Response-strengthening effects of same- and different-context DRA training: The effects of two disruptors

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Differential reinforcement of alternative behavior (DRA) involves placing problem behavior under extinction and simultaneously reinforcing a desirable behavior. Recent research revealed that, as predicted by Behavioral Momentum Theory, DRA may also increase the persistence of the problem behavior. This research has also shown that a different approach to DRA, in which an alternative behavior is trained in a separate context from the target behavior, produces less persistence than the standard procedure. The research on this phenomenon, so far, assessed persistence using extinction as the disruptor. DRA, however, is often implemented under conditions in which extinction of the problem behavior is not feasible. This study evaluated persistence of problem behavior following same- and separate- context DRA training using an alternative disruptor, an additional source of reinforcement. Following a successful reproduction of a previous study of extinction as a disruptor but with domestic hens, this study produced similar findings using an additional source of reinforcement as the disruptor. These findings add to the evidence that alternative DRA arrangements may avoid the response-strengthening effects found with traditional DRA procedures. The findings also demonstrate that disruptors other than extinction can be used to investigate response persistence following DRA and other procedures.
Key words: differential reinforcement of alternative behavior, differential reinforcement, persistence, behavior momentum, hens

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Many behavior analysts have acknowledged the gap between basic and applied research and highlighted the need for relevant translational research. Borrero et al. (2007) suggested that the use of differential reinforcement of alternative behavior (DRA), a procedure commonly used to reduce challenging behaviors, can be informed by basic research. In DRA procedures, reinforcement is arranged for an alternative, desirable behavior, while reinforcement for the challenging behavior (the problem or target behavior) is withheld (Petscher et al., 2009; Vollmer & Iwata, 1992). Although DRA has been found to reliably reduce the frequency of a broad range of problem behaviors reliably (St. Peter Pipkin et al., 2010), it can also increase the problem behaviors' strength or resistance to

disruption (i.e., their persistence; Mace et al., 2009, 2010; Nevin et al., 1990). Mace et al. (2009) suggested that this increased persistence is a result of the increased availability of reinforcement when the DRA procedure is in effect. Behavioral Momentum Theory (BMT; see Nevin, 2015, for a detailed explanation of BMT) is one conceptual framework that provides an explanation for this effect; increasing reinforcer density in a given context can increase the persistence of all responses that have occurred in that context (see Podlesnik & DeLeon, 2015; Fisher et al., 2018, for a detailed explanation of BMT as it relates to DRA procedures).

Using a laboratory model of a DRA procedure, Mace et al. (2010) investigated a potential solution to the problem of response-strengthening effects of the DRA procedure. In Part 3 of their study, rats' left and right lever presses were analogous to alternative and target (problem) behaviors. The responses were reinforced separately, each in the presence of a different stimulus, to replicate training in two separate stimulus contexts. The alternative response was reinforced under a relatively rich schedule of reinforcement and the target response under a relatively lean schedule of reinforcement. For comparison with

a standard DRA procedure, Mace et al. also arranged a concurrent schedule in which both left and right lever presses were reinforced in the presence of the same stimulus, termed the DRA Component. Then, under extinction conditions, they evaluated the persistence of the responses in the traditional DRA Component, and of the two separately trained responses, which were combined into one context during extinction (termed the Combined Component; see Table 1). Mace et al. found that target responding was less persistent when it had been trained in a "separate context" in comparison to when it had been trained in the "same context" as the alternative response, despite equal reinforcement rates during baseline. In the same study, a clinical test of this model with humans showed that, as in the laboratory model, training an alternative behavior in a separate context reduced the persistence of target responding in comparison to a condition in which alternative and target responses were reinforced in the same setting.

Using pigeons, Podlesnik et al. (2012) replicated Mace et al.'s (2010) study, adjusting the procedure slightly to account for the increased presentations of the target stimulus during the extinction tests in Mace et al.'s procedure (see Table 1 for a summary of the conditions in Podlesnik et al.'s study). Results were consistent with Mace et al.; target key responding was more persistent in the DRA Component where both responses were trained together than in the presence of the two stimuli associated with the responses trained separately and combined during extinction (i.e., the Combined Component). In other studies, higher rates of responding following exposure to higher reinforcement frequency within a particular environment have been found (Ahearn et al., 2003; Pritchard et al., 2014;

Table 1

Conditions Presented in Present and Other Relevant Studies

Condition	Component	Mace et al. (2010)		Podlesnik et al. (2012)[a] & Present Study Part 1[a]		Present Study Part 2[b]		
		Left 96 rfts/hr	Right 24 rfts/hr	Left VI 37.5 s	Right VI 150 s	Left VI 37.5 s	Center VI 150 s	Right VI 150 s
Baseline	DRA	5 f/s	5 f/s	Y	Y	Y	X	Y
	OnlyAlt	Const.	X	G	X	G	X	X
	OnlyTar	X	1 f/s	X	B	X	X	B
Disruptor 1	DRA	5 f/s	5 f/s	Y	Y	Y	R	Y
	COMB	Const.	1 f/s	G	B	G	R	B
	OnlyTar	X	1 f/s	X	B	X	X	X
Disruptor 2	DRA			Y	Y	Y	R	Y
	COMB			G	B	G	R	B
Disruptor 3[c]	OnlyAlt + DRATar			G	Y	G	R	Y
	OnlyTar [c]			X	B	X	X	X
Disruptor 4	DRATar			X	Y	X	R	Y
	OnlyAlt			G	X	G	R	X
	OnlyTar			X	B	X	R	B
Reinstatement Test/ Disruptor 5[d]	DRA			Y	Y	Y	R	Y
	COMB			G	B	G	R	B

Note. Abbreviations: DRA = the two stimuli (left and right yellow [Y]) associated with the target and alternative responses trained under traditional DRA condition, OnlyAlt = the stimulus associated with the alternative (richer) trained alone (left green [G]), OnlyTar = the stimulus associated with the target (leaner) trained alone (right blue [B]), COMB = the OnlyAlt and OnlyTar stimuli presented together, DRATar = right yellow key (presented during disruptor test), rfts/hr = number of reinforcements per hour; f/s = flashes per second (of stimulus light); Const. = constant/nonflashing stimulus light; R = red disruptor key and X = an unlit/inactive key. [a] Extinction was the disruptor in this study [b] An additional source of reinforcement (red center key) was the disruptor in this study. [c] Components were presented this way during Podlesnik et al. (2012) and Part 1 of this study, but the Only Target key was omitted during Part 2 due to a procedural error. [d] Reinstatement test in [a] Present Study Part 1 and Podlesnik et al. (2012) and Disruptor 5 in Present Study Part 2. See Method for further procedural details.

Romani et al., 2016), but Mace et al. and Podlesnik et al. specifically examined the effects of combining stimuli associated with responses that were trained in separate environments.

Further to Mace et al.'s (2010) original applied experiment, Suess et al. (2020) produced additional evidence that separate-context training prior to combining stimuli during extinction may be advantageous in applied settings when conducting functional communication training (FCT), a common DRA-based procedure. In FCT, an appropriate form of communication is the alternative behavior that is reinforced while problem behavior is typically extinguished within the same context. Suess et al. taught the communication response in a context that had little to no association with prior reinforcement and found that this separate-context approach significantly reduced resurgence of the problem behavior.

A variety of disruptors have been used to assess the strength of the response in research related to BMT, including changes in reinforcer magnitude, (e.g., Harper & McLean, 1992), but extinction has been the disruptor of choice so far in the translational research relevant to DRA. In applied settings, however, extinction is often impossible or impractical to implement (Brown et al., 2020), either for safety reasons, or because multiple sources of reinforcement often maintain a behavior, and these cannot be easily controlled or removed. In such situations, variants of the DRA procedures, in which a rich schedule of reinforcement for an alternative response is arranged while reinforcement for a target response (i.e., problem behavior) is still available, usually under a leaner schedule of reinforcement, may be useful. Such DRA procedures have been shown to be effective at reducing problem behavior in individuals with a range of developmental disabilities and severe challenging behaviors (Petscher et al., 2009). Thus, when it is not feasible or safe to implement extinction in an applied setting, an alternative behavior may still be selected and reinforced systematically even though the reinforcer for the target behavior cannot be withheld. BMT suggests that this DRA procedure will increase the persistence of the target behavior, and that this behavior will be more persistent than it would be had the alternative behavior been trained in a separate context. One disruptor that can be used to test this prediction is an additional source of reinforcement because it can be introduced without discontinuing reinforcement for the target and alternative behaviors. However, relevant applied or translational research has not yet been conducted. It would be beneficial, therefore, to examine the persistence of the target behavior following alternative-context training, as did Mace et al. (2010) and Podlesnik et al. (2012), but in the presence of a disruptor such as a signal of the availability of an additional source of reinforcement.

In an applied scenario, a newly available educational game on a tablet or attention from a new assistant who is brought into the classroom could signal the availability of additional reinforcers. In an experimental setting, an additional source of reinforcement could be made available. The provision of a separate key that signaled additional reinforcer availability has been used previously to investigate response strength in chained schedules (Nevin et al., 1981), but has not been used in a DRA-like arrangement. In the present investigation, we evaluated the influence of a stimulus associated with an additional source of reinforcement on the continued persistence of target responding following same- and alternative-context training using domestic hens (*Gallus gallus domesticus*). To make sure the stimulus signaled additional reinforcer availability, the hens were trained to peck a key that was a different color from those used in the DRA and separate-context training, in a separate experimental chamber, prior to the DRA and separate-context training. The effect of the addition of this stimulus as a disruptor was evaluated while target and alternative stimuli were combined, and reinforcement for responses to both stimuli were still in effect. Prior to exposing the hens to this additional reinforcement disruptor evaluation, we replicated the conditions of Podlesnik et al. (2012), using extinction as a disruptor, which allowed us to confirm the general phenomenon in this species and allowed for a comparison of the effects of these two disruptors.

