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A TRANSLATIONAL EVALUATION OF THE INTERPOLATED REINFORCEMENT PROCEDURE WITH YOUNG CHILDREN

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The interpolated reinforcement procedure (IRP) involves the deliberate continuous reinforcement of a previously intermittently reinforced behavior prior to implementing extinction. Basic research on the IRP has produced equivocal findings, and applied research has suffered from methodological limitations. The present study was an evaluation of the IRP with typically developing young children and a nonclinical target behavior. The IRP was demonstrated in only two of five participants. The results are discussed in the context of the IRP's clinical utility given the unreliability of the finding. Copyright © 2012 John Wiley & Sons, Ltd.

The interpolated reinforcement procedure (IRP) involves the deliberate continuous reinforcement of a previously intermittently reinforced behavior prior to implementing extinction (Quartermain & Vaughn, 1961). The IRP is based on the partial reinforcement extinction effect that states that continuously reinforced behavior is less resistant to extinction than intermittently reinforced behavior (Mackintosh, 1974). Although the IRP has been periodically recommended as a way to facilitate the extinction of problem behavior (e.g., Powell, Symbaluk, & Honey, 2009; Spira & Edelstein, 2007), its empirical support is limited. Basic research on the IRP has been equivocal (Lerman & Iwata, 1996), and applied research has suffered from methodological limitations. For example, studies have often failed to include a noninterpolated reinforcement control (e.g., Glavin & Moyer, 1975) or have employed reinforcers with unknown relations to problem behavior (e.g., Schmid, 1988). These limitations have been addressed in two investigations.

Lerman, Iwata, Shore, and Kahng (1996) evaluated the IRP with two adults with intellectual disabilities who exhibited socially maintained problem behavior. The

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authors found that one of the participants experienced a briefer extinction phase following interpolated (continuous) reinforcement, although the effect might have been a result of higher response rates during intermittent reinforcement. More recently, Higbee, Carr, and Patel (2002) used a translational preparation with a nonclinical (arbitrary) target behavior to evaluate the IRP with four children with autism. The authors demonstrated fewer sessions of extinction and fewer responses during extinction in three of four participants following interpolated reinforcement. For two of these three participants, however, IRP was implemented as the second independent variable in a withdrawal design. Thus, the briefer extinction phases might have been a result of the repeated extinction effect (Clark & Taylor, 1960) and not the IRP. In addition, preference assessments were conducted before reinforcement sessions but not before extinction sessions. This difference might have imbued the assessment with discriminative properties, which when absent prior to extinction sessions, might have hastened extinction.

The purpose of the present investigation was to further evaluate the IRP while addressing some of the limitations of prior investigations. The repeated extinction effect was controlled by always evaluating the IRP on the first implementation of extinction in a withdrawal design. In addition, preference assessments were conducted before each session to minimize the likelihood that they would exert discriminative control properties over responding in subsequent sessions. A translational preparation involving typically developing children and a nonclinical target behavior were used to control reinforcement history and prevent exposing individuals in need of problem-behavior treatment from unnecessary experimental manipulations. Furthermore, previous translational studies (e.g., Shabani, Carr, & Petursdottir, 2009) have shown comparable outcomes between typically developing children and children with developmental disabilities (a clinically relevant population) in similar experimental tasks.

METHOD

Participants, Setting, and Apparatus

Ten preschool-aged children were recruited for the study. Four children were excluded from the study because of response persistence across multiple baseline sessions, and a fifth child was excluded because a reinforcement effect could not be demonstrated. Five 3-year-old typically developing children who met both inclusion criteria participated in the study: Bob, Alan, Mike, Theresa, and Jack.

Sessions lasted for 5 min and were conducted twice each weekday in a small partitioned area (approximately 2×2 m) at the children's preschool. Two

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experimenters (trained undergraduate and graduate students) were present during each session to deliver programmed consequences and collect data. The experimenters sat across from participants at a small table during sessions.

The response apparatus consisted of multiple colored foam blocks (2.5 × 2.5 × 0.5 cm) and a transparent plastic receptacle (16 × 16 × 13 cm) with a 1 × 3-cm opening. The receptacle was placed directly in front of the participant on the table. A clear jar that contained the supply of blocks was located next to the receptacle. The participants had no prior experience with this particular response apparatus, although it is likely that they had experience placing blocks into receptacles in the natural environment.

