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RESEARCH ARTICLE

An Evaluation of Lag Schedules of Reinforcement During Functional Communication Training: Effects on Varied Mand Responding and Challenging Behavior

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Abstract We evaluated the effects of lag schedules of reinforcement during functional communication training (FCT) on the varied use of mands and challenging behavior by two individuals diagnosed with autism. Specifically, we compared the effects of Lag 0 and Lag 1 schedules of reinforcement during FCT. The results showed that each participant exhibited increases in varied mand responding during FCT with the Lag 1 schedule of reinforcement relative to Lag 0; challenging behavior remained low during both FCT lag conditions relative to baseline. Results are discussed in terms of treatment implications relating to FCT and the potential prevention and/or mitigation of clinical relapse during challenges to treatment.

Keywords Functional communication training · Lag schedules · Response variability · Clinical relapse · Resurgence

Implications for Practice
- Extension of previous research on the use of FCT to treat challenging behavior exhibited by individuals with autism
- Extension of previous research on the use of lag schedules to increase varied mand responding in individuals with autism
- First investigation to evaluate the effects of combining lag schedules and FCT on varied mand usage during treatment of challenging behavior
- Reinforcing mand variability may have utility in preventing or mitigiating clinical relapse of challenging behavior during challenges to treatment

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Behavioral variability, similar to other operant dimensions of behavior, can be controlled via manipulation of its consequences (i.e., punishment, reinforcement; e.g., Page & Neuringer, 1985). That behavioral variability can be controlled via reinforcement has been demonstrated in studies in the basic (e.g., Page & Neuringer, 1985) and applied (e.g., Lee, McComas, & Jawor, 2002) behavioral literature. One area of study in the basic literature pertaining to operant variability has focused on the effects of lag schedules of reinforcement (e.g., Page & Neuringer, 1985). A lag schedule entails the provision of reinforcers contingent on a target response that differs from a pre-specified number of responses. For example, under a Lag 2 schedule, a reinforcer is provided if a response differs from the two previous responses.

Excessive engagement in repetitive and stereotyped behavior, by individuals with autism, may be conceptualized as a deficit in varied mand responding (see Rodriguez & Thompson, 2015)for a discussion. A number of applied evaluations of the effects of lag schedules on varied mand responding in individuals with ASD have recently emerged in the behavioral literature. Lee et al. (2002) evaluated the effects of a Lag 1 schedule on varied verbal responding to social questions by individuals with autism. Lee et al. first implemented differential reinforcement of alternative behavior (DRA) in which all appropriate responses were reinforced. Next, a Lag 1/DRA condition was implemented in which reinforcement was only provided following appropriate responses that varied from the immediately preceding response. The Lag 1/DRA procedure produced elevated levels of varied mand responding relative to DRA alone with two of the three participants.

Lag schedules may also have utility within treatments for challenging behavior (e.g., functional communication training, FCT; Carr & Durand, 1985). Specifically, targeting varied mand responding during FCT may have utility in terms of the

prevention or mitigation of clinical relapse (e.g., resurgence; Epstein, 1983). Wacker et al. (2011) described several conditions that represent challenges to treatments that can result in the resurgence of challenging behavior including brief and/or prolonged periods of extinction of mands resulting from lapses in treatment fidelity. This effect has been demonstrated in several studies in which resurgence of challenging behavior occurred when extinction was applied to trained mands during FCT (e.g., Wacker et al., 2011). Subsequent studies have shown that targeting multiple mands during FCT may be effective at mitigating and/or preventing resurgence (e.g., Hoffman & Falcomata, 2014; Lambert, Bloom, Samaha, Dayon, & Rodewald, 2015). It is possible that during challenges to treatment, such as extinction of mands, the emission of alternative trained mands will be more likely following the reinforcement of varied mand responding relative to the recurrence of challenging behavior.

Given the potential benefits of training multiple mand modalities in addressing the recurrence of challenging behavior, there may be utility in programming for varied mand responding by embedding lag schedules during FCT. The purpose of the current study was to evaluate the effects of lag schedules during FCT with two individuals with autism and histories of engagement in challenging behavior.

