedules in enhancing varied responding in block building in six children with ASD. Block building responses generated were scored for variations in terms of colors or forms and the percentages of varied responses produced were calculated. The experimenters employed an ABAB design and p6 assessments were conducted prior to intervention to identify preferred tangibles or edibles. The experimenter initiated the trial by presenting the participant with blocks and instructed the child to start building. During baseline, social praise was delivered on an intermittent schedule. During the Lag 1 schedule condition, social praise together with the selected reinforcer was delivered contingent on generating a block-building response that differed from a previous response. Teaching was involved during the intervention for four subjects because the use of Lag 1 schedule alone failed to enhance variability in responding. Specifically, modeling prompts were provided and the child was instructed to imitate the experimenter in building a different

model. Additionally, follow-up probes were conducted two to three months after termination of intervention to assess maintenance.

Napolitano et al. (2010) found that variability in responding increased for all subjects. The study was noteworthy in expanding research regarding lag schedules in combination with teaching to enhance varied responding in play skills for children with developmental disabilities. Further, results from follow-up probes demonstrated maintenance in most of the subjects.

Recently, Murray and Healy (2013) compared the effect of using lag schedules of reinforcement on promoting response variability in children with ASD with that in typical children using a specially designed computer program. Two groups of ten children participated, half of whom were children with ASD. A computer program simulating an interactive game was designed and *U*-values, which indicate the probabilities of response distribution, were calculated using a formula by a computer program. The *U*-value served as an indicator of response variability. Higher *U*-values referred to higher variability and lower *U*-values referred to lower variability. The participants were required to complete a certain number of levels in the interactive game by moving the character on screen forward, which could be achieved by making varying sequences of three presses using four keys on the computer. Training sessions were provided to the participants prior to the implementation of lag criteria to build interest and teach the participants how to play the game. The control setting was used as the baseline condition. During intervention, one of the four preset program settings with specific orders of five lag schedules of reinforcement and a control condition was assigned to each participant randomly. The five lag schedules of reinforcement incorporated were Lag 1, Lag 2, Lag 4, Lag 6, and Lag 8. In the control condition, reinforcement was provided independent of response variability.

Murray and Healy (2013) found that higher levels of response variability were associated with greater lag values for both groups of participants and the greatest response variability was achieved when a Lag 6 schedule of reinforcement was in effect. The trends of levels of response variability across program settings were similar in the two groups. Further, a significant between-group effect was observed when comparing the two groups of children. Compared to the group of typical children, the group of ASD children revealed lower levels of response variability. The authors further suggested the possibility of ceiling effect when lag criterion was increased to Lag 8 as response variability was found to be lower than when Lag 6 schedule was used. The study was substantial in being the first study that compared the use of lag schedules in children with developmental disabilities with that in typical children.

Baruni, Rapp, Lipe, and Novotny (2014) studied the use of lag schedules in promoting variability of toy play with three participants with intellectual disabilities. A unique and age appropriate toy was selected for each participant and a multiple-stimulus presentation preference assessments without replacement (MSWO) of edibles was conducted prior to each session. The cumulative numbers of novel toy play responses as well as toy engagement were recorded across sessions using a nonconcurrent multiple baseline across participants design (Baruni et al., 2014). The use of a Lag 1 schedule was evaluated in all participants while Lag 2 schedule was only implemented for two of the participants. The experimenters first presented the selected toy to the subject and instructed the child to start playing. During baseline condition, no reinforcement contingencies were in place for any toy play responses. During the Lag 1 schedule phase, a preferred edible selected in the MSWO preference assessment was delivered contingent on a toy play response that differed from the previous response. Similarly during the Lag 2 schedule phase, reinforcement was delivered contingent on emission of two varied toy play responses from the initial response. The

intervention was terminated upon the absence of novel toy play responses for seven consecutive sessions. In addition, social validity was evaluated using questionnaires with three classroom paraprofessionals.

Baruni et al. (2014) found that a Lag 1 schedule was more effective in increasing the production of novel toy play responses than a Lag 2 schedule. However, levels of toy engagement were found to decrease with the use of lag schedules (Baruni et al., 2014). Baruni et al. suggested the possibility of a ceiling effect due to the absence of prompting or teaching based on the results of the Lag 2 schedule phase, meaning that the insignificant increase in novel toy play responses in this phase might be due to the participants' lack of ability in generating novel responses without additional teaching. Further, social validity measures revealed that paraprofessionals rated subjects' toy play responses as age appropriate and were on the whole satisfied with the intervention results (Baruni et al., 2014).

Studies on verbal response variability. Enhancing vocal variability with the use of lag schedules of reinforcement was examined in two studies with nonverbal individuals. Esch, Esch, and Love (2009) were the first to extend the use of lag schedules to promote vocal variability to the nonverbal population. Two children with ASD who failed to produce echoics or recognizable words participated. The experimenters used a nonconcurrent multiple baseline design across participants combined with reversal to evaluate the effectiveness of lag schedules in promoting phonemic variability. Each experimental session consisted of presenting five vocal models in block trials and a specific sequence of vocal models was created for each participant.

During baseline, producing vocal responses was reinforced with praise and a motor task was presented as an intertrial interval (Esch et al., 2009). The trial was represented if the participant did not respond. A response during the represented trial after absence of response would serve as a base response, against which the vocal response in the subsequent trial was

compared. During Lag 1 schedule, reinforcement was delivered contingent on vocal responding that differed in any way from the vocal model presented. Praise was also delivered for producing novel base responses. Esch et al. (2009) found that vocal variability was increased with the use of Lag 1 schedule for both participants and functional control of the intervention was demonstrated during a reversal to baseline condition.

To further evaluate the whether the use of lag schedules can effectively generate novel vocal responses, Koehler-Platten, Grow, Schulze, and Bartone (2013) extended Esch et al. (2009) partially. Three children with ASD who were assessed to have limited vocal behaviors participated. The experimenters employed a nonconcurrent multiple-baseline design across participants and measured both the vocal variability and cumulative number of novel vocal responses. Experimenters conducted a naturalistic observation session for each participant prior to the start of the study to record baseline frequency and phonemes production during play in a natural setting. Verbal Behavior Milestones Assessments and Placement Program (VB-MAPP), Early Echoic Skills Assessment (EESA), and echoic assessments were also conducted for comparisons of results after intervention. Three vocal models were identified for each participant and presented in specific sequence using block trials.