Data Collection and Interobserver Agreement

The target behavior was the placement of a block into the receptacle and was assessed using event recording. The resulting primary dependent measure was the frequency of responses per minute (RPM) (i.e., rate). It should be noted that consumption time was not figured into rate calculations as participants could (and did) consume the reinforcer while performing the target behavior. In addition, three dependent measures were computed to evaluate resistance to extinction: (i) the number of extinction sessions; (ii) the number of responses emitted during extinction; and (iii) responding during extinction replotted as a proportion of the response rate in the previous reinforcement condition. Total interobserver agreement (lower frequency/higher frequency × 100%) was assessed by having a second observer record at least 50% of sessions distributed across conditions for each participant. Mean interobserver agreement for each participant was at least 97.2%.

Procedures

Stimulus Preference Assessment

A list of 8–10 foods was generated for each participant on the basis of parental report and direct observation. Before each session, small portions of each food were simultaneously presented to participants who were asked to select one. Upon selection, participants were given a small piece of the food, which was used as the programmed consequence for the subsequent reinforcement (fixed ratio [FR] or variable ratio [VR]) session; the selected food was not delivered during baseline or extinction conditions. The foods delivered in the study included pretzels, raisins, cookies, and potato chips.

Experimental Design and Conditions

Before each session, the experimenter modeled the target behavior and told the participant, ‘You can use only one hand and only put in one block at a time. You

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can do as much or as little of this as you want.' Baseline sessions (no programmed consequences) were first conducted until participants emitted low and stable response rates. Bob, Alan, Mike, Theresa, and Jack met this informal criterion in 3, 20, 18, 43, and 16 sessions, respectively. Bob emitted no responses during baseline; Alan, Mike, Theresa, and Jack averaged 2.3, 1.4, 2.5, and 1.1 RPM during the final seven baseline sessions, respectively. The effects of pre-extinction reinforcement conditions on performance during extinction were then evaluated using a withdrawal design. Following baseline, each participant was exposed to the following conditions in this order: intermittent reinforcement (including schedule thinning), continuous (interpolated) reinforcement, extinction, intermittent reinforcement, and extinction. The logic of this design was to evaluate the effects of interpolated reinforcement on the first extinction condition. Comparing the results of the first extinction condition with those of the second extinction condition, which might have benefitted from the repeated extinction effect, would constitute a more conservative evaluation.

Intermittent Reinforcement

A small piece of the participant's preferred food was first delivered contingent on the target behavior according to an FR-1 schedule. When one to three consecutive sessions were observed to produce response rates greater than those observed toward the end of baseline, the schedule was thinned to FR 2, VR 3, and ultimately VR 5 where it remained throughout the condition (an exception for Jack is described later). Conditions were changed when visual inspection of seven consecutive sessions indicated no downward trend and consistent variability. The number of sessions to which participants were exposed during the second implementation of intermittent reinforcement was yoked to the total number of reinforcement (VR and FR) sessions conducted before the initial extinction condition.

Continuous Reinforcement

A small piece of the participant's preferred food was delivered contingent on the target behavior according to an FR-1 schedule.

Extinction

No programmed consequences were delivered contingent on the target behavior. Extinction sessions continued until three consecutive sessions produced response rates less than or equal to the mean response rate of the five final baseline sessions.

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Procedural Integrity

Procedural integrity was assessed by comparing the number of reinforcers delivered in a given session with the number of responses emitted in the session divided by the response requirement of the reinforcement schedule (smaller number/larger number 100%). Procedural integrity was calculated for at least 54% of each participant's FR and VR reinforcement sessions and averaged at least 89% for each participant.

RESULTS

The primary findings are depicted in Figures 1 and 2. As seen in the top panel of Figure 1, Bob was exposed to the VR-5 schedule after 10 sessions of schedule thinning. His responding reached stability at a mean of 7.6 RPM. Bob's responding immediately decreased after the introduction of the FR-1 schedule and stabilized at a mean of 2.7 RPM. Responding then extinguished in 16 sessions ($M = 3.2$ RPM). The VR-5 schedule was reintroduced after 13 sessions of schedule thinning. Response rates steadily increased across the VR-5 phase ($M = 9.7$ RPM). Responding then extinguished in 12 sessions ($M = 2.2$ RPM).

As seen in the middle panel of Figure 1, Alan was exposed to the VR-5 schedule after three sessions of schedule thinning. His responding reached stability at a mean of 6.8 RPM. Alan's responding was comparable under the FR-1 schedule ($M = 5.6$ RPM). Responding then extinguished in 16 sessions ($M = 6.5$ RPM). The VR-5 schedule was reintroduced after four sessions of schedule thinning. Responding was generally stable across the VR-5 phase ($M = 10.1$ RPM). Responding then extinguished in seven sessions ($M = 2.4$ RPM).