Method

Participant, Settings, and Materials

Participants were two individuals diagnosed with autism. John was a 23-year-old male with a history of engaging in self-injurious behavior (SIB). A previous functional analysis suggested that John's behavior served a tangible function. It was reported that John had a few vocal communicative responses in his repertoire, but they were typically unintelligible to unfamiliar listeners. It was reported by care providers that speech generating devices (i.e., Dynavox®, Cyrano®) and card exchange had been used with John in the past; however, none were utilized consistently prior to the study. Fred was a 10-year-old male who had a history of engaging in aggression. A previous functional analysis suggested that Fred's behavior served an escape function. It was reported that Fred had a few vocal communicative responses in his repertoire; however, they were typically unintelligible to unfamiliar listeners, and none functioned as mands to escape non-preferred activities. He had no other communicative responses in his repertoire at the onset of the study. Fred was enrolled in a private school for children with developmental disabilities.

Sessions were conducted in the participant's home (John) or an empty classroom room at a school (Fred). The session area contained a table and chairs, various high and/or low preferred items, and augmentative and alternative communication (AAC) devices (i.e., iPad® with Proloquo2Go™; picture icons, microswitch) depending on the condition in place.

Measurement and Interobserver Agreement

Trained observers collected data via paper and pencil during sessions. Frequency measures were taken and converted to rate for the purposes of data analysis. For John challenging behavior was defined as SIB (e.g., hitting hand to chest with audible smack, hitting head with hand with audible smack) and aggression (hitting or pushing). For Fred, challenging behavior was defined as aggression (e.g., kicking, throwing objects at people, moving hand into the space of another person's face or neck). Target mands included iPad® activation, card exchange, microswitch activation, and vocal requests (i.e., "puzzle" with John). Target mands were coded as either varied (i.e., the mand differed from the previously emitted mand) or invariable (i.e., the mand was identical to the previously emitted mand).

A second observer collected data during 32% of sessions across participants. Agreement data were calculated using the frequency ratio method by dividing the smaller number of responses recorded by the larger number recorded for each target behavior for each participant and multiplying by 100. Agreement averaged 100% for challenging behavior, 98% (range = 89%–100%) for total mands, and 97% (range = 67%–100%) for varied mands.

Experimental Design

An ABCBCAC reversal design (A = baseline; B = FCT/Lag 0; C = FCT/Lag 1) was used to evaluate effects of FCT in combination with different lag schedules on varied mand responding and challenging behavior. All sessions were 5 min in length. Prior to the evaluation, a mand topography assessment (Ringdahl et al., 2009) was conducted to confirm independent use of each of the target mands (both participants emitted each mand topography independently (i.e., pre-prompt) on at least 60% of trials and with either pre-prompt or with a vocal prompt during 90% of trials; data available upon request). Prior to the first Lag 0/FCT session, we conducted brief training trials using a four-step prompting sequence (i.e., pre-prompt, vocal prompt, gestural prompt, physical guidance) with each individual mand topography; we began the session when the participant demonstrated independence during one trial with each mand topography.

Procedures

Baseline For John, the experimenter provided 1 min of pre-session access to high-preference stimuli. When the session

began, access to the high-preference stimuli was removed/restricted. Contingent on all occurrences of challenging behavior, the experimenter provided 30 s of access to the high-preference stimuli. With Fred, the experimenter presented academic demands (e.g., sorting) using a three-step prompting procedure (with 5 s between prompts) consisting of vocal, gestural, and physical prompts. The experimenter provided a 30-s break from academic tasks contingent on all occurrences of challenging behavior. The experimenter provided brief praise contingent on compliance followed by the presentation of the next demand. Mand materials were not present during the baseline condition.

FCT/Lag 0 With John, this condition was similar to baseline except that mand topography materials were present and accessible; contingent on the occurrence of a target mand, access to high-preference stimuli was provided for approximately 30 s, and all occurrences of challenging behavior were ignored. With Fred, this condition was similar to baseline except that mand topography materials were present and accessible; 30-s breaks from academic tasks were provided contingent on the occurrence of any target mand topography, and all occurrences of challenging behavior were ignored.

