Increased number of responses may account for reduced resurgence following serial training

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Abrupt discontinuation of functional communication training can cause resurgence of challenging behavior. Teaching multiple alternative responses in sequence (serial training) may reduce resurgence, relative to teaching a single alternative. However, previous evaluations of serial training included a different number of response options across comparison conditions. In Experiment 1, we varied both training type (single and serial) and number of response options, and replicated previous findings showing that more resurgence occurred following single training relative to serial training. In Experiment 2, we varied the training type while holding the number of alternative responses constant and obtained no consistent differences in resurgence. In Experiment 3, we varied the number of alternative responses while holding training type constant (i.e., single). More resurgence occurred in the condition with fewer response options, suggesting that the number of available alternative responses, and not explicit serial training of alternatives, was critical to outcomes.

Key words: challenging behavior, differential reinforcement, human operant, resurgence, serial training

Challenging behavior may recur following successful behavioral treatment. One type of recurrence is resurgence (Lattal et al., 2017). Resurgence evaluations typically involve three phases that may closely resemble the treatment of challenging behavior using differential reinforcement of alternative behavior (DRA) procedures like functional communication training (FCT; St. Peter, 2015). In the first phase of a resurgence evaluation, challenging behavior is reinforced. In the second phase, reinforcement for the challenging behavior is withheld (extinction) and an alternative response is reinforced. In the third phase, reinforcement conditions for the alternative response are worsened in some way (e.g., reduction in reinforcement or quality of reinforcement) and challenging behavior resurges. Thus, if DRA is discontinued, modified, or not implemented consistently, the clinician risks resurgence of challenging behavior (St. Peter, 2015). For this reason, preventing resurgence may be of particular interest to applied behavior analysts.

Recent studies have examined variations of DRA that may reduce the likelihood or magnitude of resurgence. In typical DRA procedures, a single alternative response (i.e., alternative to challenging behavior) is reinforced. One alternative procedure is teaching multiple alternative responses in a sequential order, called serial training. Lambert, Bloom, Samaha, Dayton, and Rodewald (2015) compared typical DRA (hereafter, single training) and serial training using a human-operant arrangement with three adults with developmental disabilities. Each participant was exposed to both single and serial training in a multielement design that was embedded within a multiple baseline across participants design. During single training, experimenters taught the participant a single alternative response (a switch closure); only the target and a single alternative response were available. During serial training, experimenters
taught three alternative responses in sequential order; a new response option was added when the participant reliably engaged in the previously taught response, leading to four available responses by the end of training. When reinforcement was discontinued for all responses (extinction), higher rates of target responding occurred following single training than serial training. Carrasquillo and Ringdahl (in press) replicated Lambert et al. (2015) by teaching undergraduate students to click on colored squares. Similar to Lambert et al., both training type and the number of response options varied, and higher rates of target behavior occurred following single rather than serial training.

The generality of findings from both Lambert et al. (2015) and Carrasquillo and Ringdahl (in press) may be limited because they used highly controlled laboratory procedures and allowed the number of available responses to vary across components. In a follow-up study, Lambert, Bloom, Samaha, and Dayton (2017) controlled the number of available response options across conditions to evaluate persistence of alternative responses and resurgence of problem behavior for two children following single and serial training. During single training, participants were taught one alternative response (e.g., touching the therapist with a card labeled “toys please”) to access the reinforcer. During serial training, participants were taught one of three alternative responses across each of three consecutive phases. Unlike previous evaluations, materials necessary to engage in any of the responses were available across all conditions and phases. When all responses were placed on extinction (the resurgence test), appropriate requests were more persistent following serial training than single training for both participants. However, unlike previous evaluations (Carrasquillo & Ringdahl, in press; Lambert et al., 2015), the extent to which resurgence occurred across conditions varied across participants.

There are several possible factors underlying the divergent resurgence outcomes obtained across studies. One possibility is that reinforcement histories associated with socially significant responses impact resurgence. Recall that Lambert et al. (2017) included participants who had established histories of problem behavior maintained by social reinforcers. This is in contrast to both Lambert et al. (2015) and Carrasquillo and Ringdahl (in press), who conducted their evaluations using highly controlled laboratory procedures with arbitrarily selected responses. Indeed, duration of reinforcement history is known to impact subsequent resurgence (e.g., Doughty, Cash, Finch, Holloway, & Wallington, 2010). Another possibility is that the number of available alternative responses, rather than the use of serial training per se, affected resurgence. In studies demonstrating reduced resurgence following serial training (Carrasquillo & Ringdahl; Lambert et al., 2015), the number of available responses varied across training conditions. When Lambert et al. (2017) controlled for the number of available responses, serial training did not consistently reduce resurgence.