As seen in the bottom panel of Figure 1, Mike was exposed to the VR-5 schedule after 26 sessions of schedule thinning. His responding reached stability at a mean of 5.1 RPM. Mike's responding then slightly decreased under the FR-1 schedule to an average of 4.2 RPM. Responding then extinguished in 23 sessions ($M = 5.3$ RPM). The VR-5 schedule was reintroduced after six sessions of schedule thinning. Responding was variable across the VR-5 phase ($M = 5.9$ RPM). Responding then extinguished in 13 sessions ($M = 5.0$ RPM).

As seen in the top panel of Figure 2, Theresa was exposed to the VR-5 schedule after four sessions of schedule thinning. Her responding reached stability at a mean of 7.2 RPM. Subsequently, Theresa's responding decreased under the FR-1 schedule ($M = 5.0$ RPM). Responding then extinguished in eight sessions ($M = 3.1$ RPM). After seven sessions of schedule thinning, the VR-5 schedule was reintroduced and resulted in an average of 5.4 RPM. Responding then extinguished in 12 sessions ($M = 2.7$ RPM).

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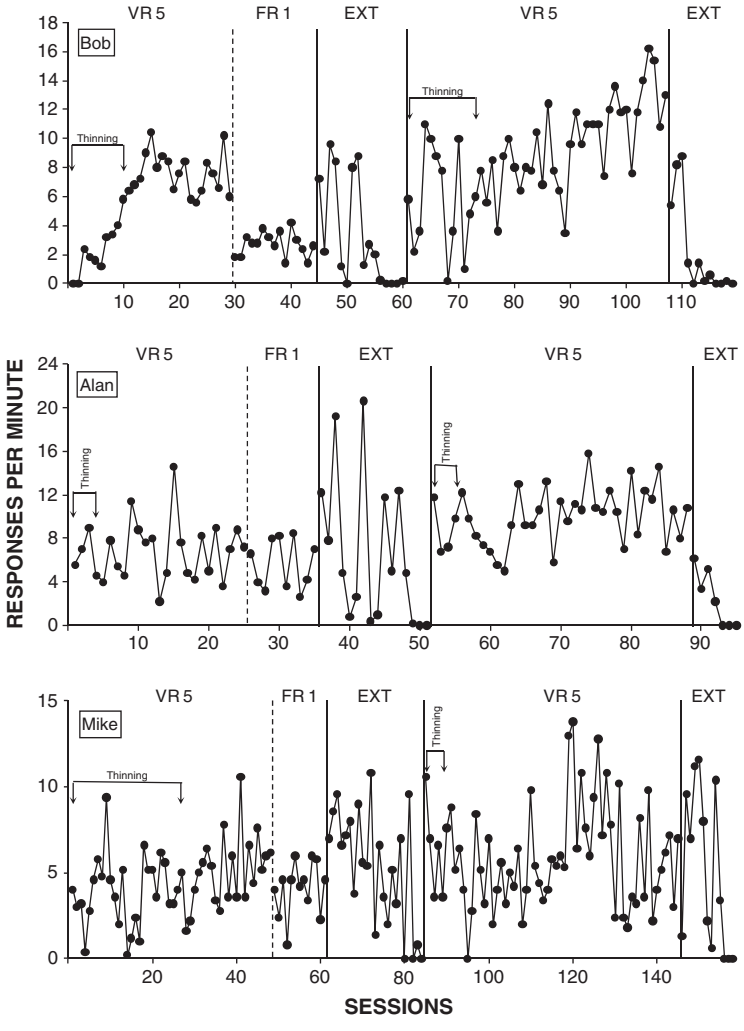

Figure 1. Responses per minute during reinforcement and extinction conditions for Bob (top panel), Alan (middle panel), and Mike (bottom panel). EXT, extinction; FR, fixed ratio; VR, variable ratio.