A continuous reinforcement schedule was used in baseline conditions (Koehler-Platten et al., 2013). During the Lag-1 Schedule, reinforcement was delivered contingent on production of a different phoneme compared to the first phoneme produced. The vocal model would be represented if the participant did not respond vocally within a specified period. Experimental procedures were adjusted for one participant due to high levels of verbal stimulatory behaviors displayed, which included the use of an attending prompt and two mastered gross motor imitation tasks. The vocal model would be issued immediately upon completion of the two tasks correctly without vocal stereotypy. Otherwise, the

attending prompt and the gross motor imitation tasks would be repeated until the participant demonstrated readiness.

Following intervention, EESA scores increased for all three participants while VB-MAPP scores improved in two of the three participants (Koehler-Platten et al., 2013). Further, Koehler-Platten et al. (2013) found that the cumulative numbers of novel phonemes produced increased after intervention when compared to baseline levels for all participants, suggesting that the use of lag schedules played a role in generating novel phonemes despite increasing vocal variability. The study was significant in expanding previous research on lag schedules, which did not place much focus on the use of lag schedules in promoting acquisition of novel verbal behaviors.

In studies that recruited subjects with higher language ability and functioning level, response variability in answering social questions or engaging in a short conversation was examined. Lee, McComas, and Jawor (2002) explored the use of lag schedules in promoting verbal response variability to social questions using a multiple baseline reversal design. Three individuals with autism participated. The social question 'What do you like to do?' was targeted for two of the participants and an alternative question 'How are you?' was identified for the remaining participant. The percentage of varied and appropriate responses to the target social question was measured as the dependent variable. A varied and appropriate response was defined as any answers that are applicable to the social question but different from the previous response given when the same question was presented (Lee et al., 2002). Differential reinforcement of alternative responses (DRA) was used in baseline condition, in which appropriate responses were reinforced while inappropriate responses were ignored after the delivery of brief negative feedback. During intervention, a Lag 1/DRA schedule was used with procedures identical to baseline condition except that reinforcement was delivered only when a varied and appropriate response to a social question

was emitted. Further, generalization probes across settings and across people were conducted throughout the experimental conditions for two participants.

Two of the three participants demonstrated increased variability of appropriate verbal responding to their respective target questions during intervention when compared to baseline condition (Lee et al., 2002). The percentage of varied responses were decreased during a reversal to baseline and increased again when Lag 1/DRA schedule was reintroduced. Similar results were observed from the generalization probes conducted, with increased variability during intervention and a decrease upon reversal to baseline. Specifically, Lee et al. (2002) found increased response variability and increased cumulative number of novel verbal responses in the two participants whose target social question was 'What do you like to do?' These results were not applicable to the participant whose target social question was 'How are you?' Lee et al. (2002) further suggested the presence of surrounding stimuli might have led to the difference in results among the participants.

To explore the influence of surrounding stimuli in promoting response variability, Lee and Sturmey (2006) extended Lee et al. (2002) and examined the use of lag schedules and the effect of varying the proportion of preferred stimuli present on response variability. Three teenage males with ASD participated and MSWO assessments were used to identify highly preferred tangibles for each of the participants prior to intervention. Response variability to a single social question 'What do you like to do?' was measured and an ABAB multielement reversal design was used. In baseline condition, appropriate responding was reinforced and inappropriate responding was ignored. In Lag 1 schedule condition, appropriate and varied responding that differed from that of the former trial was reinforced and non-varied responding was ignored. To examine the effect of presence of varied proportions of surrounding stimuli on response variability, conditions of 0%, 50% and 100% of stimuli present were randomly presented in the sessions.

The study showed that the use of lag schedules was effective in promoting response variability in two of the three subjects (Lee & Sturmey, 2006). The results revealed a decrease in response variability upon reversal to baseline and an increase upon reintroduction of lag schedules of reinforcement. Regarding the potential influence of varied proportions of preferred stimuli present in the environment, the results confirmed that this did not affect emissions of varied responses.

Susa and Schlinger (2012) further extended the study by Lee et al. (2002). The use of increasing lag criteria in promoting response variability to social questions was examined with a single subject. The target social question identified was 'How are you?' Response variability was measured and evaluated with progressing lag criteria using a changing criterion design. During baseline, no consequences were delivered upon emissions of either appropriate or incorrect responses. Echoic prompts were used in the beginning session of each lag phase to teach the subjects appropriate novel responses to the target social question. After the prompting session, production of varied responses was met with reinforcement whereas inappropriate responses were put on extinction. A particular lag phase was considered mastered when the subject could produce the respective number of varied responses to the social question according to the lag criteria in place. Susa and Schlinger increased the lag criteria up to a Lag 3 schedule.

Susa and Schlinger (2012) found that lag schedules were effective in increasing response variability, which was in line with findings from previous studies. Further, the study was significant in revealing that the number of varied responses produced can be effectively increased with progressing lag criteria and acquisition of novel responses can be promoted with echoics.

Rather than studying variability of responding to a single social question, Lee and Sturmey (2014) extended previous studies and evaluated the effectiveness of using lag

schedules and a script-fading procedure on varied responding in a three-part conversation, which consisted of 1) a greeting, 2) a question about the participant's day, and 3) a comment on the experimenter's day. Three subjects with ASD participated. An ABA design was used to evaluate the use of a script-fading procedure while a multiple-baseline-design-across-participants was used to examine the use of a Lag 1 schedule of reinforcement. A response of a particular turn during a three-part conversation was compared with the response of the same turn in the previous conversation to evaluate variability. During baseline, appropriate responses were reinforced and inappropriate responses were met with a negative feedback. When the scripting procedure was in place, the experimenter initiated the conversation and an audio device was used to act as a model for the participant to imitate the model scripts. The scripting procedure was systematically faded subsequently. During Lag 1 schedule with repeated trials condition, reinforcement was delivered contingent on varied responses in any turn of the three-part conversation and inappropriate or unvaried responses were ignored and the trial was repeated after 5 seconds. Generalization probes were taken across both instructors and settings. Further, the experimenters evaluated the social validity of the study in which the participants' language skills, social skills, and language variability were rated based on transcripts of randomly selected conversations from the study (Lee & Sturmey, 2014).

Lee and Sturmey (2014) found that variability in responding was higher during the scripting condition and the Lag 1 schedule with repeated trials condition when compared with that of the baseline condition and reversal to baseline condition. However, results from generalization probes revealed that the participants did not generalize varied responding in conversation across persons and settings, suggesting possible control by environmental variables (Lee & Sturmey, 2014). Results of social validity ratings showed that higher

ratings were associated with the use of a Lag 1 schedule with repeated trials (Lee & Sturmey, 2014).