Isolating variables that decrease resurgence of challenging behavior following serial training could have implications for practitioners. If the availability of multiple responses (rather than the explicit serial training of those responses) reduces resurgence, practitioners could explore multiple ways to teach and reinforce several acceptable alternatives to challenging behavior. These alternatives could include serial training—but might also include lag schedules, concurrent reinforcement of multiple operants, or selection of response topographies that are likely to result in response generalization. Therefore, the purpose of the current study was to determine if serial training, or simply the number of available alternative responses, affected resurgence in an analog to the treatment of challenging behavior. Experiment 1 was a replication of Lambert et al. (2015) and Carrasquillo and Ringdahl (in press); we varied both the number of responses and
training type to ensure that reduced resurgence occurred following serial training. Then we isolated each of these variables. In Experiment 2, we held the number of available alternative responses constant while varying the type of training (single or serial training). In Experiment 3, we held training type constant (single training) while varying the number of available alternative responses.

**GENERAL METHOD**

**Participants and Setting**

We recruited 10 participants through an online research-scheduling system provided by the university. Different individuals participated in each of the three experiments. Participants received course credit for every 30 min spent participating, independent of their responding during the experiment. The amount of credit that the participant earned varied by course, at the instructors’ discretion.

We conducted the experiments in a 4.1-m by 3-m university laboratory equipped with two tables, a desk, computer, and desk chair. Each participant completed the experiment in a single appointment, and only one individual participated at a time. Appointments were 140 min in duration and were divided into two 60-min sessions separated by a 20-min break.

**Apparatus and Experimental Stimuli**

We used a custom-created Visual Basic program running on a Dell OptiPlex 755 desktop computer with a 48-cm monitor to assess resurgence across all experimental procedures (the same general program and experimental arrangement as Romano & St. Peter, 2016). Participants responded by clicking on 24-mm circles of differing colors that moved across the screen at a speed of 25 mm/s. A cumulative point counter was displayed at the bottom left of the screen. Each time the participant met the criterion specified by the reinforcement schedule, the point counter incremented by one while briefly flashing orange.

**Experimental Design**

We used a multiple schedule embedded in a reversal design to demonstrate experimental control. Each 60-min session consisted of three 20-min phases. Within each phase, participants experienced two strictly alternating components. Each component presentation was 2 min in duration. We counterbalanced the first component presented across participants and phases.

**Response Measurement**

Each time the participant clicked the mouse button, the computer program recorded data about the location and time of the click. The computer program recorded whether clicks occurred on the background or on a response option (i.e., moving circle). The program also recorded the time of each point delivery and the contingency that resulted in point delivery. Upon completion of the session, we used a data file generated by the program to calculate response and reinforcement rates.

**Procedure**

At the beginning of an appointment, the experimenter gave the participant a copy of the informed-consent document and reviewed it with the participant. If the participant provided consent, the experimenter asked the participant to place all watches and electronics on a table away from the computer to prevent overt timing of the phases or reinforcement schedules. The experimenter then escorted the participant to the computer and told the participant that the session was 60 min in duration. Once the participant was seated in front of the computer, the experimenter instructed the participant to use only the mouse and the instructions on the screen (e.g., “Press OK to start”) to earn as many points as possible (see Supplemental Materials for complete instructions).
After the first 60-min session of the appointment, the experimenter asked the participant to take a 20-min break outside of the laboratory room but provided no instructions about the experiment or feedback about performance. Following the break, the experimenter escorted the participant back to the computer to begin the second 60-min session. Upon completion of the experiment, the experimenter thanked the participant and offered a copy of the informed-consent document. The experimenter asked the participant to report their age, gender, race, and the course for which extra credit was being earned. The experimenter also briefly interviewed the participant to obtain reports about whether they had any color-vision deficiencies, were taking any psychotropic medications, or had developed self-generated rules about the experimental procedure. After the interview, the experimenter debriefed the participant about the purpose of the study and answered any questions. Data sets from participants reporting having a color-vision deficiency or taking a psychotropic medication, or those that did not show clear changes in responding between Phases 1 and 2 (i.e., insensitive to changes in contingency), would have been excluded, but this did not occur.

