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Destructive Behavior Increases as a Function of Reductions in Alternative Reinforcement During Schedule Thinning: A Retrospective Quantitative Analysis

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Abstract

The behavioral processes determining the magnitude of the resurgence of destructive behavior during reinforcement schedule thinning have yet to be described, despite an uptick in prevalence research on the topic. As predicted by Resurgence as Choice theory, recent animal research has found that resurgence increases with the magnitude of a downshift in alternative reinforcement. Here we reanalyze the data from two recent prevalence studies to determine whether the size of the decrease in alternative reinforcement availability predicts the magnitude of resurgence in the clinic. Results from this retrospective analysis suggest that resurgence of destructive behavior increases significantly with decreases in the availability of alternative reinforcement. Implications for future research and translations of theoretical analyses to the clinic are discussed.

Keywords

destructive behavior; functional communication training; reinforcement schedule thinning; resurgence; translational research

Resurgence is an increase in a previously suppressed target behavior when the conditions of reinforcement for a more recently reinforced alternative behavior worsen in some way (e.g., Lattal & Wacker, 2015; Shahan & Craig, 2017). In laboratory studies, a typical resurgence preparation is comprised of three phases in which a target behavior is reinforced in Phase 1 and then extinguished in Phase 2 while an alternative behavior is reinforced. In Phase 3, the alternative behavior is also extinguished, resulting in an increase in the target behavior (i.e., resurgence). This progression shares similarities with conditions that can give rise to relapse of destructive behavior during clinical interventions that rely on differential reinforcement. For example, during functional communication training (FCT; Carr & Durand, 1985), destructive behavior that produced reinforcement during baseline

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is extinguished while an alternative behavior is reinforced according to an initially dense schedule of reinforcement. Following reductions in the rate of destructive behavior upon the introduction of treatment, reinforcement schedule thinning often follows in order to increase the practicality of the intervention procedures (Hagopian, 2011). Reductions in the rate of reinforcement for alternative behavior during reinforcement schedule thinning in the clinic constitute a worsening in reinforcement conditions similar to that produced by transitioning from Phase 2 to Phase 3 in the laboratory preparation.

Increased interest in the resurgence of destructive behavior has brought about a flurry of recent investigations on the prevalence, magnitude, and persistence of resurgence as it occurs in practice, as well as methods for mitigating such deleterious effects (Briggs et al., 2018; Brown et al., 2020; Fisher et al., 2018, 2019, 2020; Fuhrman et al., 2016; Greer et al., 2020; Mitteer et al., in press; Muething et al., 2021). Studies on the prevalence of resurgence of destructive behavior during reinforcement schedule thinning have shown the phenomenon to be quite common. For example, in two independent samples of patients whose destructive behavior was treated using FCT, both Briggs et al. (2018) and Mitteer et al. (in press) found that resurgence occurred across 76% of applications of reinforcement schedule thinning.¹ Similarly, Muething et al. (2021) recently reported that 90% of patients treated with FCT showed resurgence at some point during reinforcement schedule thinning in a cross-site replication. However, such prevalence research has been limited in that no study to date has directly examined how variables implicated by basic theoretical research might affect the magnitude of resurgence as it occurs in the course of reinforcement thinning during the treatment of destructive behavior.

Resurgence as Choice (i.e., RaC) theory suggests that resurgence is governed by the same basic processes that govern choice (see Shahan & Craig, 2017; Shahan, Browning, Nall, 2020; Shahan, Browning, Nist, et al., 2020, for full quantitative details). In brief, the theory is an extension of the concatenated matching law (Baum & Rachlin, 1969) and suggests that the allocation of behavior to target and alternative options over time is governed by the relative values of those options over time. The theory provides a means to quantify how the histories of reinforcement for the target and alternative behavior affect the values of those options, including when those histories include extinction conditions. The theory suggests that an increase in target behavior associated with extinction of the alternative behavior (i.e., resurgence) results from a precipitous decrease in value of the alternative option with the onset of extinction for that option, and as a result, a *relative* increase in the value of the previously extinguished target behavior.

Although a transition to extinction of an alternative behavior is the most common means to examine resurgence in the laboratory, RaC suggests that any change that decreases the value of the alternative option might be expected to generate an increase in target responding. Indeed, decreases in the value of an alternative imposed via reductions in reinforcement magnitude (Craig et al., 2017) or the introduction of punishment for the alternative option

¹A single individual may have more than one application of reinforcement schedule thinning during FCT. One common reason for this is when clinicians conduct reinforcement schedule thinning for distinct functions of destructive behavior independently (e.g., one progression of reinforcement schedule thinning for escape, another for attention).

(Fontes et al., 2018) have also been shown to generate resurgence. Further, and most importantly for resurgence during reinforcement schedule thinning during FCT, RaC also predicts that reductions in the value of the alternative option generated by decreases in reinforcement to non-zero levels can also generate resurgence of target behavior. Specifically, RaC predicts that the magnitude of resurgence increases with increases in the size of the downshift in alternative reinforcement rate (for simulations, see Greer & Shahan, 2019; Shahan & Craig, 2017).