Table 1

Summary of the literature review on applied studies

Study	**Sample size**	**Topography of response variability studied**	**Lag criterion/ criteria employed**	**Findings on the relationship between lag schedules and response variability**
Cammilleri & Hanley (2005)	2	Selection of classroom activities	Lag 1	Positive in both subjects
Napolitano, Smith, Zarcone, Goodkin, & McAdam (2010)	6	Block building	Lag 1	Positive in all subjects
Murray & Healy (2013)	20	Response in a computer game	Lag 1, Lag 2, Lag 4, Lag 6, and Lag 8	Positive for both group of children with ASD and group of typical children
Baruni, Rapp, Lipe, & Novotny (2014)	3	Toy play	Lag 1(for all participants), Lag 2 (for two participants)	Positive for Lag 1 schedule but less effective when Lag 2 schedule was in effect
Lee, McComas, & Jawor (2002)	3	Response to social questions	Lag 1	Positive in two of the three participants
Lee & Sturmey (2006)	3	Response to social questions	Lag 1	Positive in two of the three participants
Esch, Esch, & Love (2009)	2	Vocal response	Lag 1	Positive in both subjects
Susa & Schlinger (2012)	1	Response to social question	Lag 1, Lag 2, and Lag 3	Positive
Koehler-Platten, Grow, Schulze, & Bertone (2013)	3	Phoneme production	Lag 1	Positive in all subjects
Lee & Sturmey (2014)	3	Responses in a three-part conversation	Lag 1	Positive in all subjects

Discussion on Limitations and Future Directions

The effectiveness of lag schedules of reinforcement in increasing response variability was positive across most of the studies reviewed. Yet, there exist common limitations across the studies.

First, Lag 1 schedule was the most explored lag criterion in past studies. A fixed Lag 1 schedule may lead to the emergence of higher-order stereotypies. Schwartz (1982) first suggested the possibility of emergence of higher-order stereotypy with the use of Lag 1 schedule, meaning that the participant can produce a single fixed pattern of varying two responses to obtain reinforcement. Repeating two responses under Lag 1 conditions produces the false impression that responses were "variable." In future studies, it is suggested that experimenters would collect additional data on the topography of responses produced if a Lag 1 schedule is used. Alternatively, a variable lag schedule can be used instead to avoid shaping of higher-order stereotyped behaviors by continuously changing the variability requirement.

Second, while most existing studies focused on the use of Lag 1 schedules, the use of higher lag criteria such as Lag 2 or Lag 3 schedule was not sufficiently examined. In real life situations, the acquisition of a more varied response repertoire would ensure better social integration and the production of more varied responses beyond a Lag 3 criterion may be necessary in certain situations. For instance, in making a conversation with another, having a repertoire of just four different verbal responses would be insufficient. It is thus suggested that future researches can replicate the existing studies which used Lag 1 schedule using higher lag criteria in order to generate more convincing conclusions regarding the efficacy of lag schedules in promoting response variability.

Third, despite effectiveness demonstrated with the use of a single lag schedule, it is possible that increasing the lag criteria within an intervention would reveal a ceiling effect. In

this case, a maximum limit on response variable might be met if efforts are not taken to train response variability (Murray & Healy, 2013). In fact, Murray and Healy (2013) and Baruni et al. (2014) also mentioned about the possibilities of ceiling effect in explaining their study results. The possibility of a ceiling effect suggested that the optimal lag criterion for promoting variability for a particular kind of skill may be unique. Hence, it may be necessary to identify the optimal lag criterion for promoting variability of a particular kind of skill to ensure effectiveness of the intervention. Of the literature reviewed, only one of them used a changing criterion design to explore progressing lag criteria. In the future, a changing lag criterion can be implemented into the design so that exploration of the effect of increasing lag criteria can be more thorough. Such modification can also contribute to the identification of an optimal lag criterion for promoting response variability of a particular target skill customized to the learner.

Fourth, it is observed that the subjects in the studies reviewed above possess different repertoires. In some of the studies, typically-developing children were included. As deficits in language acquisition may not be present in typical children, effectiveness of lag schedules in promoting verbal response variability may be more evident in these children than children who possess language deficits with respect to the same intervention. The variations in participants' repertoires thus essentially limited a comprehensive evaluation of effectiveness of lag schedules, especially in individuals with developmental disabilities. Future studies can extend the current research by conducting the study with both typical and developmentally disabled groups of children. This would enable the investigation of differences in efficacy of lag schedules in promoting response variability between the two groups.

Fifth, while most of the studies measured degree of variability, few of them measured response topographies. Therefore, despite the degree of variability being revealed in the research results, the quality of response variability could not be evaluated. This restricted a

complete evaluation of the efficacy of lag schedules in promoting response variability because the subjects could have demonstrated a high level of variability without acquiring novel responses. In order to promote functional integration of individuals with disabilities through increasing their response variability, the possession of a large number of responses would be necessary as a foundation for generating variability in responding. It is hence suggested that despite measuring the level of response variability in future studies, experimenters can also measure the topographies of the responses or the level of novel responses generated as an additional dependent variable. This modification may permit evaluation of the quality of response variability generated. Further, if a lack of novel responses was observed in the preliminary sessions of the intervention, procedural modifications such as the introduction of systematic teaching or prompting can be made to assist acquisition of response variability.

Sixth, it was observed that generalization probes were not incorporated in every study reviewed. With the absence of generalization probes, the conclusion regarding effectiveness of lag schedules in promoting response variability is weakened, as it is unsure if the target response acquired during intervention can be generalized across settings. It is hence recommended that future studies incorporate a systematic plan for generalization within the intervention in aim to generate more convincing results. Systematic generalization of response variability across persons delivering the instructions and across settings with differential stimuli present can be two dimensions worthy to be explored.

The literature review presented a review of 11 studies on the use of lag schedules in promoting either verbal or nonverbal response variability in animal and human subjects, respectively. Further, common limitations across the studies were identified and potential procedural modifications were suggested. The aim to enhance the quality of lives of individuals with developmental disabilities through better social integration calls for the

development of effective interventions to overcome their deficits. Continuous effort to better the current studies will obviously contribute to more comprehensive and convincing uses of lag schedules in promoting verbal response variability in individuals with developmental disabilities, especially those with ASD.

Statement of Purpose

The effectiveness of lag schedules and especially Lag 1 schedule in promoting response variability has been demonstrated in studies reviewed above. However, as mentioned, Lag 1 schedules might result in higher-order stereotypy (Lee, McComas, & Jawor, 2002; Lee & Sturmey, 2006; Schwartz, 1982). In other words, the participant might have gained access to reinforcement by alternating two responses when a Lag 1 schedule was in effect. Thus, although a high level of variability was achieved, this variability might not take place between sets of responses.