**Phases**

Alternating components were signaled by the background color on the computer screen. The components associated with serial training or five response options (i.e., moving circles) had a vermillion background. The components associated with single training or two response options had a blue background. For each experiment, the same response options were available across phases and components, except as described below (see Supplemental Materials for a complete list of colors and Red-Green-Blue (RGB) values used for background and response options).

**Target reinforcement.** During both components in all three experiments, points were delivered for the first click on the black circle after 2 s elapsed (a fixed interval [FI] 2-s schedule). Clicks on any available alternative response options (i.e., different colored circles) were not reinforced.

**Alternative reinforcement (DRA).** During both components in all three experiments, points were no longer delivered for clicking the black circle (extinction). Instead, points were available for clicking a designated alternative response (e.g., orange circle) on an FI 2-s schedule. The designated alternative response differed across components.

**Resurgence.** During both components in all three experiments, all responses were placed on extinction (no points were delivered). We defined resurgence as an increase in target response rate during at least one component presentation during extinction relative to the last three presentations of the same component in DRA. This definition is similar to that used in previous evaluations (e.g., Romano & St. Peter, 2016), and may be considered stringent as some responding during extinction (i.e., at a lower rate than during the final component presentations of DRA) would not be considered resurgence.

**EXPERIMENT 1**

**Method**

One male (Participant B) and three female undergraduate students participated in Experiment 1. Participants were 19 or 20 years old ($M = 19.3$ years) and were Caucasian. During Experiment 1, the two alternating components differed in background color on the computer screen, as well as in the number of available response options. The target response (clicking on the black circle) was available in both components. During the component associated with serial training, four alternative responses (orange, blue, green, and yellow) were available. During the component associated with single training, one alternative response (purple) was
available. Thus, regardless of phase, five circles moved around the screen during the component associated with serial training and only two circles moved around the screen during the component associated with single training.

In addition to the differences in the number of circles available, the components included different reinforcement contingencies during the alternative-reinforcement phase. During the serial-training component, four alternative responses were reinforced sequentially on independent FI 2-s schedules for 30 s of each component presentation. Clicking the orange circle was reinforced for the first 30 s, clicking the sky-blue circle was reinforced for the second 30 s, clicking the blue-green circle was reinforced for the third 30 s, and clicking the yellow circle was reinforced for the final 30 s of the 2-min component. The four alternative responses were reinforced in the same order (orange, blue, green, yellow) during each presentation of the serial-training component. During the single-training component, clicking on the purple circle was reinforced on a FI 2-s schedule throughout the 2-min component.

**Results and Discussion**

Figure 1 displays target-response rates for all components and phases for each participant, and shows control by the active reinforcement schedules during each phase of the experiment. For all participants, response rates changed as reinforcement schedules changed across phases, suggesting that points functioned as a reinforcer. During the target-reinforcement phase

![Figure 1](image-url)

Figure 1. Each graph shows results for a participant from Experiment 1. Note the differences in y-axes across participants. Open circles depict target responding during the serial-training component and filled circles depict target responding during the single-training component. Condition labels show baseline (BL), differential reinforcement of alternative behavior (DRA), and extinction phases (EXT).
(denoted as baseline, BL, in the figure), target responding occurred at high rates during both components for all participants, but was differentiated across components during the first baseline for Participant D. During DRA, target responding rarely occurred in either component for all participants. During the resurgence phase (denoted as extinction, EXT, in the figure), target responding surged during both components and exposures to extinction for Participants A, B, and C, although rates sometimes increased relative to the end of DRA by only a few responses (i.e., Participant C, second EXT phase). For Participants A and B, more target responding occurred during the component associated with single training than serial training in both replications of the resurgence phase. Participant C also engaged in more instances of target responding following single training than serial training during the first EXT phase. During the second extinction phase, response rates met our definition of resurgence in both components, but few target responses occurred overall and the number of target responses was approximately equivalent (25 and 23 total responses during extinction following serial and single training, respectively). Responding by Participant D met our definition of resurgence in both components during the first extinction phase, with more target responding following single training than serial training. However, resurgence only occurred during the serial-training condition during the second extinction phase, although the total number of target responses was identical (seven responses) across both components. Thus, although the total number of target responses varied widely across participants, each participant engaged in more total target responses during EXT following single training relative to serial training.