As in Mace et al. (2010) and Podlesnik et al. (2012), we used a three-component multiple schedule procedure in this study (Table 1). In the DRA Component, as shown in Figure 1, two keys were illuminated yellow; pecking of the left key was reinforced under a rich schedule and pecking of the right key was

reinforced under a lean schedule of reinforcement, representing the conditions of a standard DRA procedure. In the Alternative Component, the left key was illuminated green and pecks to this key were reinforced under a rich schedule of reinforcement; in the Target Component, the right key was illuminated blue and pecks to this key were reinforced under a relatively lean schedule of reinforcement. These two latter components represent a procedure in which an alternative behavior is trained in a separate context from the target behavior. In test sessions, the Combined Component involved presenting the blue and green keys together, which represented adding stimuli associated with the separately trained alternative behavior to the context in which the target behavior had been reinforced. The persistence of these responses was examined using extinction in a variety of

different stimulus contexts in the test conditions, (see Fig. 1 for exact key presentations). Extinction Tests 1 and 2, as in Podlesnik et al. (2012), were designed to investigate the persistence of responding to the DRA Component and the Combined Context Component, with the addition of the Only Target key in Extinction Test 1. Extinction Tests 3 and 4, also replications of Podlesnik et al. (2012), were designed to investigate the effects of combining the alternative stimulus trained alone during baseline, with the various target stimuli and the persistence of responding to these stimuli alone. Combining the alternative response trained alone with the target response trained in the DRA Component during Extinction Test 3 allowed for examination of whether persistence of responding was due to the overall reinforcement rate in the DRA context during baseline. Presenting the stimuli individually allowed for the persistence toward each stimulus to be examined. Extinction Test 5, as in Podlesnik et al. (2012), was designed to investigate relapse of target responding.

To evaluate the influence of an additional source of reinforcement as a disruptor, in Part 2, hens were exposed to a lean reinforcement schedule for responding to a red key in a separate chamber, as mentioned previously, prior to the DRA and separate-context training After the DRA and separate-context training there were disruptor tests, in which a red center "disruptor" key was introduced in the main experimental chamber along with the relevant target and alternative response stimuli as shown in Figure 2. The disruptor tests, outlined in Table 1, allowed assessment of the

Figure 1

Key Colors and Schedules as arranged for each Component during Baseline of Parts 1 and 2
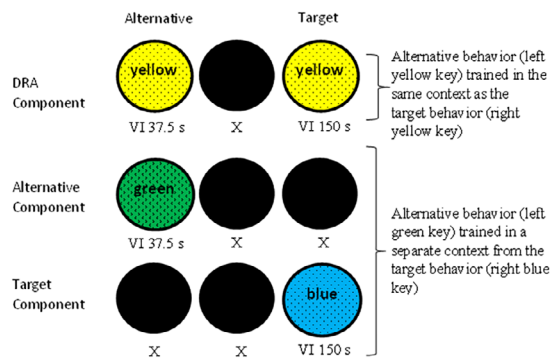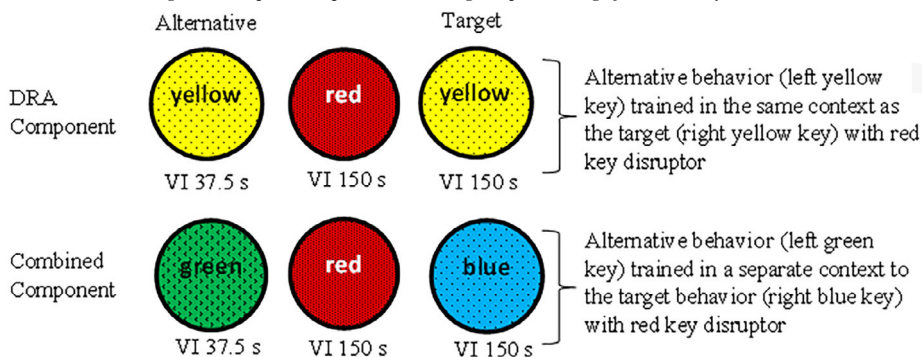

Figure 2

Key Colors and Schedules during the Disruptor Components, showing the positioning of the Red Key in Part 2

persistence of the target behavior as in Part 1. Given that there was no extinction, the test for relapse of the target behavior was not relevant here. All schedules of reinforcement associated with each key during training remained in effect during testing, in contrast to the replication of Podlesnik et al.'s (2012) tests, where extinction was in effect for all responses.

Method

Subjects

The subjects were six domestic Brown Shaver hens, numbered 8.1 to 8.6, all approximately 2 years old at the start of the study. They were housed in individual cages with a 12-hr light and 12-hr dark cycle. The hens always had free access to water in their home cages. They were weighed daily and were maintained at 85% (+/- 5%) of their free-feeding body weight by supplemental feeding with commercial laying pellet after each experimental session. They received grit weekly and vitamins as part of their usual feeding routine. All hens had served as subjects in an undergraduate psychology laboratory, in which they were trained to eat from a magazine and to peck a key, then they each experienced four sessions with manually arranged progressive-ratio schedules. This research was approved by the University of Waikato Animal Ethics Committee (Protocol 939).

Apparatus

The experimental chamber used in Part 1 (see Table 1) was 600 mm long by 450 mm wide and made of plywood. Three keys were situated in one side wall of the chamber, approximately 360 mm above the floor. All keys required a force of over 0.1 N to be operated. Multicolor LED light panels allowed each of the keys to be transilluminated with different colors. A 100 mm wide rectangular hole below the keys, situated in the center of the wall, allowed the hen access to wheat in a magazine. When a reinforcer was delivered, the magazine was raised and lit for 3 s. The walls inside the chamber were painted white, and there was a black rubber mat on the floor of the chamber that could be removed for cleaning. A computer running MED-PC® controlled all conditions and data collection in both parts of the experiment.

In Part 2, to train responding to an additional key, the additional source of reinforcement that would be used as a disruptor, an additional experimental chamber with a single red key in the center of the panel was used. The chamber size and layout were otherwise identical to the chamber described above, including the magazine that gave access to wheat as a reinforcer. The same chamber as described in Part 1 of the present study was used after this initial training to the red key was complete.

Procedure

Shaping and Training

For the present experiment, training started by presenting both the left and right key concurrently during three 40-s components, signaled by different key light colors. The components were separated by an inter-component interval (ICI) of 10 s during which time the keys were unlit. Each component was presented twice, so there were six presentations in total and the order was determined randomly. In the first component the left and right keys were lit yellow. In the second component the left and right keys were lit green. In the third component the left and right keys were lit blue. The left and right keys in all components were associated with a VI 10-s schedule. Training was completed to establish equal responding to both keys illuminated with all the colors to be used in the experiment. No changeover delay was scheduled. At times, if a hen responded exclusively to one key, the other key was deactivated until the hen was responding reliably to the remaining lit key, at which point the other key was reilluminated. After approximately 25 sessions, all hens were responding steadily to both keys in each component. At this point the 30-session baseline began, as outlined below.

Part 1 Baseline

Figure 1 shows the arrangement of the keys and schedules for each component. In baseline there were repeated presentations of three components, each 60 s long. In the DRA Component, the left and right keys were lit yellow and were concurrently available. A VI 37.5-s schedule of reinforcement was programmed for left key pecks and a VI 150-s schedule for right key pecks, with 12 intervals in each schedule (Fleshler & Hoffman, 1962). In the

Alternative Component, the left key was lit green and was associated with a VI 37.5-s schedule, and the right key remained dark and inoperative. In the Target Component, the right key was lit blue and was associated with a VI 150-s schedule, and the left key remained dark and inoperative.

The three components were each presented 12 times per session (36 component presentations per session). The components were presented in random order and were separated by a 20-s ICI. The first baseline was in place for 30 sessions to establish stable baseline responding, after which baseline conditions were implemented for six sessions between extinction tests as per Podlesnik et al. (2012). Responding during these six sessions was observed and, if deemed stable, extinction tests proceeded.

Part 1 Extinction Tests

Table 1 displays the arrangement of the components and keys during the extinction tests. Each extinction test involved different combinations of the keys and colors associated with their respective schedules of reinforcement in the components during the baseline condition, but in all cases food reinforcement was withheld. Exposure to the first two extinction tests was counterbalanced, but the remaining extinction tests were carried out in the order shown in Table 1, lasting for six sessions each. Extinction Test 5 was programmed to continue until all hens' responding on each key dropped to below 10% of baseline levels; it took five sessions for all hens to meet this criterion. After meeting the criterion, Extinction Test 5 was repeated, but with three fixed-time food presentations added to the first presentation of each of the two components in a session as a reinstatement test. The hopper was raised at 5 s, 10 s, and 15 s during this first presentation, as in Podlesnik et al. (2012), and then no further food was available for the remainder of that session. The hens were exposed to a total of five sessions with these fixed-time food deliveries.

Part 2 Center Key Exposure

After Extinction Test 5, hens were exposed to a single center red key, under a VI 150-s schedule in the separate chamber. The key was illuminated at the start of the session and stayed lit other than when the food hopper was raised. Sessions were conducted for 12 min, the same as the duration of one presentation of a component during the baseline procedure employed in Part 1. There was a maximum of six reinforcers available during these sessions. This occurred for 12 sessions.

Part 2 Baseline

Following the initial sessions with the red key, the hens were returned to the same baseline procedure and chamber as employed in Part 1 (see Fig. 1) for six sessions. This baseline procedure remained the same for the duration of Part 2. As in Part 1, hens were exposed to six sessions of baseline conditions in between disruptor tests.

Part 2 Disruptor Tests

These tests were not conducted under extinction conditions and the red key, termed the disruptor key and associated with a VI 150-s schedule, was active through all disruptor tests as shown in Figure 2. Immediately after each disruptor test the hens were returned to the second chamber for a further six sessions with the single red key and the VI 150-s schedule, prior to the next six sessions of baseline. This ensured that red key exposure was consistent prior to each baseline and subsequent disruptor test and minimized any carryover effects from the previous disruptor test.

The testing conditions are outlined in Table 1. The same combinations of stimuli and keys were used as in Part 1. However, the right blue key was not presented on its own during the first and third disruptor tests as it was in Part 1. This was intentional during the first disruptor test (see Table 1), as there had been no systematic difference in the results in Part 1 between when this key was presented and when it was not. During the third disruptor test, however, this omission was a procedural error, so the data from this disruptor test are not presented here. This omission meant no comparison was possible, so these data do not contribute to the findings in a meaningful way. Because schedules of reinforcement associated with each key/color were in effect throughout all disruptor tests, instead of arranging FT food presentations as in Experiment 1 in the fifth and final disruptor test, conditions were identical to the first two tests.