In light of addressing the issue of possible repetition and to further refine lag schedules of reinforcement, the goal of the present study is to evaluate the feasibility of an alternative lag schedule, which incorporates both within response and between response lag criteria in promoting response variability. To determine whether or not the proposed lag schedule can alleviate the concern of higher-order stereotypy, it is essential to first discover if children are able to produce response variability under a lag within/lag between reinforcement schedule.

A task-based activity was used in Experiment 1 to examine the practicality of the proposed lag schedule in promoting response variability. The study also aimed to extend the examination to the effectiveness of the alternative lag schedule in promoting vocal-verbal response variability in a multiplayer game, I Spy game in Experiment 2. One potential implication of the study is that if the lag within/lag between schedule is proven effective,

future research can employ it to explore possibilities in alleviating the problem of stereotyped responding.

CHAPTER II: METHOD

Participants, Settings, and Materials

Five participants from Hong Kong with a diagnosis of ASD who have been receiving behavioral therapy service from Autism Partnership Hong Kong for at least half a year were selected. Participants have been receiving intensive one-on-one behavioral therapy from 9:00am to 3:30pm, packaged one-on-one behavioral therapy of two and a half hours per day, Monday through Friday, or one-on-one behavioral therapy of two and a half hours per day, two or three sessions per week.

The study took place in therapy rooms at the center or at the client's bedroom at home. The rooms contained a table, chairs, various tangible and edible reinforcers, and instructional materials. All sessions took place at the table area and were conducted by the participants' behavioral therapists, who were trained to execute the procedures prior to the intervention. The task-based activity in Experiment 1 required fifteen same-sized blocks, five each of three different colors: red, blue, and yellow in Phase 1 and twenty-one same-sized blocks, seven each of three different colors: red, blue, and yellow in Phase 2. Experiment 2 required a box of I Spy® game, which consisted of five cards with over twenty objects on each.

Response Definition and Data Collection

The dependent variables of the study were the percentage of varied responses per session based on response topography (i.e., color order of the block structure from bottom to top). The participant was required to build the structure respective to the phase in a trial and a varied response was defined as a response that differs from a specific number of preceding responses, depending on the lag criterion or criteria in effect.

Each experimental session lasted for approximately ten to fifteen minutes and was conducted prior to or after the participant's regular behavioral therapy session. Four trials

were conducted each session. Each trial consisted of building multiple block structures depending on the lag criterion or criteria in place. A data collection form as shown in Appendix C1 was used to record trial-by-trial data using '+' or '-' signs, with a varied response indicated by '+' and an unvaried response indicated by '-'. The data tracking form shown in Appendix C2 was used to record response topography. Trial-by-trial varied responses data were then converted to a percentage by dividing the number of trials with varied responding by the total number of trials, which is four, and multiply it by 100. A third data collection form as shown in Appendix C3 was used to record the percentage data per session. For instance, if varied responding was scored in two of the four trials, the percentage of varied responding will be 50% for that session. The fourth data collection form, as shown in Appendix C4 was used to record the duration the participant used to complete the block-building requirements in one trial. Experimenters used digital timers to record the duration. Recording was initiated when the participant reaches for the first block from the tray presented and stopped when the participant finished building the last structure.

Interobserver Agreement and Observer Training

Interobserver agreement. Data on interobserver agreement (IOA) were collected on variability measures and response topography across all phases by a second observer watching videotaped sessions. IOA was calculated using exact count.

Observer training. Observer training was provided prior to the intervention. Employees from Autism Partnership Hong Kong with a minimum of one year experience implementing behavioral therapy and recording treatment data were selected. The observer training included an initial meeting with the potential observer to explain the training process and time commitment. The training included 1) an explanation of definitions and tracking forms, 2) an oral test, and 3) role-playing data collection. The trainees' performances on oral

test of the definitions and role-playing data collection were recorded in a form as shown in Appendix A.

Explanation of definitions and tracking forms. Definitions of a varied response and non-varied response respective to each phase were explained by the author and data collection components were elaborated, including the data recording procedures, use of '+' and '-' signs, phase progression, and termination criteria. A note sheet as shown in Appendix B was distributed to the potential observers. Copies of the three data tracking forms were also distributed and explained. The author addressed all questions raised and ensured that the potential observers were clear about all essential information before moving on to the next part of the training.

Oral test. The author met with potential observers a day after the explanation of definitions. An oral test was conducted with the potential observers and questions about the definitions listed on the note sheet were tested. If the potential observer was able to answer all questions, he or she would move on to role-play collecting data. If not, the potential observer would be given a second opportunity to review the note sheet and take the oral test again a day later. If he or she still failed to answer all questions for the second time, he or she would not be qualified as an observer for the experiments.

Role-playing data collection. A video clip of approximately 10 to 15 minutes long was prepared by the author for each phase. The video clip simulated an experimental session, consisting of four trials each. In the video, the author conducted each phase of Experiment 1 with an adult who acted as the participant of the study.

The observer was given a pencil, a rubber, and a blank data tracking form to role-play data collection. Subsequent to data collection on the first phase, the author compared the data on varied responding and topography of response sequences collected by the observer with a previously completed data collection form. IOA was calculated using exact count. An

observer who had an IOA score of 100% would be invited to collect data for the subsequent phase. However, if a score of 100% is not obtained, the observer was given a second opportunity to record data for the same phase again. He or she would not be qualified to be an observer if an IOA score of 100% is still not achieved for the second time. The role-playing continued until data collection on videos of all phases was completed.

All experimental sessions were videotaped for IOA scoring. IOA agreement data for a mean of 50% of the experimental sessions across all five participants were collected (range, 48% to 51%). Percentage agreement for each session was calculated by dividing the number of agreements by the number of agreements plus disagreements and converting to a percentage. Mean agreement was 98% for P1, 100% for P2, 100% for P3, 97% for P4 and 95% for P5.

Experimental Design and Procedure

A changing criterion design embedded within a multiple baseline across subjects design was used. A MSWO preference assessment (DeLeon & Iwata, 1996) was conducted prior to the start of the study using preferred tangibles or edibles reported by the participants' behavioral therapists and caregivers. The highly preferred reinforcers would be delivered to the participant contingent on varied responding according to the reinforcement schedule. Sessions were carried out in the table area in the room and the blocks were placed on a tray on the table with the participant sitting approximately 0.5m away from the tray. In case of occurrences of challenging or disruptive behaviors during the study, the experimenters employed consistent reactive procedures to handle the participant's behaviors as those used in the participant's regular behavioral therapy sessions.