As seen in the bottom panel of Figure 2, Jack was exposed to the VR-5 schedule after eight sessions of schedule thinning. After 26 VR-5 sessions failed to produce a consistent reinforcement effect, Jack was exposed to a VR-3 schedule that became his target intermittent reinforcement schedule for the remainder of the evaluation. His responding increased to a mean of 3.2 RPM under the VR-3 schedule. Jack's responding subsequently increased under the FR-1 schedule ($M = 4.5$ RPM). Responding then extinguished in eight sessions ($M = 2.9$ RPM). After seven sessions

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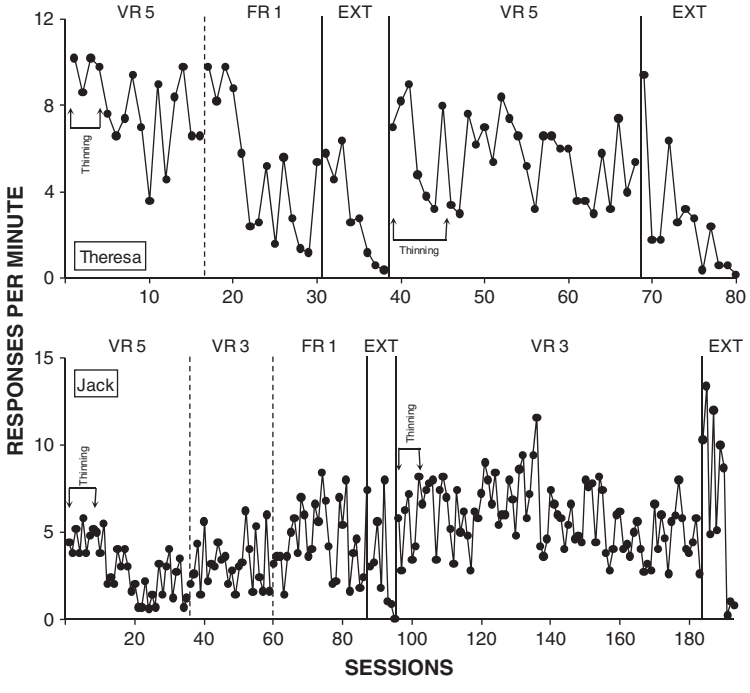

Figure 2. Responses per minute during reinforcement and extinction conditions for Theresa (top panel) and Jack (bottom panel). EXT, extinction; FR, fixed ratio; VR, variable ratio.

of schedule thinning, the VR-3 schedule was reintroduced and resulted in an average of 5.8 RPM. Responding then extinguished in 11 sessions ($M = 6.3$ RPM).

Figure 3 depicts summary data on the number of sessions of extinction and the number of responses during extinction across conditions for each participant. As seen in the top panel, Bob, Alan, and Mike required 33%, 129%, and 77% more sessions, respectively, to meet the extinction criterion after interpolated reinforcement (VR → FR) compared with intermittent reinforcement alone (VR). Conversely, Theresa and Jack required 50% and 38% fewer sessions, respectively, to meet the extinction criterion after interpolated reinforcement compared with intermittent reinforcement alone. As seen in the bottom panel, Bob, Alan, and Mike emitted 98%, 509%, and 85% more responses, respectively, during extinction after interpolated reinforcement compared with intermittent reinforcement alone. Conversely, Theresa and Jack emitted 54% and 66% fewer responses, respectively, during extinction after interpolated reinforcement compared with intermittent reinforcement alone. Thus, on the basis of the two dependent measures described previously, Bob, Alan, and Mike did not respond to the IRP, but Theresa and Jack did.

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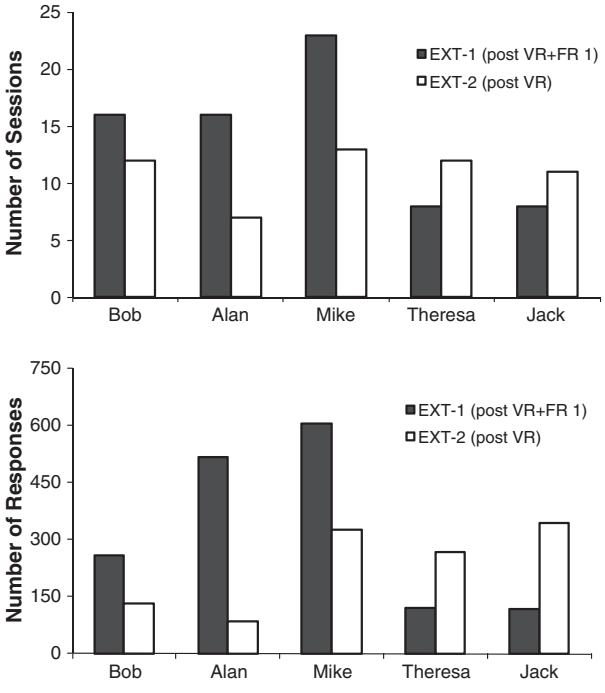

Figure 3. Number of sessions during extinction in each condition (top panel) and number of responses during extinction in each condition (bottom panel) for each participant. EXT, extinction; FR, fixed ratio; VR, variable ratio.