Results

Part 1 Baseline

Figure 3 displays the mean baseline response rates for each hen and for each key in each component over the six baseline sessions prior to each extinction test. For all hens, response rates were lowest on the target key of the DRA Component. Response rates for the analogue alternative behavior trained alone were highest for three hens. A two-way repeated measures ANOVA evaluating the effect of key position/color and session number on response rate showed the interaction was statistically significant, $F(12,60) = 5.67$, $p < .001$, $\eta_p^2 = .53$; a main effect of key position/color, $F(3,15) = 16.57$, $p < .001$, $\eta_p^2 = .77$; but no main effect of session, $F(4,20) = 2.27$, $p = .097$, $\eta_p^2 = .32$.

Part 1 Extinction Tests 1 and 2

The purpose of these extinction tests was to present both the DRA component and the Combined Component to evaluate the persistence of responding to the target stimuli in those components. Extinction Test 1 also presented the Only Target key in a separate, third component, with Hens 8.1, 8.3, and 8.5 exposed to this extinction test first, and Hens 8.2, 8.4 and 8.6 exposed to Extinction Test 2 first. There was no evidence that suggested the order of exposure affected the results.

Figure 4 shows responding as a proportion of baseline plotted across successive sessions of Extinction Test 1 in the left panel, and of Extinction Test 2 in the right panel for each hen. Proportion of baseline for each key/color was calculated by dividing the mean number of responses to the relevant key/color across extinction sessions by the mean number of responses to the relevant key/color across the same number of baseline sessions preceding the relevant extinction test. This method of calculation was used for the proportion of baseline data presented throughout.

Mean responses on the DRA Target key, as a proportion of baseline, were higher than on the Combined Target key during Extinction Tests 1 and 2 for all hens (Fig. 3). In addition, these measures were lower for Hens 8.1, 8.2, 8.4, and 8.5 on the Combined Target key than they were on any other key. A clear pattern was not evident for Hens 8.3 and 8.6. A two-way repeated measures ANOVA evaluating the three types of

right key responding (DRA Target [right yellow] key, Combined Target [right blue] key, Only Target [right blue] key) across Extinction 1 sessions showed there was a statistically significant interaction, $F(10,50) = 19.26$, $p < .001$, $\eta_p^2 = .79$; a main effect of type of response; $F(2,10) = 7.11$, $p < .001$, $\eta_p^2 = .59$; and a main effect of session, $F(5,25) = 17.41$, $p = .012$, $\eta_p^2 = .77$. A two-way repeated measures ANOVA evaluating the two types of right key responding (DRA Target key and Combined Target key) in Extinction 2 sessions showed a significant interaction between sessions and response proportions on the two right keys (DRA and Combined), $F(5,25) = 6.57$, $p < .001$ $\eta_p^2 = .57$. There were significant main effects of response type, $F(1,5) = 9.42$, $p = .028$, $\eta_p^2 = .65$, and of session, $F(5,25) = 3.014$, $p = .029$, $\eta_p^2 = .37$. Overall, target key responding was greater during the DRA Component (yellow) than during the Combined Component (blue).

In Extinction Tests 1 and 2, extinction bursts, defined as rises in response rates above the baseline level in the first session (i.e., greater than 1 in Fig. 4) were evident in many cases. However, extinction bursts were never observed with responding on the Combined Target key. Responding on the DRA Target key of the DRA Component was also greater, proportionate to baseline, than responding on the Combined Target of the Combined Component, regardless of whether the Only Target (right blue) key was available alone as well (see Fig. 4). Presenting this Only Target key alone did not seem to make any other difference to response rates on other keys, or overall.

Part 1 Extinction Tests 3 and 4

These two extinction tests were designed to investigate the persistence of responding to the individual stimuli and evaluate the impact of baseline reinforcement rates on the effects of combining the separately trained stimuli. Figure 5 shows responding on the Combined Alternative key and the DRA Target key when presented concurrently and the Only Target key when presented on its own during the Extinction Test 3, plotted as proportions of the corresponding baseline responses on a log scale. For four hens (the exceptions were 8.2 and 8.6), the response proportion was greater on the DRA Target key than on the Only Target or on the Combined Alternative key. Hen

Figure 3

Mean Number of Responses across the Last Six Baseline Sessions before each Extinction Test
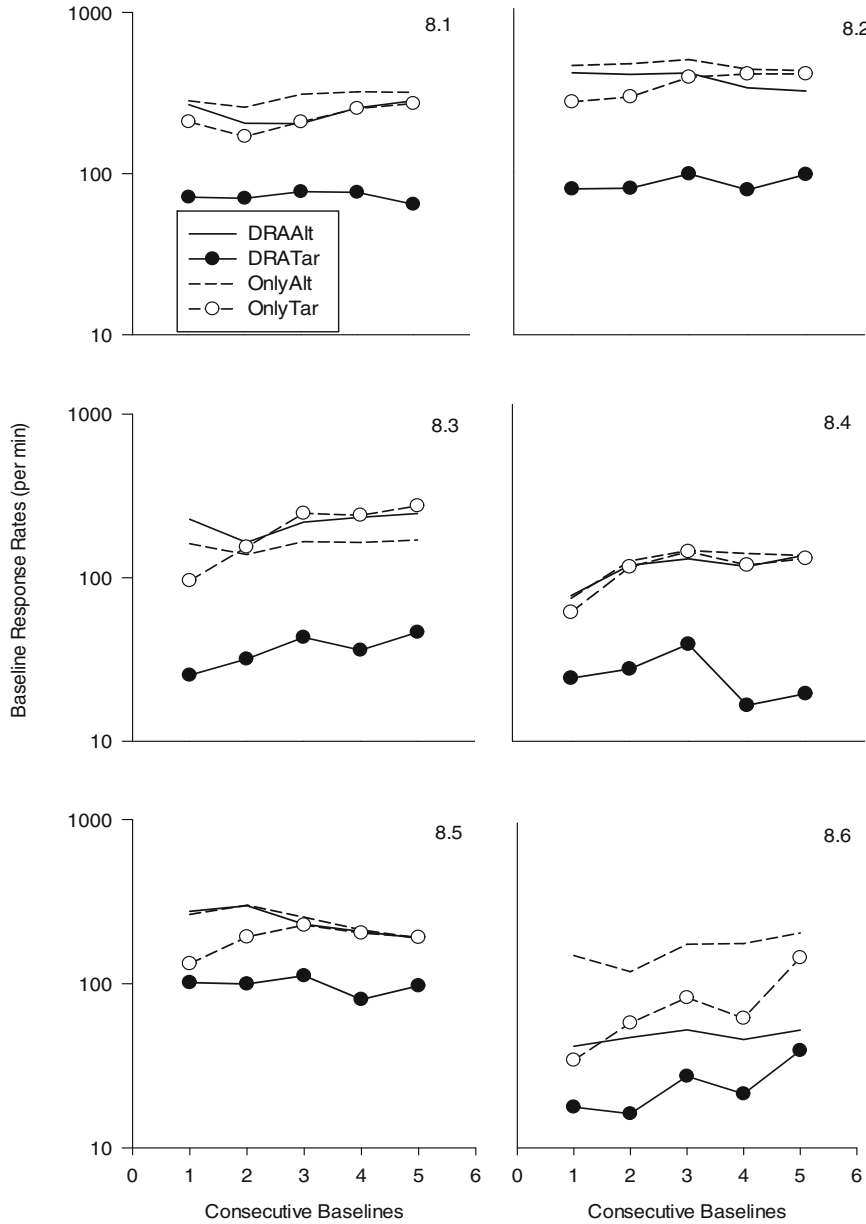

Note. The y-axis is presented on a log scale. Lines with circles show target (right key) responding in the DRA Component (black circles) and the Only Target Component (white circles). Lines without circles show responding to the DRA Alternative (left key, solid line) and Only Alternative Component (left key, dashed line).

8.2's DRA Target key responding, proportionate to baseline, was greatest in only the first session of the test. Hen 8.6's DRA Target key response proportion was generally lower than those of the other responses over this test.

Figure 6 displays the number of responses as a proportion of baseline plotted across the sessions of Extinction Test 4. This test presented the key colors individually rather than combined with another key color at any