The prediction that resurgence should increase with larger reductions in alternative reinforcement was recently confirmed in a study with rats by Shahan, Browning, Nist, et al. (2020). Specifically, following training on a variable-interval (VI) 30-s schedule in Phase 1, five groups of rats were exposed to extinction of the target behavior and reinforcement of an alternative behavior on a VI 10-s (i.e., 360 rein/hr) schedule in Phase 2. During Phase 2, target responding of the rats in all groups was reduced to the same low level. In Phase 3, the different groups received different magnitudes of downshifts in alternative reinforcement spanning from no change to complete extinction (i.e., VI 10 s, VI 20 s, VI 40 s, VI 80 s, and extinction). Target response rates in Phase 3 increased exponentially as a function of the magnitude of the alternative reinforcement rate decrease.

The results of Shahan, Browning, Nist, et al. (2020) have important implications for implementing reinforcement schedule thinning while treating destructive behavior with FCT. However, applied parallels to this study do not yet exist, limiting our understanding of whether such findings hold in the clinic. Thus, the purpose of the present investigation was to take one step toward such a prospective study by extracting data from two recent studies on the prevalence of resurgence of destructive behavior during FCT reinforcement schedule thinning to determine retrospectively if resurgence similarly tends to increase in the clinic with increases in the size of the downshift in alternative reinforcement.

Method

The first authors of Mitteer et al. (in press) and Muething et al. (2021) provided us with summary spreadsheets relevant to their recent analyses of resurgence during FCT reinforcement schedule thinning that contained average baseline rates of destructive behavior and information on session duration, rate of destructive behavior, and alternative reinforcement availability for each transition in which they concluded resurgence had occurred (see below). Because response rates varied widely across participants, we converted all rates of destructive behavior during FCT to a proportion of baseline responding by dividing each session's response rate by the baseline average used in their analyses of resurgence. Both studies used compound schedules of reinforcement during reinforcement schedule thinning, and decreases in alternative reinforcement consisted of increasing the amount of time in which extinction of alternative responding was in effect relative to the amount of time in which alternative reinforcement was available (e.g., by lengthening the extinction component relative to the reinforcement component of a multiple schedule).

Data from Mitteer et al. (in press) contained information on the number of seconds of each treatment session in which the participant had access to the functional reinforcer; however,

this same information was inconsistently available for participants in Muething et al. (2021). Therefore, we used the highest resolution possible from each dataset by analyzing the reinforcement- and extinction-component durations to quantify decreases in the availability of alternative reinforcement for Muething et al. but precise reinforcer-access durations to quantify this same information for Mitteer et al. Because the number and duration of reinforcers and session duration could vary, we divided the total number of seconds in which the alternative reinforcer was available (Muething et al., 2021) or delivered (Mitteer et al., in press) during a session by the duration of the session to derive a proportion that served as the measure of alternative reinforcement availability. These proportions were then averaged across sessions that preceded (typically two sessions) or followed (typically three sessions) a decrease in alternative reinforcement availability. The difference in reinforcer availability from before and after the transition quantified the decrease in alternative reinforcement availability (e.g., a 0.1 decrease in alternative reinforcement availability representing a 10% drop in the proportion of session duration in which the alternative reinforcer was available). We included only those transitions in which the availability of alternative reinforcement decreased and resurgence of destructive behavior occurred (i.e., an increase in the rate of destructive behavior in at least one of the three sessions that followed a decrease in the availability of alternative reinforcement compared to the immediately preceding response rates). Ensuring that resurgence had occurred in each included transition allow us to analyze resurgence magnitude, which is likely to be especially relevant in the clinic. For all transitions meeting this criterion, average response rates increased following the decrease in alternative reinforcement availability.

Applying these criteria to the two studies resulted in 10 and 25 applications of FCT schedule thinning for Mitteer et al. (in press) and Muething et al. (2021), respectively. This equated to 38 and 70 transitions, respectively, in which the availability of alternative reinforcement decreased and destructive behavior resurged. However, several included FCT applications across the two studies ($n = 7$) had only a single transition meeting these criteria, and although the majority of included FCT applications ($n = 28$) had at least two eligible transitions, many of those FCT applications ($n = 18$) involved transitions with decreases in the availability of alternative reinforcement within a narrow range. Therefore, we restricted our analysis to only those included FCT applications that had at least two eligible transitions that spanned a total decrease in alternative reinforcement availability of at least 20% (e.g., a 10% decrease in Transition 1, but a 30% decrease in Transition 2). This was done to permit both within- and across-participant analysis of resurgence magnitude. The final dataset was comprised of 10 total FCT applications (four from Mitteer et al., in press; six from Muething et al., 2021) and 41 total transitions (19 from Mitteer et al., in press; 22 from Muething et al., 2021).