Probes with non-ASD adults. Experimental probes with non-ASD adult participants were conducted prior to the study with participants with ASD to investigate the necessity of providing visual feedback, that is, the completed block structures, in order to set up the best

possible conditions for promoting varied responding. Probes were conducted at the table area with blocks of three colors placed randomly in a tray, approximately 0.5m away from the participant. The experimenter probed the intervention phases of the study. If the phase required the participant to build more than one block structure, the experimenter would take away every tower after the participant completed building it. That is, the visual feedback was removed.

A verbal praise was provided contingent on varied responding. Conversely, the experimenter would say 'That's not right!' contingent on absence of varied responding. Phase progression was contingent on production of varied responding in three consecutive attempts. On the other hand, the participant would be removed if varied responding were not produced for five consecutive attempts at any particular phase. The probe session would continue until all experimental phases are probed or until the termination criterion was met.

If both adult participants could produce varied responding in all phases without the provision of visual feedback, the same procedure would be used with participants with ASD. However, if any of the two adult participants failed to complete all phases during the probe sessions, visual feedback would be provided to the participants with ASD in the actual study. In other words, if more than one block structure was required to be built in a particular phase, the experimenter would not remove the completed block structures within a trial.

Baseline. During baseline, the therapist presented a tray of randomly-located, same-sized blocks of three colors and conducted probes on building two- or three-level structures. Each baseline session consisted of two attempts. The therapist initiated the attempt by inviting the participant to build the required structure or structures. If participants were found to have difficulties understanding the instruction during baseline probes, a visual prompt was provided to the participant throughout the experiment. The visual prompt was an A5 size paper with the required block structure or structures printed in black and white. No

consequences were delivered regardless of whether or not a varied response was produced. If the participant failed to begin building the required structure within five seconds, the therapist would clear the table and represent the tray of blocks and instruction for a second time. If the participant still failed to build the required structure upon representation, the attempt would be counted as a negative.

Each participant's beginning phase in the intervention was determined by the participant's best performance in baseline sessions. If the participant produced a varied response for two consecutive attempts, probes on the subsequent phase would be initiated. Conversely, if the participant failed to produce a varied response for two consecutive attempts on a phase, intervention would begin with that specific phase. For instance, if the participant failed to produce a varied response for two attempts consecutively during baseline probes in Phase 1C, intervention for that participant would begin at Phase 1C. On the other hand, if the participant completed all the structures perfectly, he or she would be removed from the study.

Intervention. Phase 1 targeted variability within a two-level structure and between two or more two-level structures. A trial in the study was defined as the necessary number of block structures to fulfill the between response lag criterion. Four trials were conducted per session. Depending on the participant's therapy service package, sessions might be conducted every day, Monday through Friday, or only on alternate days during weekdays. Phase progression was contingent on three consecutive sessions with varied responding on all four trials. The participant would be removed from the study if 100% responding were not obtained at least once within ten consecutive sessions.

In each trial, a tray of randomly-located blocks was presented to the participant and an instruction to build the required structure or structures was delivered. Reinforcement was delivered contingent on varied responding in accordance to the lag criterion or criteria in

effect. If varied responding was not produced, a hierarchy of verbal corrective feedback was provided to the participant. As there were four trials per session, the hierarchy of feedback would consist of four different feedback statements, with increasing specificity. Upon the first failure, the therapist would say 'Try again!' Contingent on a second consecutive failure, the therapist would say 'Try a different way!' If the participant failed in a third consecutive trial, the therapist would say 'That's not right, you need to try different structures!' If the participant failed for the fourth time consecutively, the therapist would say 'That's not right, you need to try different colors!' The therapist would only provide a corrective feedback with increased specificity when the absence of varied responding occurs consecutively. For instance, if the participant failed in the first trial, the least specific corrective feedback would be provided. If the participant then produced varied responding on the second trial, reinforcement would be delivered. If the participant failed on the third trial, the least specific corrective feedback would again be provided. If on the fourth trial the participant failed again, the second-least specific corrective feedback would be delivered.

In Phase 1A, a Lag 1 within schedule was used and reinforcement was delivered contingent on producing a response that differs from one previous response. For instance, the participant would gain access to the chosen reinforcer if he or she placed a blue block on top of a red block. As a between lag criterion was not in place in this phase, reproducing the blue-on-top-of-red structure on subsequent trials during that session could also lead to reinforcement.

In Phase 1B, a Lag 1 within/Lag 1 between schedule was in place. In this phase, the participant was required to build two two-level structures in each trial. A varied response was scored if 1) the second block differed in color from the first block within a structure, and 2) the second structure was different from the first structure. For instance, reinforcement would be delivered if the first structure was blue on red and the second structure was blue on

yellow or if the first structure was blue on red and the second structure was yellow on red. Further, if the first structure was blue on red and the second structure was red on blue, reinforcement would too be delivered.

In Phase 1C, a Lag 1 within/Lag 2 between schedule was in place. In this phase, the participant was required to build three two-level structures in each trial. Variability was scored if 1) all three structures were comprised of two colors and 2) no two structures repeated the same pattern.

The lag criterion between structures continued to increase by 1 on each progression up to a Lag 5 between schedule while the lag criterion within remained at Lag 1 schedule across Phase 1.

Phase 2 of the study targeted variability within a three-level structure and between two or more three-level structures. In Phase 2A, a Lag 2 within schedule was implemented, meaning that each of the three blocks must be of differing colors. In Phase 2B, a Lag 2 within/Lag 1 between schedule was in place. The participant was required to build two three-level structures in a trial. Variability was scored if 1) within a structure, each block was of a different color, and 2) the second structure differed from the first structure. In Phase 2C, a Lag 2 within/Lag 1 between schedule was implemented. A trial would consist of building three three-level structure. Varied response was scored if 1) within a structure, each block was a different color, and 2) each of the three structures was different.

Similar to the Phase 1, the lag criterion between sets continued to increase by 1 on each progression but the lag criterion within a set remained at Lag 2 schedule. The phase progression and termination criteria were identical to that in Phase 1.

Generalization Probes. Across Experiment 1, probes on I Spy game were conducted to investigate possible generalization effect. The procedures and data collection of the

generalization probes were identical to the intervention phase except that no consequences were delivered regardless of the variability of the response.

Follow-up Experiment. Experiment 2 was set to investigate the possibility of the alternative lag schedule in promoting verbal response variability using the I Spy® game. One card from the game set would be presented to the participant and the therapist would instruct the child to play 'I Spy' with the experimenter. The conventional 'I Spy' game was modified to a simpler version with rules as follows. First, the participant would have to say 'I spy with my little eyes, a/ an (object).' Then, the experimenter would find and point out the specified object on the card and say 'Here it is!' or 'I found it!' or any other statements with similar meanings. A varied verbal response was defined as the production of an 'I Spy statement' that differs from a specified number of previous statements, depending on the lag criterion or criteria in place.