A final analysis was conducted to determine whether the number of extinction sessions or responses during extinction might have been unduly affected by response rates in the preceding reinforcement condition. Figure 4 depicts response rates during extinction sessions replotted as a proportion of the median response rate during the final seven sessions of the previous reinforcement condition. Consistent with the summary data in Figure 3, Bob, Alan, and Mike emitted proportionally more responses during extinction following interpolated reinforcement than during extinction following intermittent reinforcement alone. Theresa and Jack's response patterns were comparable across conditions.

DISCUSSION

The present study's equivocal findings are consistent with prior research on the IRP. Using typical learners with a known reinforcement history (within the experiment), the interpolated reinforcement effect was only demonstrated with two

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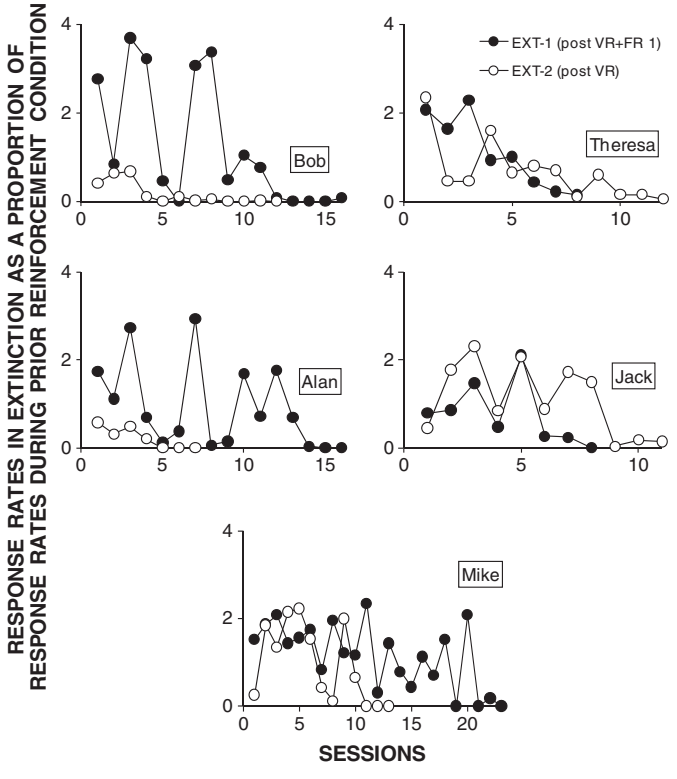

Figure 4. Data from extinction conditions replotted as a proportion of responding from prior reinforcement conditions. EXT, extinction; FR, fixed ratio; VR, variable ratio.

of five participants (Theresa and Jack). Furthermore, when one considers the additional interpolated FR-1 sessions (and the behavior they generated), the clinical utility of the effect is mitigated. The present findings are not surprising given the difficulty in demonstrating the partial reinforcement extinction effect at the within-subject level (Lerman et al., 1996), as well as the numerous factors that have historically been demonstrated to affect resistance to extinction (Capaldi, 1967; Mackintosh, 1974).

It is possible that evaluating the effects of the IRP during the first extinction condition was overly conservative. In other words, the effect might have been masked in the comparison with the second extinction that could have been affected by multiple exposures to extinction (i.e., the repeated extinction effect). It is also possible that intermittent reinforcement schedules leaner than VR 3 and VR 5 would have produced larger and perhaps more reliable effects. In addition, although we yoked the number of reinforcement (FR and VR) sessions prior to extinction across conditions, a better control might have been to yoke the number of reinforcers

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delivered as this variable has been demonstrated to correlate with resistance to extinction (Zarcone, Branch, Hughes, & Pennypacker, 1997). However, if the IRP depends on such methodological considerations, its applied utility could be questioned.

The IRP is a counterintuitive and perhaps somewhat controversial intervention because it requires caregivers to actively reinforce problem behavior prior to extinction. Unfortunately, the present study failed to detect evidence of a reliable and meaningful effect of the IRP, like the research that preceded it. Additional clinical and research attention to the IRP should be weighed against (i) the current unreliability of the IRP, (ii) the potential risk inherent in the IRP (i.e., purposefully increasing response rates prior to extinction), (iii) the probable social invalidity of the IRP, and (iv) the availability of numerous effective function-based approaches for reducing problem behavior (e.g., Neidert, Dozier, Iwata, & Hafen, 2010). Thus, we suspect that although continued research on the IRP might have value for the experimental analysis of behavior, its eventual contribution to an effective technology for a behavior change will be quite limited.

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