FCT/Lag 1 This condition was similar to the FCT/Lag 0 condition, except that reinforcement was provided contingent on varied mand responses (i.e., varied from the immediately preceding mand response). At the onset of the session, any target mand was reinforced with 30 s of access to high-preference stimuli (John) or escape (Fred). The initial emitted target mand was not scored as varied or invariable. Following the initial emitted target mand and the subsequent 30-s reinforcement interval, the session was initiated and the Lag 1 schedule (for target mand topographies) was programmed. Specifically, 30 s of access to the reinforcer was provided contingent on target mand topographies that differed from the immediately preceding emitted target mand. All occurrences of challenging behavior and invariable target mands (i.e., target mands that were identical to the immediately preceding mand response) were ignored.

Results and Discussion

Figure 1 shows the results of the FCT lag evaluation. With John (top panel), challenging behavior occurred at elevated levels during both baseline conditions (M = 0.9 responses per minute (rpm)). During both FCT/Lag 0 conditions, challenging behavior occurred at zero levels; varied mands occurred at near zero levels (M = 0.07 rpm), and total mands occurred at elevated levels (M = 1.7 rpm). During each FCT/Lag 1 condition, challenging behavior occurred at zero levels; varied mands emerged and occurred at elevated levels (M = 1.6 rpm), and total mands continued to occur at elevated levels (M = 2 rpm). With Fred (bottom panel), challenging behavior occurred at consistent and elevated levels during both baseline conditions (M = 2 rpm). During both FCT/Lag 0 conditions, challenging behavior occurred at levels (M = 0.2 rpm) with some initial variability during the second implementation of the condition. Variable but decreasing levels of varied mands (M = 0.1 rpm) and elevated levels of total mands (M = 2 rpm) occurred during both FCT/Lag 0 conditions. During each FCT/Lag 1 condition, challenging behavior occurred at zero levels; varied mands emerged and occurred at elevated levels (M = 1.6 rpm), and total mands continued to occur at elevated levels (M = 2 rpm).

The results demonstrated that the Lag 1 schedule produced high levels of varied mand responding relative to the Lag 0 schedule with both participants. While each participant tended to exhibit a single, invariable mand topography under the Lag 0 schedule conditions, we anecdotally noted that they both exhibited a variety of mand topographies under the Lag 1 schedule conditions. The current results also showed that each lag schedule, combined with FCT, produced low levels of challenging behavior relative to baseline; levels of challenging behavior were similar during the Lag 1 and Lag 0 schedules. Thus, these results replicate and extend previous studies evaluating the clinical utility of lag schedules as well as the general literature pertaining to FCT. Specifically, the current study provides an initial evaluation of the utility of procedures for increasing response variability pertaining to multiple communicative responses during the treatment of challenging behavior during FCT.

The current results also suggest that there may be utility in embedding lag schedules when targeting multiple mands (e.g., Hoffman & Falcomata, 2014; Lambert et al., 2015) during FCT for the prevention or mitigation of resurgence of challenging behavior during challenges to treatment (e.g., failure to reinforce target mands during FCT; Wacker et al., 2011). Specifically, the conditions created by the FCT/Lag 1 schedule approximated the sequence of conditions that often produce resurgence [i.e., (a) the provision of a reinforcer following the emission of a target mand topography, (b) the application of extinction (within the lag schedule arrangement) to the previously emitted mand topography, and (c) the provision of a reinforcer when the lag schedule requirements were eventually met]. However, no recurrence of challenging behavior was observed during the FCT/Lag 1 schedule arrangement despite the previous reinforcement of challenging behavior and contact of mands with extinction within the arrangement.

Although the current FCT lag schedule procedures created conditions that approximated those that often produce