Experimental conditions were set to be similar to those in the block-building activity. The results from baseline probes and generalization probes on I Spy game would determine the participant's beginning phase of the intervention in Experiment 2. For example, if the participant produced two responses within that differ but repeated the sequence on a separate run of statements, the beginning phase of this participant would be Phase 3B, which is Lag 1 within/Lag 1 between.

In Phase 3, variability within and between two verbal responses would be targeted. The lag criteria would progress from Lag 1 within schedule to Lag 1 within/Lag 1 between schedule to Lag 1 within/Lag 2 between schedule, and so forth, with an increase of 1 for the between response lag schedule per progression from Phase 3A to Phase 3F. In Phase 4, variability within and between three verbal responses would be targeted and the lag criteria progression would be from Lag 2 within schedule to Lag 2 within/Lag 1 between schedule to Lag 2 within/Lag 2 between schedule, etcetera, with an increase of 1 for the between

response lag schedule per progression from Phase 4A to Phase 4F. Phase progression and termination criteria were set to be identical to that of Experiment 1. Across conditions, verbal response variability and topography of verbal responses would be recorded.

However, since three of the participants were terminated from the study in Experiment 1 whilst 100% varied responding were achieved consistently in the probes for I Spy game up to Phase 3D with the remaining two participants, Experiment 2 was not conducted.

CHAPTER III: RESULTS

Results of experimental probes with the two non-ASD adults showed that both participants could not complete all experimental phases during the probe sessions without a visual feedback provided. These results suggested that the provision of visual feedback was necessary to set up the best possible conditions for promoting varied responding during intervention with individuals with ASD.

Figure 1 shows the percentage of varied responding for the five participants throughout the study and results of experimental probes for I Spy game. For P1, 100% varied responding was produced in building one and two towers of two levels during baseline and intervention began with Phase 1C. During intervention, varied responding increased with the introduction of Lag 1 within/Lag 2 between schedule and mastery of this phase was achieved after 7 sessions. For Phase 1D, mastery was achieved after 23 sessions. P1 was terminated from the study in Phase 1E after 10 consecutive sessions without achieving 100% varied responding. For all four probes of I Spy game, P1 achieved 100% varied responding.

For P2, intervention started with Phase 1A. Mastery of Phase 1A was achieved after 7 sessions. P2 mastered Phase 1B and 1C after 4 and 6 sessions respectively. For both Phase 1D and Phase 1E, P2 only required 3 sessions to achieve mastery. In Phase 1F, P2 achieved mastery after 4 sessions. In conducting probes of Phase 2, P2 produced 100% varied responding in all six probes across the phases thus no intervention was needed for Phase 2. For I Spy game probes, 100% varied responding was achieved in all 4 probes.

For P3, intervention began from Phase 1A. Upon introduction of Lag 1 schedule, varied responding increased and mastery of Phase 1A was achieved after 6 sessions. During Phase 1B, varied responding remained at 0% for the first 6 sessions. Mastery of this phase was achieved after 9 intervention sessions and an abrupt increase of percentage of varied responding to 100% was observed in the seventh session of this phase. In Phase 1C,

percentage of varied responding was at 0% across 10 consecutive sessions and P3 was thus terminated from the study. Six experimental probes were conducted with P3 during the study, with five on Phase 3A and one on Phase 3B. Percentage of varied responding of probes for Phase 3A was low with three probes of 0% and one probe of 50%. On the fifth probe for I Spy game, varied responding increased to 100%. 100% varied responding was also achieved for the probe for Phase 3B later.

For P4, intervention began with Phase 1B. 5 sessions were required by both Phase 1B and Phase 1C respectively to attain mastery. For Phase 1D to Phase 1F, P4 produced 100% varied responding consistently and mastery was achieved after three consecutive sessions in each phase. During baseline probes for Phase 2, 50% varied responding was produced on three consecutive probes for Phase 2A. Intervention began from Phase 2A. Except for the first session in Phase 2A, 100% varied responding was produced consistently across the phases. For all four probes on I Spy game, 100% varied responding was recorded.

For P5, intervention sessions were intermittent because of the participant's irregular therapy schedule. For Phase 1B, 16 sessions were required for mastery. P5 was dismissed from the study in Phase 1C after the termination criteria was met. For the two probes on I spy game, 100% varied responding was recorded.