Figure 4

Extinction Responding Plotted as a Proportion of Baseline Responding during the First and Second Extinction Tests
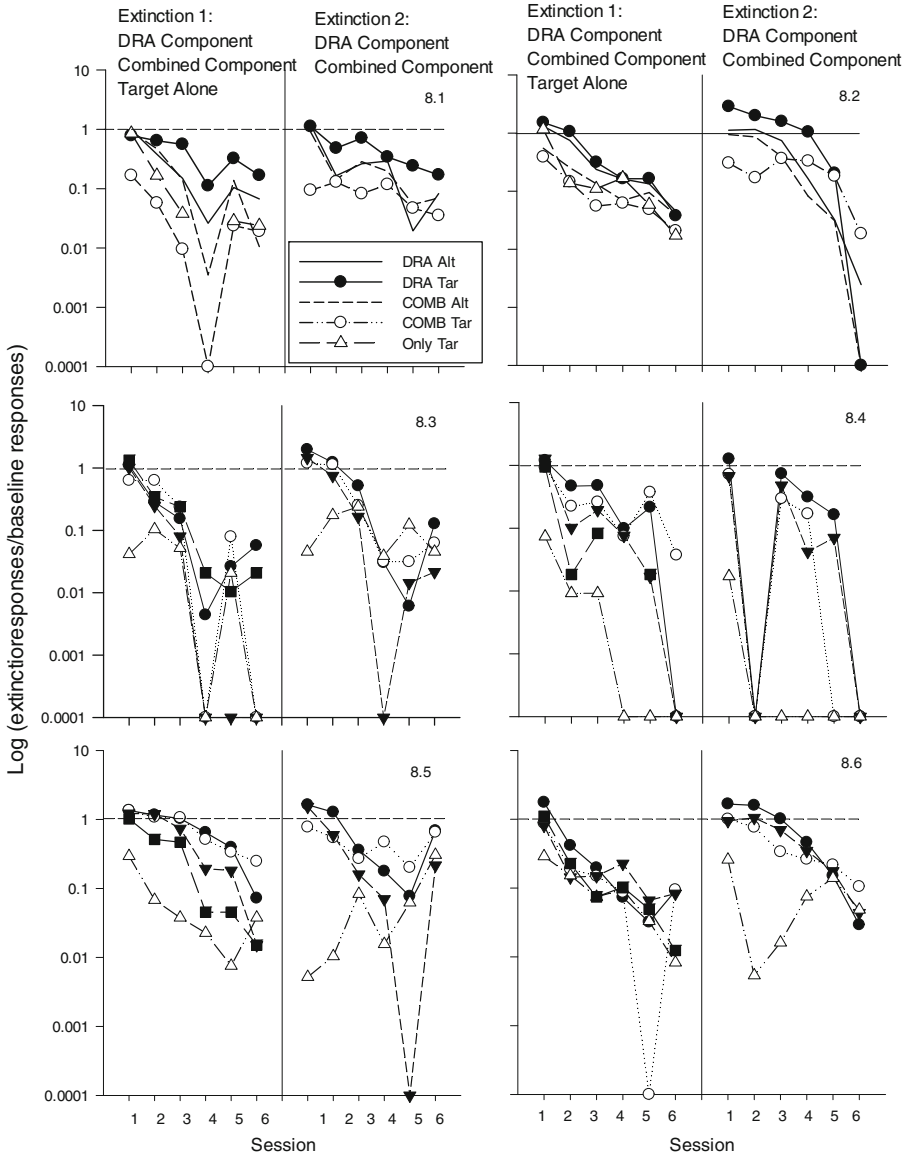
Note. In both columns, the y-axis is on a log scale, lines with data points show target (right key) responding (DRA Target = black circles; COMB Target = white circles, Only Target = white triangles) and lines without data points show alternative (left key) responding (DRA Alternative = solid line; COMB Alternative = dashed line). Data points at 0.0001 represent zero responses and the horizontal dashed line represents the baseline levels of responding

time. For all hens, except 8.6, responding proportionate to baseline was greater on the DRA Target key during this test than on either the Only Alternative or Only Target keys. Hen 8.6's responding on the DRA Target key ceased altogether by the fourth session of the test, while her responding on
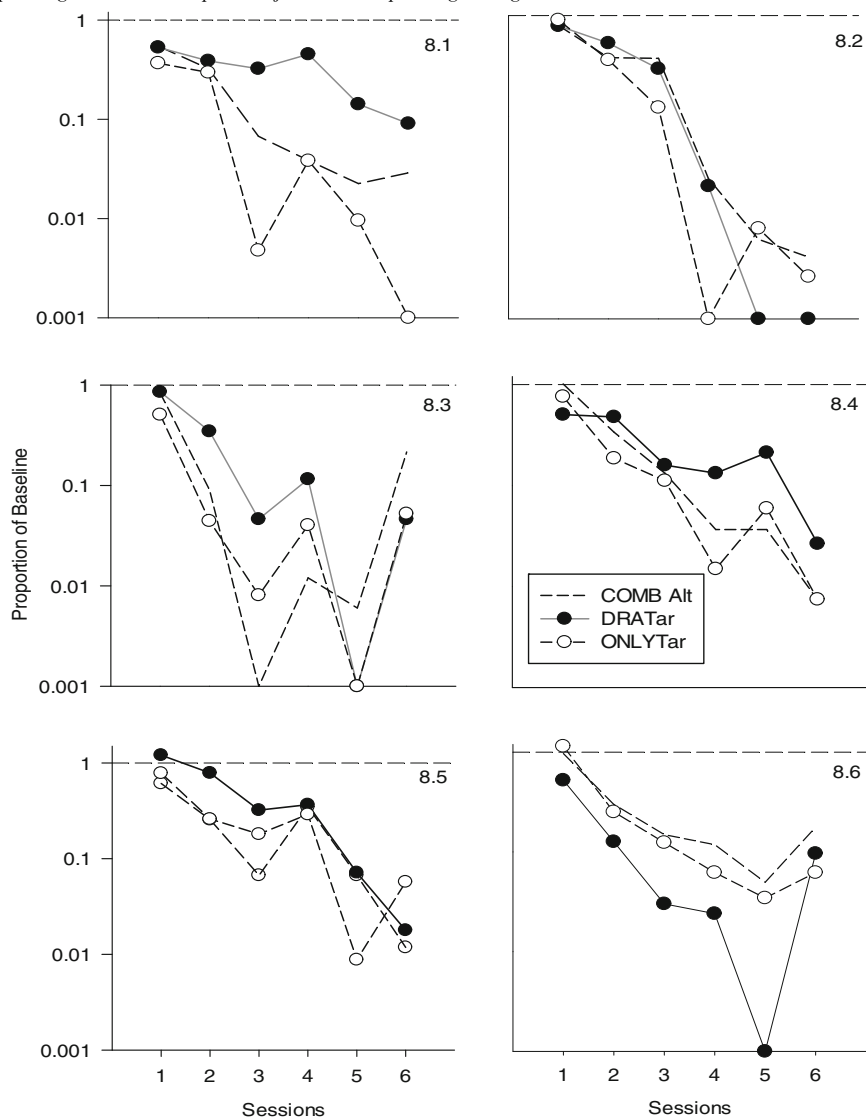
both the Only Alternative and Only Target continued.

Part 1 Extinction Test 5

The final extinction test involved response-independent food presentations on a fixed-time

Figure 5

Extinction Responding Plotted as a Proportion of Baseline Responding during Extinction Test 3

Note. In this test, the COMB Alternative key and DRA Target key were presented together in one component and the Only Target key was presented individually in a second component. The y-axis is presented on a log scale, with the circles representing target (right key) responding (DRA Target = black circles; COMB Target = white circles) and the dashed line without data points representing responding to the COMB Alternative (left) key. Data points at 0.001 represent zero responses and the horizontal dashed line represents baseline levels of responding.

schedule as a reinstatement test, after responding during extinction had dropped to below 10% of baseline for all hens. It took five sessions for all hens to meet this response criterion. The purpose of the test was to measure the relapse of target responding following extinction. As seen in Figure 7, for three of the hens, responding on the DRA Target key was greater proportionate to baseline than responding on the Combined Target key; for 8.1, 8.4 and 8.6 this was not the case in every session. A two-way repeated measures ANOVA comparing responding on the DRA Target key with that of the Combined Target key across

sessions showed no significant interaction, $F(4,20) = 2.54$, $p = .075$, $\eta_p^2 = .34$, and no significant main effect of response type, $F(1,5) = .069$, $p = .803$, $\eta_p^2 = .014$, but a significant effect of session, $F(4,20) = 4.33$, $p = .011$, $\eta_p^2 = .46$.

Part 2 Baseline

Figure 8 displays the mean baseline response rates for each hen for each component over the six baseline sessions prior to each disruptor test on a log scale. Responding was reasonably consistent across the repeated baselines. Response rates for all hens were lowest on the DRA Target key than for any other key/color combination during each repeated baseline. Response rates for the DRA Alternative, and Only Alternative options were similar across baselines for all hens. Only Target response differed across hens, some similar to the levels of responding seen on the alternative keys, some lower and some higher. A two-way repeated measures ANOVA comparing the mean number of responses on all keys across baseline sessions showed no significant interaction across the five repeated baselines, $F(12,60) = 1.86$, $p = .059$, $\eta_p^2 = .27$, but a significant main effect of response type, $F(3,15) = 9.74$, $p = .001$, $\eta_p^2 = .66$, and of session $F(4,20) = 3.251$, $p = .03$ $\eta_p^2 = .4$.

Part 2 Disruptor Tests 1, 2 and 5

These three disruptor tests were designed to examine the persistence of target responding in both the DRA and the Combined components. Figure 9 shows responses as a proportion of baseline response rates plotted across successive sessions of the first and second disruptor test. For all hens in both tests, proportion of baseline responding on the Combined Target key (trained alone) was lower than that on the DRA Target key (trained alongside the alternative response) for all except Hen 8.6 in Disruptor Test 2. Hens 8.4 and 8.5 did not respond on the Combined Target key at all during several of the sessions of both tests. Additionally, Combined Target key responding, proportionate to baseline, was lower than responding on either the DRA Alternative key or the Combined Alternative key in both tests. Responding on both the DRA Alternative and the Combined Alternative keys remained close to baseline levels throughout the first disruptor test for all hens except Hen 8.5. Overall, the measure for

Combined Target key responding was lower than that for DRA Target key responding for all hens throughout the tests. A paired-samples *t*-test comparing the mean proportion of baseline responding on the Combined Target key with the mean proportion on the DRA Target key during the first disruptor tests was significant, $t(5) = 6.36$, $p = .001$, $d = 2.48$.

In general, responding increased on all keys for all hens during the second disruptor test compared to the first disruptor test, however, proportion of baseline responding on the Combined Target key remained lower than that of both yellow keys and the Combined Alternative key for five out of the six hens, Hen 8.6 being the exception. A paired-samples *t*-test compared the mean proportion of baseline responding on the DRA Target key with that of the Combined Target key during the second disruptor tests, and was significant, $t(5) = 3.34$, $p = .021$, $d = 2.05$.

The procedures for Disruptor Test 5 were the same as for Disruptor Tests 1 and 2. The number of responses proportionate to baseline for the Combined Target key was lower than for all the other keys. Hens 8.4 and 8.5 did not respond on this key at all in more than one session. A paired-samples *t*-test comparing the mean proportion of baseline responding on the DRA Target key with that on the Combined Target key during the disruptor tests revealed a statistically significant difference, $t(5) = 7.32$, $p = .001$, $d = 2.45$.