Figure 2 displays only target-response rates during the last three presentations of each component during DRA and all component presentations during EXT for each participant (baseline data are omitted for axis scaling). Both serial and single training effectively suppressed target behavior during DRA; target responding rarely occurred in either condition of DRA for all participants. The scaling of these graphs more clearly shows the increased resurgence following serial training than single training for both replications of extinction for Participants A and B, and the first extinction phase for Participant C.

The results of Experiment 1 replicate the previous literature in several ways. Similar to previous evaluations (e.g., Kestner, Diaz-Salvat, St. Peter, & Peterson, 2018; Romano & St. Peter, 2016), the overall magnitude of resurgence decreased across successive extinction phases for each participant. We also replicated previous studies by demonstrating that less resurgence occurred following serial training relative to single training (Carrasquillo & Ringdahl, in press; Lambert et al., 2015). These findings suggest that serial training may be beneficial in reducing the overall magnitude of resurgence.

However, like the previous studies demonstrating positive effects of serial training on resurgence (Carrasquillo & Ringdahl, in press; Lambert et al., 2015), differences in training type were confounded with the number of available response options across components. During extinction, there were four (Lambert et al., 2015) or five (our study and Carrasquillo & Ringdahl, in press) available response options in the component associated with serial training, but only two available response options in the component associated with single training. Reduced resurgence may be due to participants allocating responses across an increased number of available response options, rather than because of serial training. To evaluate this possibility, we calculated the total number of responses allocated to each response option during extinction. Results of this analysis are shown in Figure 3, where the top graph shows results from Experiment 1. Overall, bar heights are equivalent for Participants A, B, and D, suggesting that the
reduction in target responding during serial training (shown with black shading in the bars) resulted in changes in allocation of responding across available options rather than changes in overall response output. Thus, it seemed likely that equating the number of available responses, regardless of explicit use of serial training, may reduce overall resurgence of target responding. To evaluate the impact of number of response options, we controlled for the number of available alternative responses while varying training type during Experiment 2.

EXPERIMENT 2

Method

Three female undergraduate students participated in Experiment 2. Each participant was 18 years old and Caucasian. We used the same conditions and experimental arrangement as Experiment 1, except that all five alternative responses (i.e., orange, blue, green, yellow, and purple) were available in both conditions across all phases. The same alternative responses were reinforced during the serial-training and single-training conditions as during Experiment 1. Thus, the only procedural differences between Experiments 1 and 2 was that all five alternative response options were available in the single-training condition.

Results and Discussion

Figure 4 displays target-response rates for all components and phases for each participant. During the target-reinforcement phase (labeled...
During DRA, target responding suppressed to near-zero rates in both components for each participant. During the resurgence phase, resurgence occurred for each participant during at least one component presentation across both EXT phases. However, responding during extinction differed from that of the final three presentations of extinction by a few responses in some cases (e.g., second extinction phases for Participants G and F).

Figure 5 displays only target-response rates during the last three presentations of each component during DRA and all presentations during extinction for each participant. Both variations of DRA eliminated target responding for Participant E. During the first exposure to
extinction, seven more target responses occurred in the serial-training condition than the single-training condition, suggesting nearly equal resurgence. During the second extinction exposure, more resurgence occurred in the single-training condition (69 total responses) than in the serial-training condition (15 total responses). Similar results were obtained for Participant F. More resurgence occurred during the serial-training condition (41 total responses) than the single-training condition (36 total responses) during the first extinction phase, but the opposite was true during the second extinction phase (5 total responses during serial-training condition and 13 total in the single-training condition). For Participant G, data were more difficult to interpret because of the low overall rates of responding during the extinction phases coupled with the variability in target responding during the second phase of DRA. Because of this variability, responding during the serial condition of the second extinction phase technically did not meet our criterion to be considered resurgence. Thus, although equivalent resurgence occurred across both conditions during the first extinction phase (58 and 63 total responses in the serial and single conditions, respectively), resurgence occurred only in the single-training condition during the second extinction phase. However, more total target responses occurred during the serial-training condition in this phase (28 total responses) than in the single-training condition (23 total responses).

The allocation of responses across available options is shown in the second graph in Figure 3. When all six response options were available during extinction, participants largely allocated equivalent numbers of total responses to each option across both conditions. As with Experiment 1, these data underscore that the number of available alternatives, rather than the
use of serial training, seemed to impact responding during extinction.