Results

Figure 1 displays destructive behavior as a proportion of baseline responding plotted against decreases in the availability of alternative reinforcement. The data are separated by FCT application (i.e., participant). The first four panels in the left column are from Mitteer et al. (in press), and the remaining panels are from Muething et al. (2021). A positive function emerges for the majority of FCT applications within and across the two studies. Only two of

the 10 panels (third and fourth panels in the right column) show a function that is less than clearly positive. The logarithmic scaling of the y-axis suggests a robustly positive relation in the other eight panels.

Figure 2 plots these same data in a common space. Linear regression conducted on semilogarithmic-transformed (base $\ln$) data revealed that destructive behavior increased significantly with larger decreases in the availability of alternative reinforcement $F(1,39) = 19.23, p < .001$. This outcome suggests that the size of the decrease in alternative reinforcement availability predicted the magnitude of resurgence of destructive behavior. This retrospective analysis produced a coefficient of determination (R^2) value of .33. The significant linear relation in the semi-logarithmic space implies a positively accelerating exponential function. The inset panel shows the same function in arithmetic space and its corresponding equation.

Discussion

The present retrospective analysis suggests that destructive behavior during FCT reinforcement schedule thinning increases with increases in the magnitude of downshifts in alternative reinforcement availability. This outcome is consistent with recent findings from the animal laboratory (Shahan, Browning, Nist, et al., 2020), as is the roughly exponential form of the function relating resurgence to downshifts in alternative reinforcement. The similarity of findings across these settings is noteworthy given the extensive differences between them, including the species, procedures employed, and nature of the measures used. Although these differences make direct comparisons of the animal and clinical data difficult, the overall similarity in form of the functions suggests that similar processes could be at work.

RaC suggests that resurgence associated with reductions in alternative reinforcement to non-zero levels results from decreases in the value of the alternative option, and thus, a relative increase in the value of the previously suppressed target option. The changes in value of the alternative option increase with increases in the size of the downshift in alternative reinforcement, and as a result, more resurgence is expected. The fact that RaC provides a good quantitative description of such effects from the animal laboratory and that similar functional forms are apparent in retrospective clinical data suggest that RaC might have some utility for describing and predicting resurgence in the clinic. Although the studies involved in this reanalysis involved only decreases in alternative reinforcement access time, RaC suggests that resurgence in the clinic might also be an increasing function of any other manipulation that similarly decreases alternative reinforcement value (e.g., increasing delay, effort, decreases in quality; see Greer & Shahan, 2019; Shahan & Craig, 2017, for discussion).

One limitation of this retrospective analysis is that 25 of the 35 FCT applications (71.4%) could not be included due to having too few transitions or having transitions comprised of only a very narrow window of decreases in the availability of alternative reinforcement. Reasons for why clinicians rarely attempted larger decreases in the availability of alternative reinforcement likely varied. But, it seems reasonable that the relationship described herein

between increased resurgence and decreased availability of alternative reinforcement might already control clinical decision making, at least implicitly through the development of clinical lore or verbal rules that guide standard practice (e.g., always ensuring at least a 1:4 ratio of reinforcement availability to unavailability; Greer et al., 2018).

A related limitation is that we analyzed only transitions with resurgence to gain a clearer understanding of whether resurgence magnitude (i.e., when resurgence had occurred) was predicted by decreases in the availability of alternative reinforcement. A prospective analysis of differing transition magnitudes (e.g., a 10%, 25%, and 50% decrease in alternative reinforcement) in which all participants experience each transition type, and data from all transitions are included for analysis, appears to be a logical next step for determining whether this retrospective analysis holds up under prospective, experimental analysis.

The results of such studies could advance not only our understanding of the translational value of basic research and the theoretical underpinnings of resurgence (e.g., Greer & Shahan, 2019; Shahan, Browning, Nall, 2020; Shahan, Browning, Nist, et al., 2020) but could also help to define empirically guided progressions for reinforcement schedule thinning in the clinic. One hope is that the clinical lore that often determines how and when reinforcement schedule thinning occurs might be supplanted by an approach that better maps out quantitative regularities in clinical data in order to make better empirically and theoretically informed decisions.

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Figure 1.

Resurgence as a Function of Decreased Alternative Reinforcement by Participant

Note. Proportion-of-baseline increase in destructive behavior across sessions that preceded and followed a decrease in the availability of alternative reinforcement. Each panel displays the data of one participant. Note the logarithmic y-axes and expanded y-axis range of the top two panels.

Figure 2.

Resurgence as a Function of Decreased Alternative Reinforcement

Note. Proportion-of-baseline-adjusted increases in destructive behavior across sessions that preceded and followed a decrease in the availability of alternative reinforcement. The line in the main panel is a linear regression. Note the logarithmic y-axis. The inset panel shows the same regression line presented in arithmetic space.