Part 2 Disruptor Tests 3 and 4

Due to a procedural error, the Only Target key was not presented during the third disruptor test, as it should have been, so data from this test cannot be interpreted in any meaningful way and are not presented here. Disruptor Test 4 was designed to measure the persistence of responding to each of the individual stimuli while presented alongside the disruptor key. Figure 10 shows responding plotted as a proportion of baseline for the DRA Target key, the Only Alternative key, and the Only Target key for the fourth disruptor test, which presented these stimuli in individual components, all paired with the red disruptor key. Responding on the DRA Target key was generally greater than that on the Only Alternative key and the Only Target key for all hens. Responding on the Only Target key was

Figure 6

Extinction Responding Plotted as a Proportion of Baseline Responding during Extinction Test 4
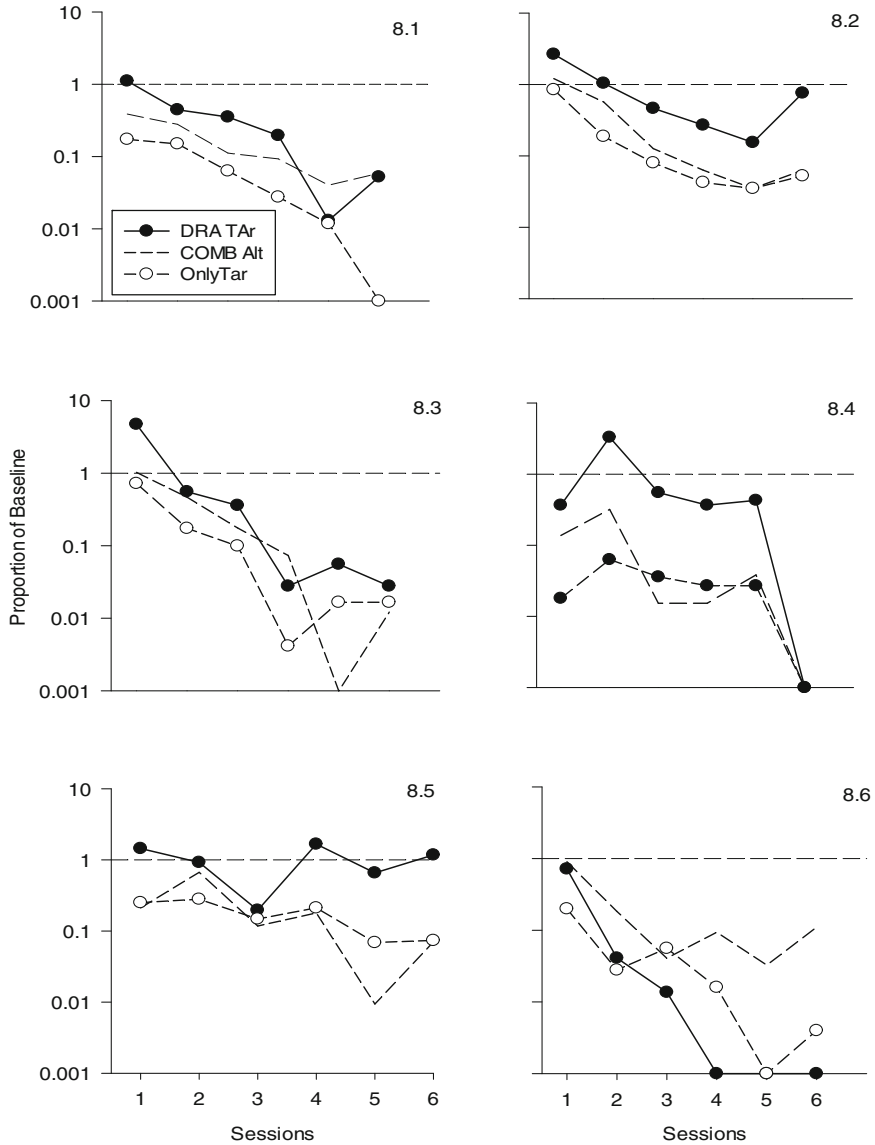
Note. In this test, the DRA Target key, COMB Alt key and Only Target key were presented individually in three components. The y-axis is plotted on a log scale, with the circles representing target (right key) responding (DRA Target = black circles; COMB Target = white circles) and the dashed line without data points representing responding to the COMB Alternative (left) key. Data points at 0.001 represent zero responses and the horizontal dashed line represents baseline levels of responding.

lower than that on the DRA Target key, and this difference was significant; $t(5) = 4.64$, $p = .006$, $d = 1.75$. Responding on the Only Alternative and Only Target keys dropped compared to baseline levels (less than 1) for most of the hens in the presence of the disruptor key, with Hen 8.4's responding
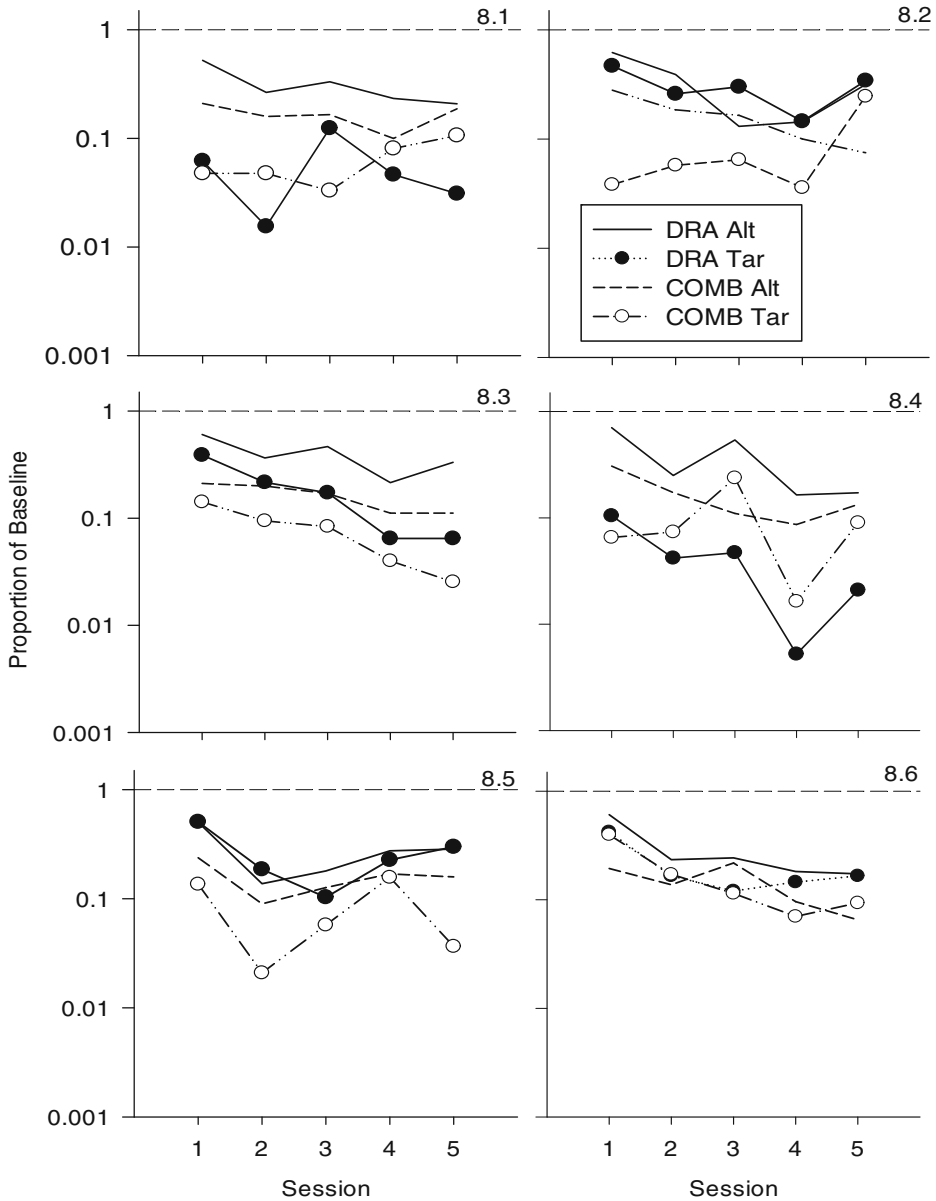
dropping to below baseline levels on all keys from the second session onward.

Part 2 Disruptor Key Responses

Figure 11 shows the number of responses on the disruptor key during Disruptor Tests

Figure 7

Extinction Responding Plotted as a Proportion of Baseline Responding during Extinction Test 5


Note. The y-axis is on a log scale, lines with data points show target (right key) responding (DRA Target = black circles; COMB Target = white circles) and lines without data points show alternative (left key) responding (DRA Alternative = solid line; COMB Alternative = dashed line). The horizontal dashed line represents the baseline levels of responding.