For participants in Experiment 2, the order of exposure to the conditions during extinction appeared to exert a stronger influence on the observed resurgence than did the participants’ histories with a particular variation of differential reinforcement. More total target responses occurred in the first condition during extinction in all six replications of extinction in this experiment. This outcome is consistent with prior research demonstrating possible sequence effects in resurgence studies using multielement experimental designs (e.g., Romano & St. Peter, 2016).

There was a lack of within-subject replication of resurgence effects for all participants, suggesting that training type was unlikely to lead to systematic differences in resurgence. Thus, it is possible that the effects observed in previous studies (Carrasquillo & Ringdahl, in press; Lambert et al., 2015) may not have been due to serial training. However, one major limitation of Experiment 2 was the lack of response differentiation across components during extinction. This lack of differentiation was expected to occur if serial training was not a potent variable influencing responding. Nonetheless, Experiment 2 did not experimentally demonstrate the role of varied numbers of available responses on subsequent resurgence. Instead, it merely showed that training type did not seem to be a strong predictor of resurgence.

To evaluate the influence of the number of

Figure 5. Rates of target responding during DRA and EXT phases only for participants from Experiment 2. Note the differences in y-axes across participants. Condition labels show differential reinforcement of alternative behavior (DRA) and extinction phases (EXT).

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available response options on resurgence, we controlled for the type of training while varying the number of available response options during Experiment 3.

EXPERIMENT 3

Method
Three female undergraduate students participated in Experiment 3. Each participant was 18 or 19 years old ($M = 18.7$ years) and Caucasian. We used the same conditions and experimental arrangement as Experiment 1, except that we used single training in both components. Thus, conditions differed only in background color and the number of available response options. During the condition with four alternative responses, clicking on the orange circle was reinforced on a FI 2-s schedule during DRA. During the condition with one alternative response, clicking the purple circle was reinforced on a FI 2-s schedule during DRA. No other alternative responses were reinforced throughout the experiment.

Results and Discussion
Figure 6 displays target-response rates across all phases during the five-response-option and two response-option components for all participants. During the target-reinforcement phase (labeled BL), target responding occurred at relatively high rates in both components for each participant. During DRA, target responding rarely occurred, regardless of component type. During the resurgence phase (labeled EXT), more target responding occurred during the component associated with two response options than the component associated with

![Figure 6](image_url)

Figure 6. Each graph shows results for a participant from Experiment 3. Note the differences in y-axes across participants. The open circles denote responding during the five-response-option and the closed circles denote responding during the two-response-option component. Condition labels show baseline (BL), DRA, and extinction phases (EXT).
five response options during both extinction phases for all participants.

Figure 7 displays rates of target responding (clicks on the black circle) during the last three presentations of each component during DRA and all presentations during extinction for each participant. Results were consistent across participants. During the last three presentations of each component during DRA, target responding rarely occurred, regardless of condition. During all six extinction phases, an average of 42 more target responses occurred during the two-option condition than during the five-option condition, with at least 10 more target responses occurring in the two-option condition during each replication for each participant.

The bottom graph of Figure 3 shows the allocation of responses during extinction for each participant. As with Experiments 1 and 2, participants generally emitted similar overall numbers of responses in each condition during extinction. However, the distribution of the responses varied across conditions. As in the previous experiments, approximately equal numbers of responses were allocated to each of the available options. This approximately equal distribution across fewer options led to more target responding in the two-option condition than in the five-option condition.

Results of Experiment 3 demonstrate that the number of available response options impacts resurgence. More target responding recurs during extinction when participants have

![Figure 7](image_url)
fewer ways to allocate their responding. These results further underscore the potential importance of teaching multiple appropriate responses when subsequent resurgence of challenging behavior is of concern.

Notably, in the current study, less resurgence occurred in the condition associated with more response options even though those responses were never explicitly reinforced in the experiment. There were likely idiosyncratic features of our experiment that contributed to this outcome. First, available responses were clearly signaled to participants by the number of circles that moved around the computer screen. The available responses may be less obvious to clients who engage in socially significant behavior (e.g., a vocal mand rather than challenging behavior to access attention). This may be particularly true for clients for whom particular methods of communication may be more salient or preferred than others. For example, a client who could engage in appropriate alternative responses using a picture-exchange system, sign language, or rudimentary spoken language may not readily identify all three responses as “available” options. Second, available responses were all topographically identical (clicking on moving circles), which may have increased the likelihood of response induction, making never-reinforced responses more likely to occur. Such topographically identical responses are unlikely to occur as forms of both target and alternative behavior during clinical use of DRA, and induction seems an unlikely explanation for reduced resurgence of first-trained responses in evaluations of serial training using highly controlled animal studies (e.g., Lattal, Solley, Cançado, & Oliver, 2019). Nonetheless, these features of our experiment may be useful fodder for further evaluations of DRA variations that might reduce resurgence. Future researchers might examine the role of signaling availability of previously taught alternatives, or whether teaching topographically similar alternatives (e.g., multiple variations of a spoken request) results in less resurgence than topographically distinct alternatives.