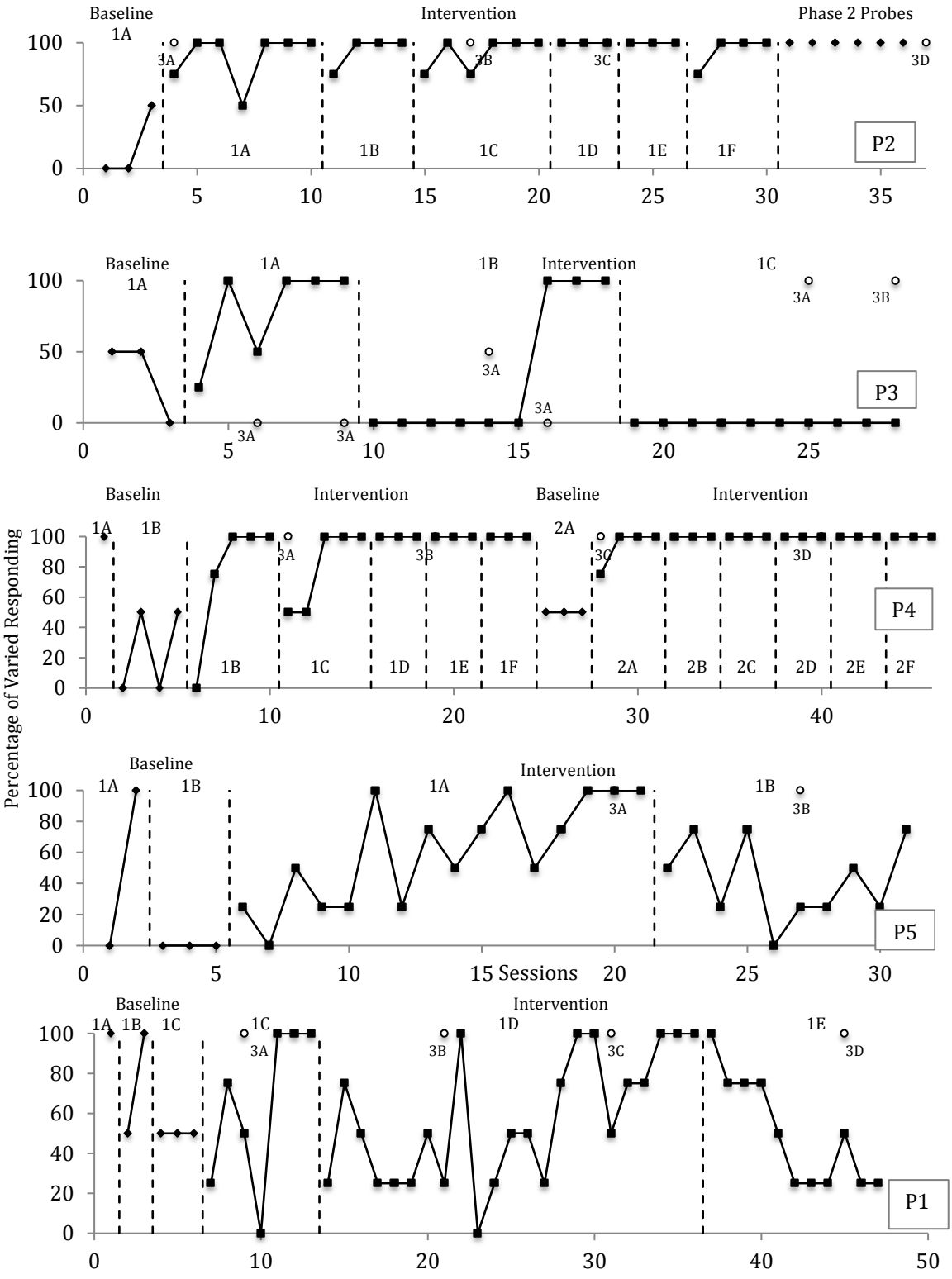

Figure 1. Percentage of varied responding for P1, P2, P3, P4, and P5 across baseline, lag reinforcement schedules, and probes for I Spy game.

CHAPTER IV: DISCUSSION

This study attempted to evaluate the effectiveness of a lag within/lag between schedule of reinforcement in increasing response variability in a block-building activity with children with ASD. Overall, the results showed that the proposed lag schedule was effective in increasing varied responding in two of the participants in the block-building activity. The study results extended previous research on the use of lag schedule in increasing varied responding in individuals with ASD. Moreover, the inclusion of I Spy probes in the design of the study attempted to demonstrate social validity of the proposed lag schedule. The results of the last two experimental probes with P3 showed possible generalization of the effect of intervention to production of varied responses in I Spy game.

The findings of this study are potentially significant for several reasons. First, unlike previous research, this study included the collection of topography data, which allowed for analysis on quality of response variability with response topographies. Second, while most existing studies focused on investigating the use of a fixed lag schedule of reinforcement, the current study attempted to use a changing criterion design to explore the effect of progressing lag within and lag between criteria more thoroughly. Third, the design of the study included generalization probes on I Spy game in aim to display possible generalization of the proposed lag schedule of reinforcement to real-world application.

Although it was originally hypothesized that a language-based activity, that is, the I Spy game, would be more difficult than a color-based block-building activity in producing varied responding, the results of the study demonstrated the opposite. One of the possible explanations to this is that the combinations of responses in I Spy game are vast compared to that in the block-building activity. In the current the block-building activity, the combinations of responses are finite, limited to variations of the three colors in building the towers. Further, there were more response options in the I Spy game than in the block-

building activity since each of the I Spy game cards consists of at least 20 different objects whilst only three colors of blocks were provided in the block-building activity. Another explanation to the results is that the production of an 'I Spy statement' is considered a single response and consequences were delivered upon each response. Conversely in the block-building activity, a single response was counted as the production of specific numbers of two-level or three-level towers, which may be comparatively difficult. To better explore the effectiveness of the proposed lag schedule, future studies can thus replicate the study using a language-based activity like the I Spy game. Future studies can also explore if the results would be different if the intervention began with Phase 2 instead of Phase 1, that is, starting with the building of three-level structures.

Additionally, it is possible that whether or not reinforcement is embedded in the activity task might have affected the child's production of response variability. I Spy game may be automatically reinforcing whereas a block-building activity may not be as attractive to a child. From anecdotal observations, task avoidance behaviors in the form of verbal protests were observed during intervention sessions of Phase 1E with P1. The decreasing trend of percentage of varied responding of this participant in Phase 1E might potentially be due to a lack of motivation. This suggested that rote tasks like block building may not be the best activity choice to promote learning varied responding. Future research can better evaluate the effectiveness of the proposed lag schedule by using activities that are embedded with reinforcement, such as games like the I Spy game.

There are several limitations of the study that warrant discussion. First, the child's problem solving repertoires may have affected the evaluation of the lag schedule. The topography data of P1 suggested that a pattern was developed in completing the first three towers during Phase 1D. That is, P1 would use three different-colored blocks for building the first level of the towers and vary the order of the three blocks in completing the second level.

This pattern resulted in difficulties in completing more than three towers for P1. In Phase 1D and Phase 1E, P1 was observed to take longer time in building the fourth and fifth tower after completing the first three. For instance, P1 built the first three towers, B, Y; R, B; and Y, R., with all three colors included in the first and second level respectively. In building the fourth tower, P1 might pick up two different-colored blocks, for example, blue and yellow, but failed to produce a varied responding by building the blue on yellow to make a tower that is different from the first. It may be the case that a limitation in P1's repertoire contributed to failure in generating a varied responding beyond varying the colors within a tower.

Second, whether or not the child spontaneously checks the towers before declaring completion might have affected the results of the study. From the intervention sessions, it was observed that P1 and P3 would not check the towers before declaring completion to the experimenter. Conversely, P2 and P4 would pause and check when building the towers and double check again after completing the required number of towers before declaring completion. This difference suggested that for children who do not demonstrate the behavior of double-checking independently, visual feedback alone might not be sufficient to help them in promoting varied responding. In future studies, prompting may be added prior to the trial to remind participants to check their responses before declaring completion.

Third, the child's repertoire in adjusting behavior contingent upon verbal feedback might have influenced the evaluation of the lag schedule. It was originally hypothesized that the provision of a verbal corrective feedback hierarchy with increasing specificity contingent on consecutive failures could promote response variability. However from anecdotal observation, this hypothesis might not be true for all participants. Some participants may not respond to 'try a different way', 'try different structures', or 'try different color'. The topography data of P3 showed that he did not adjust his behaviors with more specific verbal feedback provided within a session. Moreover during intervention sessions, P3 was observed

to repeat the experimenter's verbal feedback or say 'I don't know!' to initiate help. It is possible that P3's comprehension is limited and thus a hierarchy of feedback was not effective in promoting response variability. Future studies can include probes for inclusion in the study prior to the start of the intervention to evaluate the participant's ability to comprehend different verbal feedback.