1, 2, and 5. These are presented on log axes to allow comparison between the three conditions where the disruptor key was presented but resulted in differing levels of responding on it. For most hens, responding on the disruptor key was initially slow and, for some hens, increased slightly during the second disruptor test. It increased again, in some cases greatly, during the fourth disruptor test (Fig. 10) and in the fifth disruptor test it did

Figure 8

*Mean Number of Responses across the Last Six Baseline Sessions before each Disruptor Test*
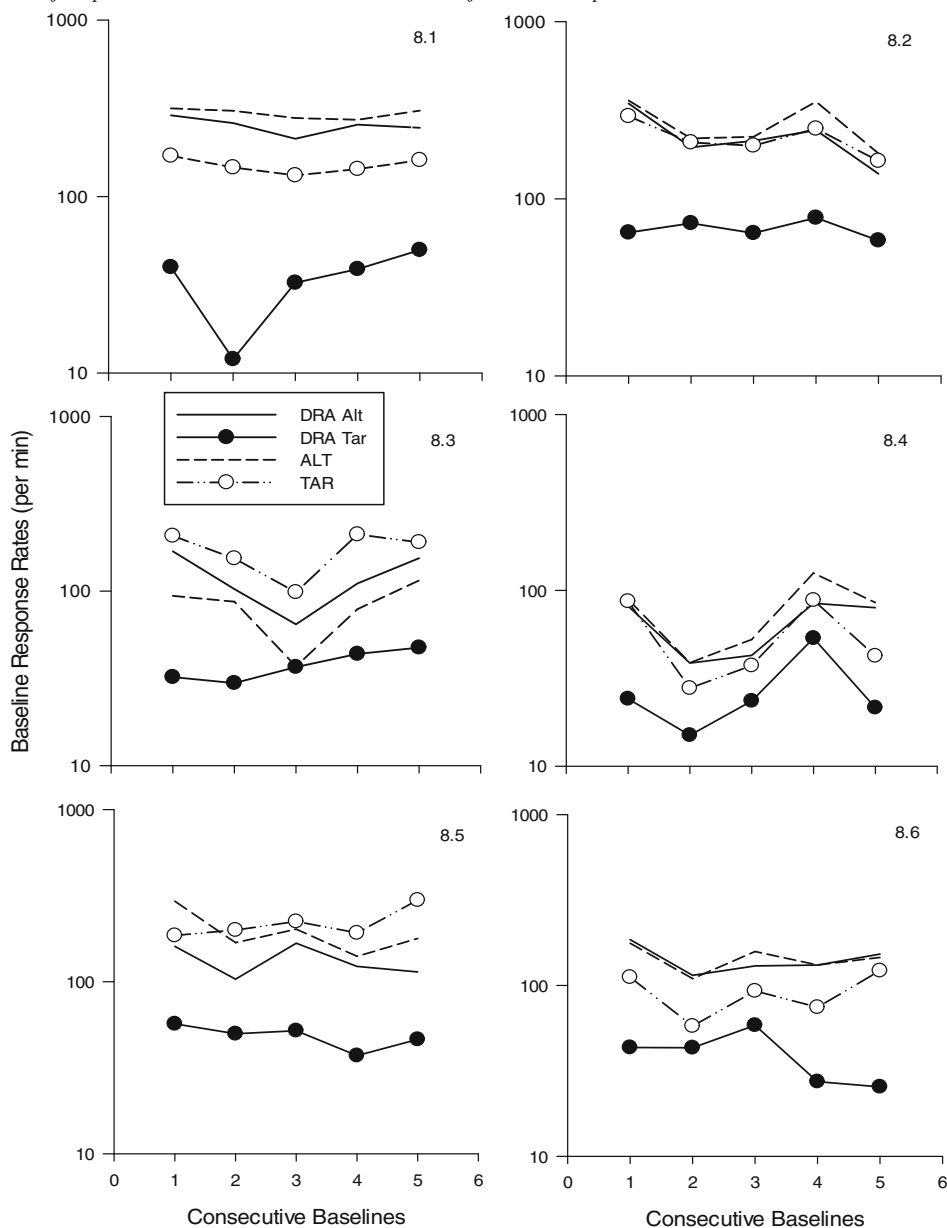
Note. Lines with circles show target (right key) responding in the DRA Component (black circles) and the Only Target Component (white circles). Lines without circles show responding to the DRA Alternative (left key, solid line) and Only Alternative Component (left key, dashed line).

not reduce to the levels previously seen (Fig. 9). In most cases, during the first, second and fifth disruptor tests, responding on the disruptor key was higher in the Combined Component compared to the DRA Component.

Figure 12 shows the data from the fourth disruptor test, plotted separately for clearer presentation. Responding on the disruptor key was similar when it was presented alongside the DRA Target and Only Target key, both

Figure 9

Responding during Disruptor Tests 1, 2 and 5, Plotted as a Proportion of Baseline Responding
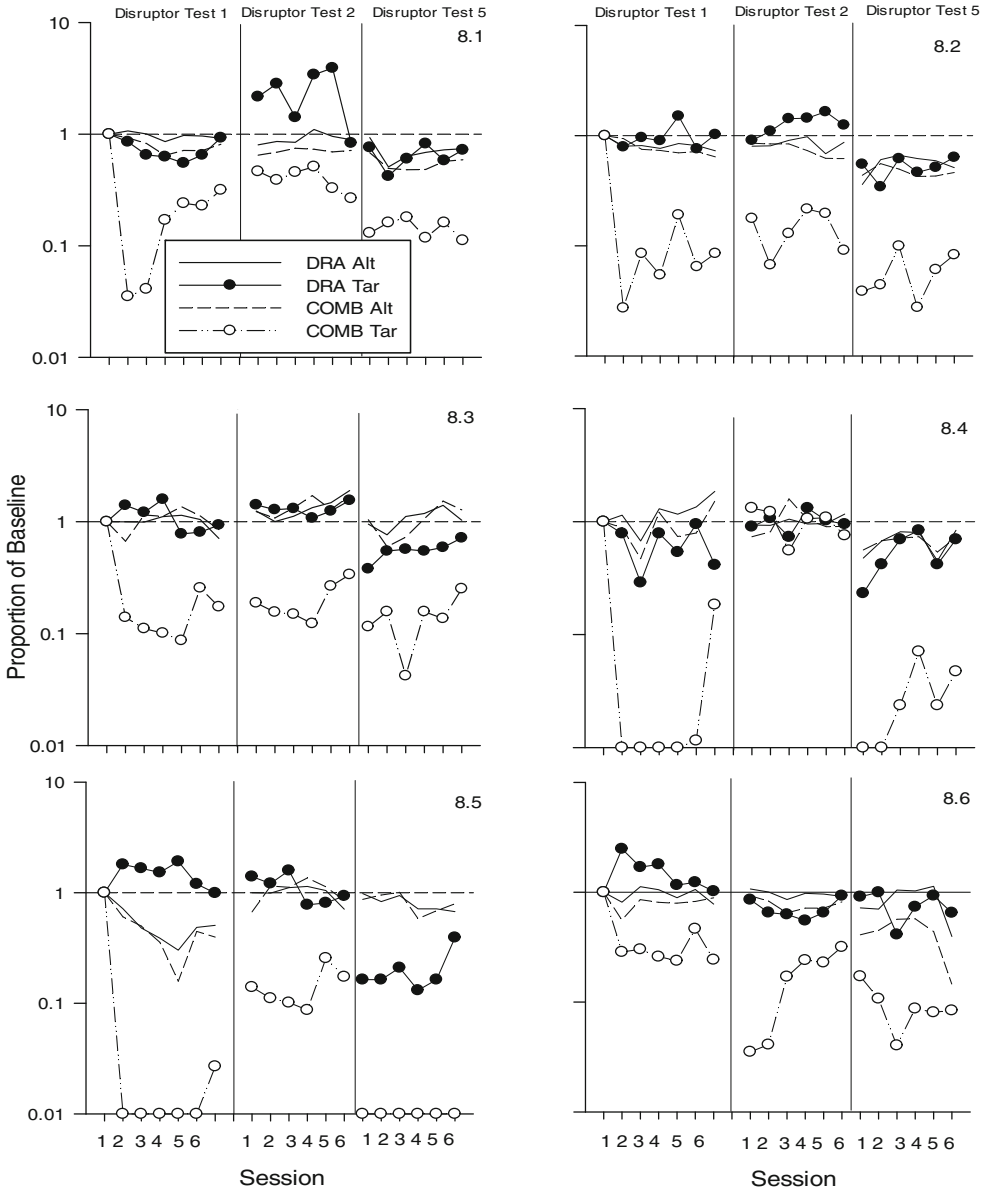
Note. In both columns, the y-axis is on a log scale, lines with data points show target (right key) responding (DRA Target = black circles; COMB Target = white circles, Only Target = white triangles) and lines without data points show alternative (left key) responding (DRA Alternative = solid line; COMB Alternative = dashed line). Data points at 0.0001 represent zero responses and the horizontal dashed line represents the baseline levels of responding.

associated with the same schedule as the red key (VI 150 s), and it was lowest in this test when presented alongside the Combined Alternative key that was associated with a richer schedule (VI 37.5 s).

Comparison

Figure 13 shows the mean log proportion of baseline responding on the target keys during the first two extinction tests of Part 1, and first two disruptor tests of Part 2. As one might

expect, responding during the second part remained higher, as reinforcement remained in effect unlike in Part 1, when extinction was used. Responding to the Combined Target key remained lower than responding to the DRA Target key, regardless of the disruptor used, but was lower overall when extinction was in place (because reinforcement was not maintained).

Discussion

To date, extinction has been the main disruptor used in the translational research investigating the persistence of a target behavior following DRA procedures (Brown et al., 2020). The aim of the present study was to examine persistence following same- and separate-context DRA training in the presence of an additional source of reinforcement, as well as extinction, as the disruptor. Since this study used domestic hens, a species not used with this procedure previously, it was important to assess initially whether the hens' behavior was affected in the same way as that of other species when extinction was the disruptor (Part 1). The findings of Part 1 of the study align with those of Podlesnik et al. (2012) and others, in that the target behavior was more persistent under extinction conditions when it had been trained in the same context than when it had been trained in a separate context from the alternative behavior. Given that hens performed similarly to other species (humans, pigeons, and rats) in Part 1, the findings from Part 2 can be taken to be the result of changes in the procedure and not a result of using a different species.

Podlesnik et al. (2012) used their first two extinction tests to examine whether the procedure used by Mace et al. (2010), which resulted in greater exposure to the stimulus associated with the target response when trained alone, influenced Mace et al.'s findings. These conditions in our study revealed no systematic differences over these two extinction tests, suggesting that the additional exposure to the trained-alone target stimulus in Mace et al.'s procedure did not impact the persistence. Also, in line with the findings of Podlesnik et al., we observed greater target response extinction bursts in the DRA procedure compared to the separate-context training procedure, a finding of applied significance.