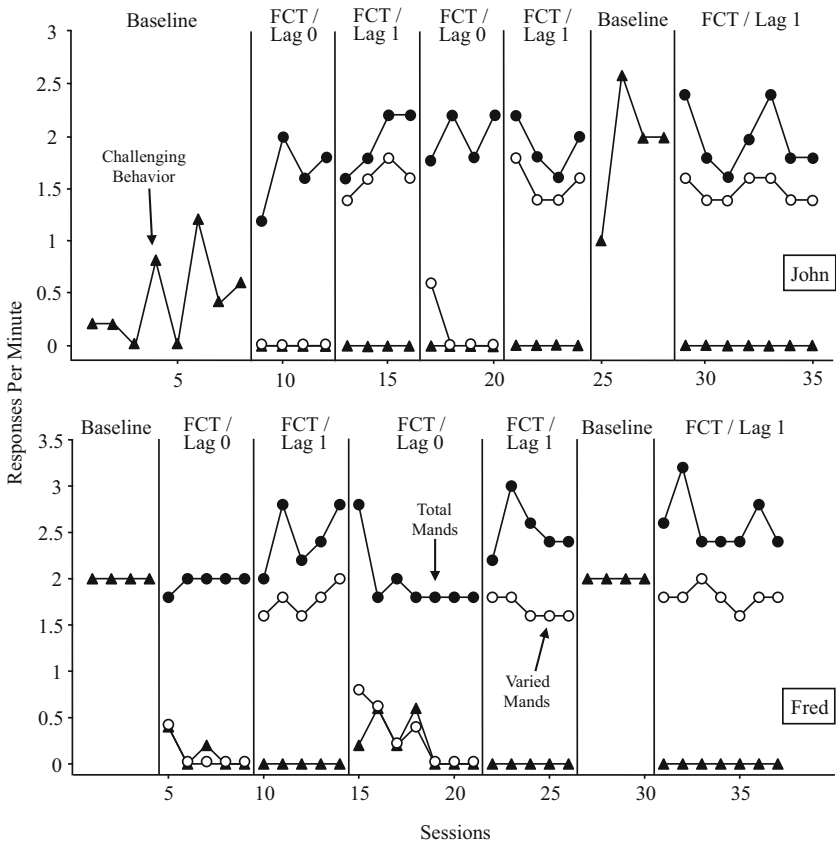

Fig. 1 Challenging behavior and varied mands per minute during the FCT lag evaluation for John (*top panel*) and Fred (*bottom panel*)

the resurgence of extinguished behaviors, we did not isolate the effects of lag schedules during FCT within a resurgence experimental preparation. Thus, although the current procedures may be useful for preventing or mitigating the recurrence of challenging behavior, these results should be interpreted with caution with regard to their possible utility in preventing or mitigating the recurrence of challenging behavior. As such, future research should evaluate the effects of lag schedules on the recurrence of behavior in more basic and translational experimental arrangements that would allow for a more systematic isolation of their effects.

In addition to possible basic and translational studies evaluating the effects of lag schedules on the recurrence of behavior, the current results suggest several other potential avenues of future studies. First, future studies could isolate and evaluate the effects of reinforcing behavioral variability on challenging behavior via lag schedules during FCT within arrangements pertaining to the various treatment relapse models (i.e., resurgence, e.g., Hoffman & Falcomata, 2014; Lambert et al., 2015; renewal, e.g., Kelley, Liddon, Ribeiro, Greif, & Podlesnik, 2015; reinstatement, e.g., Falcomata, Hoffman, Gainey, Muething, & Fienup, 2013). Second, future studies could also evaluate the effects of lag schedules during FCT on the recurrence of challenging behavior relative to (a) single responses, and/or (b) multiple responses when behavioral variability is not specifically targeted (e.g., mands are reinforced on concurrent FR schedules or via serial method; e.g., Lambert et al., 2015). Third, future studies could evaluate the effects of lag schedules at increasingly larger schedule requirements (e.g., Lag 2, Lag 3, Lag 4 schedules) on mand variability, persistence of mands, and challenging behavior during FCT.

Several limitations should be noted. First, we did not include mand materials during the baseline condition, precluding an evaluation of the effects of lag schedules during FCT on total mand responding relative to baseline conditions. Instead, we opted to configure our baseline condition to reflect (a) the relevant functional analysis condition for each participant and (b) a condition that reflected the absence of FCT treatment (e.g., a "naturalistic" baseline that would reflect pre-treatment conditions (i.e., prior to the inclusion of target mand materials)). Future studies should consider the inclusion of mand materials during baseline conditions within similar arrangements to allow for a more systematic evaluation of the effects of the lag schedule during FCT when mands contact extinction. Second, we did not conduct a systematic evaluation of the variability with which the participants used individual mand topographies during the lag schedules. However, we observed anecdotally that they both exhibited a variety of mand topographies under the Lag 1 schedule conditions and patterned responding did not occur.

Compliance with Ethical Standards

Funding This study was not funded by a grant or any other external sources.

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Procedures All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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