GENERAL DISCUSSION

Previous evaluations showing positive effects of serial training on subsequent resurgence have confounded training type and the number of available response options (e.g., Carrasquillo & Ringdahl, in press; Lambert et al., 2015). We isolated serial training and the number of available response options across a series of experiments to examine which variable had a more substantial impact on resurgence. During Experiment 1, we systematically replicated previous studies (Carrasquillo & Ringdahl, in press; Lambert et al., 2015) by varying both the type of training (single or serial) and the number of available responses. As was demonstrated in previous studies, more resurgence occurred in the condition associated with single training (with one alternative response available) than the condition associated with serial training across multiple alternative responses. During Experiment 2, we varied the type of training (single or serial) while holding the number of available responses constant. Resurgence appeared to be more affected by the condition order than by the variation of DRA. During Experiment 3, we varied the number of available response options while holding training type constant (i.e., single training in both components). Less resurgence occurred in the condition associated with more available response options, although additional response options had not contacted reinforcement. Collectively, these results suggest that the number of available response options, and not serial training per se, may have led to reduced resurgence in previous studies.

Several variables are known to influence resurgence. One such variable is the reinforcement rate during baseline and alternative reinforcement phases. A history with high rates of reinforcement may increase resurgence relative
to a history with lower reinforcement rates (Cançado, Abreu-Rodrigues, & Aló, 2015; Podlesnik & Shahan, 2009, Experiment 2). We attempted to control for differences in reinforcement rate by using interval schedules. Despite this attempt at control, it remained possible that obtained reinforcement rates differed across conditions and may have accounted for differences in resurgence. To ensure differences across conditions were not due to differences in reinforcement rate, we calculated mean reinforcement rates across conditions and phases (see Supplemental Materials for tables showing obtained reinforcement rates). Mean reinforcement rates across all participants differed minimally across conditions in baseline. Mean reinforcement rates in the single-training DRA condition ($M = 27.8$ reinforcers/minute) consistently exceeded those in the serial-training DRA ($M = 25.7$ reinforcers/minute). Because resurgence differed across experiments, but reinforcement rates did not, such differences seem unlikely to be due to reinforcement rate alone. Nonetheless, future studies may wish to more fully yoke reinforcement rates across conditions.

Explicit histories of reinforcement were not necessary for new alternative responses to emerge during extinction (Experiment 3). Thus, although an explicit reinforcement history is considered necessary for resurgence, more than just these histories contributed to responding in the current study. The behavioral variability during extinction in our study may have occurred because of extinction-induced variability (Grow, Kelley, Roane, & Shillingsburg, 2008) or because variability was reinforced (Galizio et al., 2018). Recent basic research suggests that the sequence in which responses are taught affects the likelihood of later resurgence, with more recently taught responses resurging at higher rates than responses with a more distant reinforcement history (Lattal et al., 2019). In our study, both conditions had a more recent history of reinforcement than did target responding. It remains possible that one (perhaps unintended) effect of serial training is that the time required to teach new responses in sequence necessarily promotes a more distant history of reinforcement for challenging behavior. In our study, the duration of training was equated across serial and single conditions, which may be unlikely to occur in clinical practice. Future studies might compare the training time required to meet a preset criterion with serial and single training, and evaluate whether training time or training type has a stronger influence on later resurgence.