In Part 2 of the study, disruptor tests were carried out in the presence of the additional source of reinforcement (a red center key

associated with a VI 150-s schedule of reinforcement), the target response that was reinforced separately from the alternative response was less persistent than the target response that was trained together with the alternative response. The separate-context target was also less persistent than both alternative responses. These findings align with those obtained using extinction as a disruptor in previous research and in the present study (Part 1), but also extend the research with the addition of a different disruptor, and with a different species. Although we anticipated a reduction in the separately trained target response when two additional sources of reinforcement (the separately trained alternative behavior and the separately trained additional behavior) were made concurrently available during disruptor tests in Part 2, the size of the effect was larger than expected. In some cases, target responding ceased altogether (see Fig. 9). The reductions in the proportion of the separately trained target response compared to baseline when the disruptor key was introduced, even though there was sometimes no significant disruptor key responding, suggests that it was the addition of this key (i.e., the addition of a stimulus associated with a schedule of reinforcement) that disrupted responding and not the responses allocated to that key. Of applied interest would be an examination of the degree of disruption caused by the addition of stimuli associated with a range of different schedules of reinforcement. Do stimuli associated with different schedules have different disruptive effects? Podlesnik et al. (2016) found that differing reinforcement rates associated with the alternative stimuli decreased the persistence of target responding when alternative and target stimuli were combined within the same extinction test, so it could be worthwhile investigating any effect that altering the reinforcement rate of the disrupting stimuli had on target responding.

When the target response from separate-context training was available with the disruptor key and there were no other response options available (in the fourth disruptor test in Part 2), its decrease, proportional to baseline, was not as great as when the alternative response was also available, as it was in the other disruptor tests. However, this target response was disrupted more than the target response from the same-context training under the same circumstances (i.e., when it was the only response option, other than the disruptor key). Thus, the introduction

Figure 10

Responding Plotted as a Proportion of Baseline Responding during Disruptor Test 4
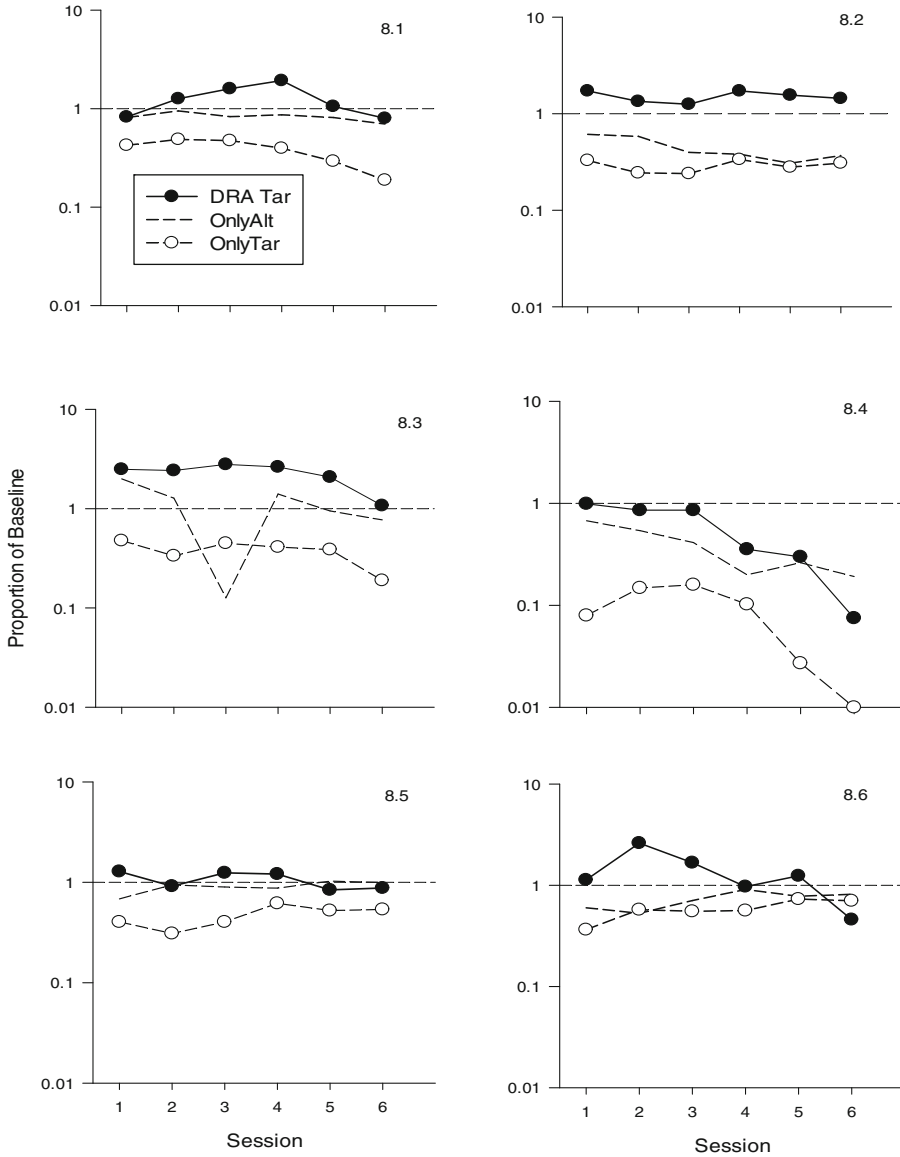

Note. In this test, the DRA Target key, COMB Alt key and Only Target key were presented individually in three compo-
nents with the red key disruptor. The y-axis is plotted on a log scale, with the circles representing target (right key)
responding (DRA Target = black circles; COMB Target = white circles) and the dashed line without data points rep-
resenting responding to the COMB Alternative (left) key. Data points at 0.001 represent zero responses and the horizon-
tal dashed line represents baseline levels of responding.

of the disruptor key affected the target response
from separate-context training more than it did
the target response from the same-context train-
ing. Furthermore, in the fourth disruptor test,
the target response from the DRA training

actually increased above baseline levels for five
of the six hens rather than decreasing below
baseline levels, as did the target response from
separate context training. This finding is of
applied significance because it suggests that if,

Figure 11

Responses on the Red Key during Disruptor Tests 1, 2 and 5
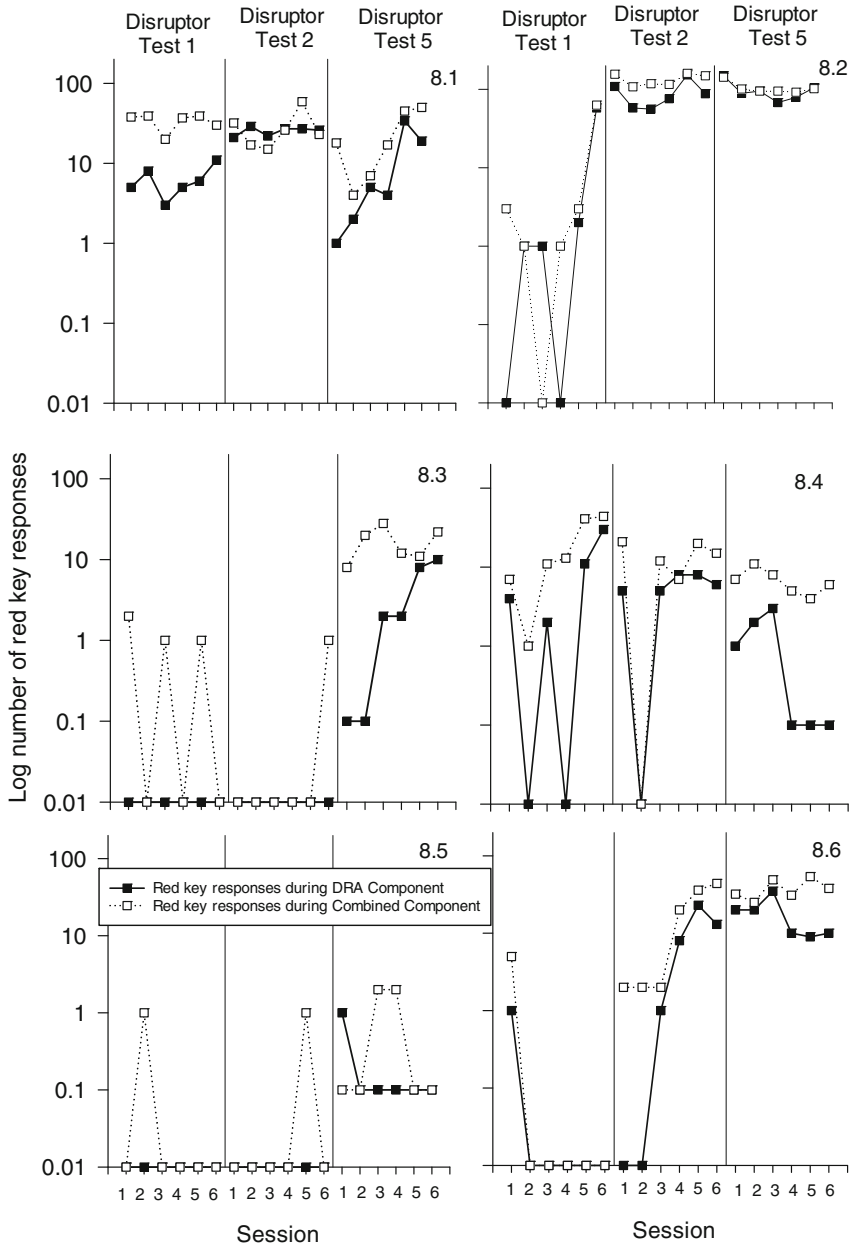

Note. Red key responses during the DRA Component are represented by a filled square, red key responses during the Combined Component are represented by an open square. Data points at 0.01 represent no responding on the red key.

after DRA training, the richer source of reinforcement for the alternative response was removed and a leaner source of reinforcement became available, the target response might increase over its previous baseline level.