Fourth, intervention sessions for one of the participants, P5, were not implemented regularly due to absenteeism, which might have affected the results. In future, experimenters may include attendance as one of the inclusion criteria of the study, such that the participant has to commit to attend a certain number of sessions per week to be recruited. This may ensure better evaluation of the effectiveness of the proposed lag schedule.

In summary, this study demonstrated that the lag within/lag between schedule of reinforcement can be used with individuals with ASD to promote varied responding. Although limitations were found in the study, it was expected, as the experiment was a preliminary attempt. Future studies can further refine the use of the proposed lag schedule and explore if the lag within/lag between reinforcement schedule can help in alleviating the problem of stereotyped responding in individuals with developmental disabilities, especially those with ASD.

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Appendix A: Observer Training Performance Record

Potential Observer Initials: _____

Training Start Date: _____ Training End Date: _____

Final Result: QUALIFIED/ NOT QUALIFIED

Task	Date/ Percentage Correct											
	First Training						Second Training (If necessary)					
1. Explanations on definitions **Check the box if completed and note the date of training session*												
2. Oral Test												
2a. Observer Role-Play: Data Collection - Response topography	1A	1B	1C	1D	1E	1F	1A	1B	1C	1D	1E	1F
	2A	2B	2C	2D	2E	2F	2A	2B	2C	2D	2E	2F
2b. Observer Role-Play: Data Collection - Varied responding	1A	1B	1C	1D	1E	1F	1A	1B	1C	1D	1E	1F
	2A	2B	2C	2D	2E	2F	2A	2B	2C	2D	2E	2F

Appendix B: Observer Training – Explanations of Definitions

Trainee Initials: _____

Training Date: _____

Training Materials – Note Sheet

Essential Definitions of the Study	
Terms	**Definitions**
Lag N schedule	A reinforcement schedule where reinforcement is delivered when the response is different from N previous response(s)
Lag 1 schedule	Reinforcement is delivered when the response is different from 1 previous response
Lag 2 schedule	Reinforcement is delivered when the response is different from 2 previous responses
Within response lag schedule	A reinforcement schedule which targets variability within a two- or three- block structure
Between response lag schedule	A reinforcement schedule which targets variability between two- or three- block structures
Varied responding	A response that differs from a specific number of preceding responses, depending on the lag criterion or criteria in effect
Topography of response	The color of the block formation(s)
Trial	The necessary number of block structures to fulfill the between response lag criterion
Session	A session consists of four trials
Phases	**Reinforcement Schedule**
Lag 1 within/Lag 1 between schedule	Reinforcement is delivered when the second block differs in color from the first block AND the second structure is different from the first structure
Lag 1 within/Lag 2 between schedule	Reinforcement is delivered when the second block differs in color from the first block AND the third structure is different from the 2 previous structures
Lag 1 within/Lag 3 between schedule	Reinforcement is delivered when the second block differs in color from the first block AND the fourth structure is different from 3 previous structures
Lag 1 within/Lag 4 between schedule	Reinforcement is delivered when the second block differs in color from the first block AND the fifth structure is different from 4 previous structures
Lag 1 within/Lag 5 between schedule	Reinforcement is delivered when the second block differs in color from the first block AND the sixth structure is different from 5 previous structures
Lag 2 within/Lag 1 between schedule	Reinforcement is delivered when the third block differs in color from the two previous blocks AND

	the second structure is different from the first structure
Lag 2 within/Lag 2 between schedule	Reinforcement is delivered when the third block differs in color from the two previous blocks AND the third structure is different from 2 previous structures
Lag 2 within/Lag 3 between schedule	Reinforcement is delivered when the third block differs in color from the two previous blocks AND the fourth structure is different from 3 previous structures
Lag 2 within/Lag 4 between schedule	Reinforcement is delivered when the third block differs in color from the two previous blocks AND the fifth structure is different from 4 previous structures
Lag 2 within/Lag 5 between schedule	Reinforcement is delivered when the third block differs in color from the two previous blocks AND the sixth structure is different from 5 previous structures

Data Collection

Terms/ Signs	**Definitions**
Observer role	Record two things: 1) occurrence/ non-occurrence of varied responding and 2) topography of response sequence(s)
'+'	Use when varied responding is observed
'-'	Use when varied responding is not observed
'R'	Red block
'B'	Blue block
'Y'	Yellow block
Percentage of varied responding	Calculated at the end of each session: (Number of trials with varied responding / 4) x 100%
Phase progression	Three consecutive sessions with 100% varied responding
Termination criteria	Ten consecutive sessions without 100% varied responding

Appendix C: Tracking Form 1
Varied Responding

Participant: _____ Beginning Phase: _____

Data Collection: Put a '+' if varied responding is observed, otherwise put a '-'
Example: In each box, put down '2/11 (1)/ +'

Phase	Date Started	Date (Trial)/ Data																				Date Mastered
1F																						
1E																						
1D																						
1C																						
1B																						
1A																						

Phase	Date Started	Date/ Trial / Data (+/-)																				Date Mastered
2F																						
2E																						
2D																						
2C																						
2B																						
2A																						

Appendix D: Tracking Form 2
Response Topography

Participant: _____ Beginning Phase: _____

Data Collection: Record the response topography from bottom to top. Use ‘R’ for red block, ‘B’ for blue block, and ‘Y’ for yellow block

Phase	**Date (Trial)**	**Response Sequence**
e.g. 1A	*2/11 (1)*	*R, B*
e.g. 1B	*5/11 (3)*	*R, B; Y, R*

Appendix E: Tracking Form 3
Percentage of Varied Responding

Participant: _____ Beginning Phase: _____

Data Collection: Calculate the percentage of varied responding after every session by the following formula:
(Total number of trials with varied responding/ 4) x 100%
Mastery Criterion: Three consecutive sessions with 100% varied responding

Phase	Date Started	Date/ Data (%)																								Date Mastered
1F																										
1E																										
1D																										
1C																										
1B																										
1A																										

Phase	Date Started	Date/ Data (%)																								Date Mastered
2F																										
2E																										
2D																										
2C																										
2B																										
2A																										

Appendix F: Tracking Form 4
Duration of Block-building

Participant: _____ Beginning Phase: _____

Data collection: Record down the duration (in minutes and seconds) the participant took to complete all block structures required in a trial.

Phase	**Date (Trial)**	**Duration**
e.g. 1B	*2/11 (1)*	*2m 30s*
e.g. 2C	*5/11 (4)*	*5m 27s*