Similar to previous evaluations (e.g., Lambert et al., 2015), we demonstrated control during each experiment using a multielement design in which we alternated between two conditions (i.e., serial and single training) with different background colors distinguishing the conditions. We obtained differentiated responding across conditions during the baseline and DRA phases, suggesting that participants discriminated between the two conditions, and participants often verbally reported that the “right” circles changed between conditions. One critical feature of our study was ensuring that participants’ behavior changed during serial training as the contingencies changed. To ensure that this was the case, we analyzed the number of responses allocated to each alternative option during the serial condition of the alternative-reinforcement phase during Experiments 1 and 2. Data showed clear changes in responding as the reinforcement contingencies shifted (see Supplemental Materials, Figures A and B). Despite these changes in responding corresponding to changes in the contingencies, participants may have experienced the alternation between single and serial training as learning five alternative responses serially, rather than as one serial-training condition and one single-training condition. An additional limitation of the multielement design is that one condition necessarily must
precede the other following the transition to extinction. The sequence in which participants experience conditions may affect responding, with more resurgence occurring during the condition occurring first in the extinction phase. This sequence effect appeared to influence responding during Experiment 2. Using group designs in future research may avoid both of these limitations but may sacrifice examination of within-subject differences.

We used dense reinforcement schedules (FI 2 s) during baseline and DRA to facilitate rapid contact with the contingencies, and changes in contingency. The frequent delivery of reinforcement (which averaged 27 reinforcers/minute across all participants and response-dependent reinforcement phases) likely contributed to the rapid changes in behavior, allowing demonstration of experimental control over a 2-hr session. Frequent reinforcer delivery may have also made the shift to extinction highly discriminable for our participants, thereby reducing persistence of alternative behavior and potentially contributing to decreased resurgence during the second extinction phase. Changes in contingency are unlikely to be highly discriminable in clinical applications of DRA, and future researchers may wish to conduct longer sessions with leaner reinforcement schedules to approximate clinical practice more closely.

The obtained resurgence in our study was fairly small and usually transient. Although transient recurrence may not initially seem concerning, continued extinction in the face of resurgence may be critical for recovering treatment effects. In our clinical experience, recurrence of challenging behavior following treatment may result in treatment integrity errors in which a reinforcer is delivered after a challenging response (i.e., commission error; St. Peter Pipkin, Vollmer, & Sloman, 2010). Higher levels of resurgence (e.g., Participants A and B) may result in a greater likelihood of commission errors, and therefore a greater chance of challenging behavior continuing. Conversely, reducing the likelihood of resurgence might reduce the probability of accidental reinforcement of challenging behavior. However, these hypotheses remain speculative and should be directly addressed in future research.

Our results suggest that the number of available responses influences subsequent resurgence more than the type of training used to promote the alternative responses. Thus, practitioners should fully consider the needs and current repertoires of their clients rather than focusing on the use of serial-training procedures. Explicit comparisons of training methods that promote multiple responses (e.g., lag schedules, concurrent schedules, serial training) are warranted. Regardless of the specific training procedures used, practitioners should consider ways to increase the number of appropriate response options available to their clients.

The teaching of multiple responses need not be limited to those traditionally considered communicative. In addition to teaching appropriate ways to ask for functional reinforcers, practitioners could consider expanding functional response classes to include other topographies, like completing work or appropriately engaging with leisure activities. Practitioners might also consider reinforcing variable or “spontaneous” appropriate alternative responses, which may mitigate resurgence similarly to teaching new alternatives (e.g., Grow et al., 2008). Lastly, practitioners should consider that clients are likely to already have learned multiple topographies of challenging behavior (e.g., hitting, kicking, biting, and grabbing) and resurgence of multiple topographies may be likely (see Lieving, Hagopian, Long, & O’Connor, 2004, for an example). When clients have robust repertoires of challenging behavior, it may be particularly important to include multiple alternative responses to reduce subsequent resurgence.
The necessary and sufficient strategies for increasing the number of available responses should be empirically identified. Although serial training is one method of teaching multiple responses, researchers should consider other variations of DRA that provide reinforcement for multiple alternative responses. For example, researchers may reinforce several alternative responses concurrently rather than sequentially. In this case, each alternative response may be associated with a separate schedule of reinforcement and participants may engage in any or all responses to earn reinforcement. Alternatively, researchers may expose participants to lag schedules of reinforcement (e.g., Adami, Falcomata, Muething, & Hoffman, 2017), in which reinforcement is contingent on responding differently than a specified number of previous responses. Unlike serial DRA arrangements which reinforce a programmed set of alternative responses in a sequential order, lag schedules explicitly reinforce diverse topographies and may incidentally teach additional alternative responses beyond those that would be programmed for reinforcement in other DRA arrangements (e.g., traditional [single], serial, or concurrent). Further investigations of these DRA variations may improve long-term treatment outcomes for clients by identifying effective and efficient strategies to mitigate resurgence.

REFERENCES


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Additional Supporting Information may be found in the online version of this article at the publisher’s website.