It was advantageous to use the same hens in Part 1 (extinction as a disruptor) and Part 2 (an additional source of reinforcement as a disruptor) of this study so that their performance in the presence of the two disruptors could be

Figure 12

Number of Responses on the Red Key during Disruptor Test 4

Legend:
- Red key responses during DRA Tar
- Red key responses during Only Alt
- Red key responses during Only Tar
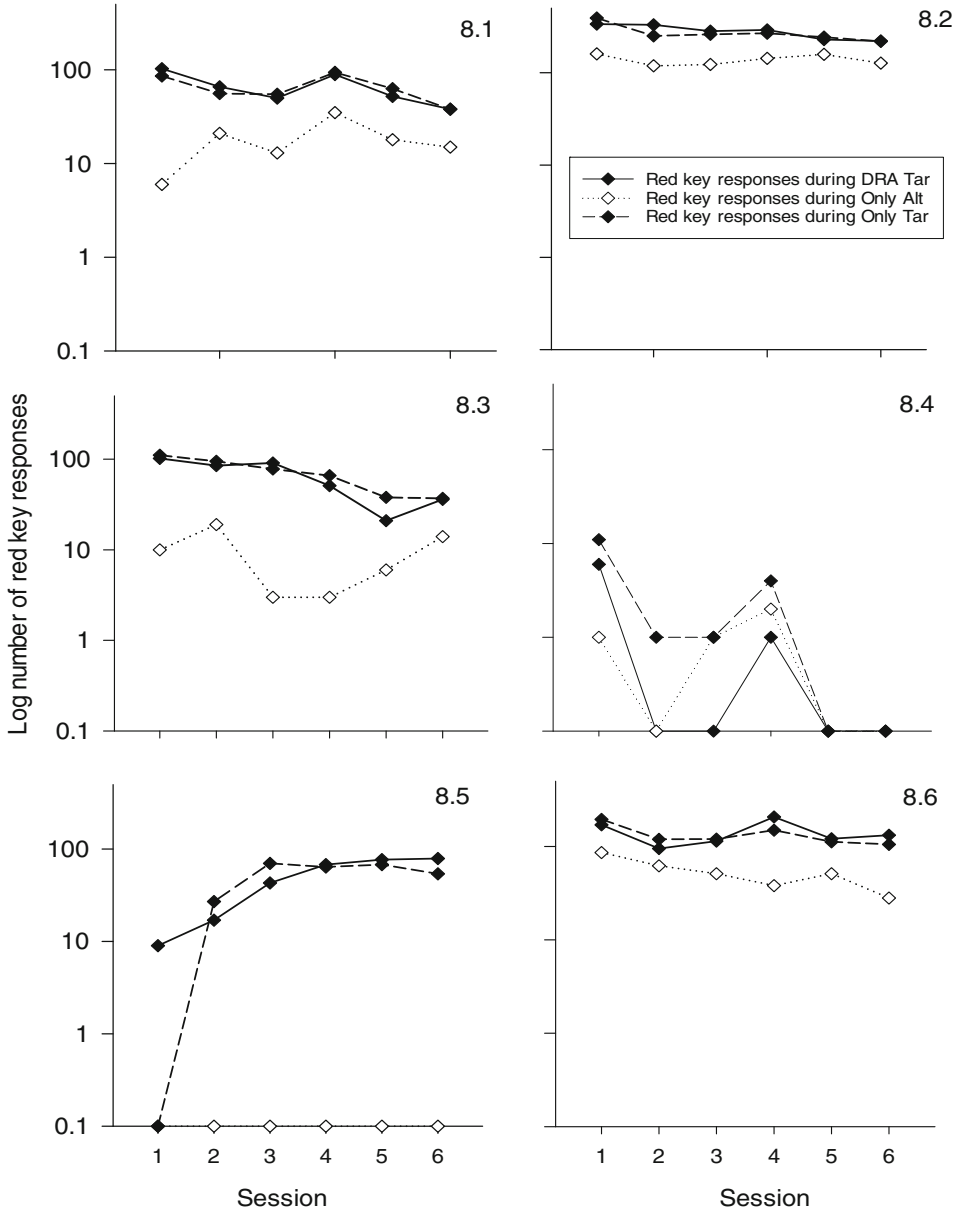
Note. Filled diamonds represent responding on the red key in the presence of the DRA Target key, open diamonds represent red key responding in the presence of the Only Alt key, and diamonds with the dashed line represent responding on the red key in the presence of the Only Target key. Data points at 0.01 represent no responding on the red key.

compared directly. However, this arrangement also presented the possibility of sequence effects, which may have influenced the Part 2 findings. There is some evidence that the procedural sequence was not problematic. Firstly, in Part

1, three hens were exposed to Extinction Test 2 first, and three hens to Extinction Test 1, as per Podlesnik et al. (2012). This was done to evaluate any effects of over-exposure to the Target key, presented alone in the first extinction

Figure 13

Log Mean Proportion of Baseline Responding on the DRA Target Key (dark grey bars) and Combined Target Key (light grey bars)
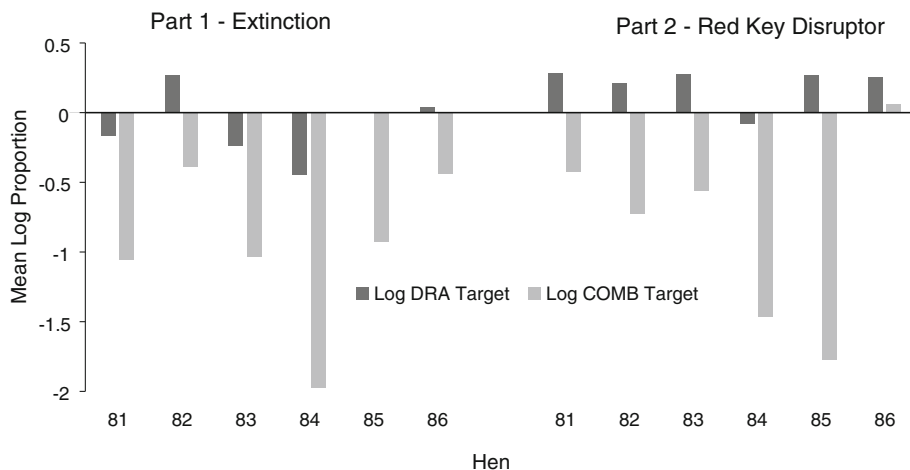
test, but only as part of the DRA and Combined Components in the second extinction test. There was no difference in responding to this Target key alone, regardless of the order in which the hens were exposed to it.

Secondly, when the hens were exposed to the combination of the stimuli associated with target and alternative responses from separate-context training in the first disruptor test in Part 2, they had already been exposed to this combination (without the disruptor key) three times in Part 1. During Part 1, the target response trained separately occurred in the first few sessions of each extinction test and it did not disappear over the tests, but in Part 2, where the disruptor key was introduced, there was little, in some cases none, of this responding in the initial disruptor test. In addition, the replications of the same conditions in the second and last disruptor test of Part 2 found no systematic changes in responding over these tests. Thus, the absence of the separately trained target responding in the first Part 2 test appears to be a result of this being the first introduction of this combination—the disruptor key and the stimuli associated with the target and alternative responses trained in a separate context—rather than a result of the previous exposures to the combination of stimuli associated with separately trained responses during extinction tests in Part 1.

Although the relative persistence of the target response trained separately, and the target response from the analogue DRA were similar in Part 1 and Part 2, persistence of the alternative response trained separately and the alternative response from DRA differed over the two parts. In Part 1, all response rates gradually declined across sessions of each disruptor test, after some initial extinction bursts, as is typically seen with extinction. However, in Part 2, although both the analogue alternative responses did, in most cases, reduce, relative to their baseline rates, when the disruptor key was introduced in a test, they did not reduce gradually as seen in Part 1. In each test, they started off below baseline levels from the first session and then remained stable at that level throughout the rest of the test. This difference might be expected given that there was a continuation of reinforcement throughout the tests. It shows there was an immediate effect of the addition of the red stimulus, which was not possible in the extinction tests where there was no additional stimulus signaling the onset of extinction. Had sessions continued in each test in Part 2 until some response stability criterion had been reached then we would predict the proportion of responses on each key would have moved to show some degree of matching to the proportion of obtained reinforcers as seen in two- (Baum, 1974, 1979) and three-key concurrent schedules arrangements. Although there were greater levels of responding overall in Part 2 of the present study, likely due to the continuation of reinforcement, responding to the

Combined Target key was still reduced regardless of which disruptor (extinction or red key) was presented. These results support the predictions of behavioral momentum theory (Nevin, 2015). They suggest that the concurrent arrangement in the analogue DRA (the two yellow keys) resulted in greater target responding from the DRA, proportional to baseline, than the same measure from either of the alternative responses or the target response from the separate-context training. In both parts of the study, then, the two yellow keys in the analogue DRA component functioned as one richer reinforcement context. Similar results have been found when stimuli providing richer reinforcement rates have been combined on the same key as well (Podlesnik & Bai, 2015).

One limitation of the general translational procedure used in this study and by Podlesnik et al. (2012) and Mace et al. (2010) is its direct transfer to applied settings, such as in the extension of this procedure by Suess et al. (2020). In these settings, the target response associated with the traditional DRA procedure, often a problem behavior, normally occurs prior to the introduction of the alternative response trained in the DRA procedure. To increase the validity of this translational approach, it seems that an appropriate comparison could be made by first establishing baseline target responding in the absence of an alternative response. This could then be followed by conducting either DRA training or separate-context training with the alternative behavior. Not only would the initial baseline serve as a better reference for measures of persistence, but this sequence of events would map more closely onto that associated with applied settings, in which the target behavior is usually ongoing (and hence being reinforced) for some time before the introduction of the DRA intervention. Another potential limitation is that the alternative and target behaviors in each of these studies were all topographically similar: a lever press with Mace et al.'s rats, and a key peck with Podlesnik et al.'s pigeons and our hens. The target and alternative responses were differentiated according to the color and position of the key (or the position of the lever and the state of a nearby light in the case of Mace et al.). Each "response" had a unique antecedent or contextual stimulus, so this is not conceptually problematic when

the operant is defined as a three-term contingency (Sidman, 1986). In practice, however, target and alternative behaviors in DRA procedures, including FCT, are frequently topographically dissimilar. It may be beneficial to explore translational procedures that involve topographically dissimilar responses when evaluating response persistence following DRA.

In conclusion, given the previously discussed multitude of contingencies and reinforcers acting in any environment (Craig et al., 2014), the possibility of removing all of these in an applied setting, if they could even be identified, are remote. The addition of new sources of reinforcement as a disrupting stimulus may be useful in applied situations where extinction cannot be implemented. The results of Part 2 of the present study suggest that even if such a disruptor were introduced to the situation, the persistence of the target behavior would be less following separate-context training than following traditional DRA methods. Of course, it is not possible to conclude that this effect would occur irrespective of what else was going on in the environment, such as in a busy, applied setting, but it does suggest that this approach merits continued further investigation.

Acknowledgement

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