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TEMPORAL CONTEXT, PREFERENCE, AND RESISTANCE TO CHANGE

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According to behavioral momentum theory, preference and relative resistance to change in concurrent-chains schedules are correlated and reflect the relative conditioned value of discriminative stimuli. In the present study, we explore the generality of this relation by manipulating the temporal context within a concurrent-chains procedure through changes in the duration of the initial links. Consistent with previous findings, preference for a richer terminal link was less extreme with longer initial links across three experiments with pigeons. In Experiment 1, relative resistance to change and preference were related inversely when responding was disrupted with response-independent food presentations during initial links, replicating a previous finding with rats. However, more food was presented with longer initial links, confounding the disrupter and initial-link duration. In Experiment 2, presession feeding was used instead and eliminated the negative relation between relative resistance to change and preference, but relative resistance to change was not sensitive to relative terminal-link reinforcement rates. In Experiment 3, with more extreme relative terminal-link reinforcement rates, increasing initial-link duration similarly decreased preference and relative resistance to change for the richer terminal link. Thus, when conditions of disruption are equal and assessed under the appropriate reinforcement conditions, changes in temporal context impact relative resistance to change and preference similarly.

Key words: behavioral momentum theory, conditioned value, preference, resistance to change, concurrent chains, response rates, keypeck, pigeon

According to behavioral momentum theory, discriminative-stimulus contexts acquire value as a result of their Pavlovian relation with primary reinforcement (Nevin & Grace, 2000a). Therefore, discriminative stimulus contexts associated with higher rates or larger magnitudes of reinforcement accrue greater conditioned value than contexts with less favorable reinforcement conditions. For instance, Nevin, Tota, Torquato, and Shull (1990) presented equal rates of variable-interval (VI) food reinforcement to pigeons in two stimulus contexts, or components, of a multiple schedule. Additional food was presented response independently according to a variable-time (VT) schedule in one component. Response rates decreased in the component with added food as a result of degrading the relation between responding and reinforcement (i.e., response–reinforcer relation). However, the added food improved the Pavlovian relation between that component stimulus and rate of food presentation (i.e., stimulus–reinforcer relation). Tests of resistance to change, or disruption[1], revealed that the added food enhanced the conditioned value in this component relative to the component without added food. Specifically, when assessed relative to baseline response rates, responding was more resistant to satiation and extinction in the component with added food. Moreover, these findings support a primary assumption of behavioral momentum theory that response rates and resistance to change are separate aspects of discriminated operant behavior: Pavlovian stimulus–reinforcer relations mediate resistance to disruption while operant response–reinforcer relations mediate response rates (but see Podlesnik & Shahan, 2008, for exceptions).

According to behavioral momentum theory, relative resistance to change is a power function of the relative rate of reinforcement across components of a multiple schedule (Nevin, 1992a):

$$\frac{m_1}{m_2} = \left(\frac{r_1}{r_2}\right)^b \tag{1}$$

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[1] *Resistance to change* and *resistance to disruption* are used interchangeably within the manuscript, although it can be argued that resistance to change is more general than resistance to disruption.

where m is resistance to disruption and r is the rate of reinforcement for two components denoted by the subscripts. The b parameter is sensitivity of relative resistance to disruption to relative reinforcement rate and has been estimated from 0.35 to 0.5 (Nevin, 1992a, Nevin, 2002). Equation 1 closely resembles the generalized matching equation (Baum, 1974), which describes the relative allocation of two concurrently available operant responses (i.e., choice) as a power function of relative reinforcement rates between those options:

$$\frac{B_1}{B_2} = b\left(\frac{r_1}{r_2}\right)^{a} \tag{2}$$

where B is responding and r is reinforcement for responses to two options denoted by the subscripts. The a parameter scales sensitivity of choice performance to relative reinforcement rate and the b parameter indicates bias for one option over another independent of changes in relative reinforcement rates. Sensitivity estimates for Equation 2 approximate 0.8 (Baum, 1979). Given that Equations 1 and 2 describe operant responding as a power function of reinforcement, both relative resistance to disruption and choice performance have been construed as expressions of relative value (Baum & Rachlin, 1969; Grace & Nevin, 1997; Killeen, 1972).

Choice performance measured as preference for one stimulus context over another in concurrent-chains procedures also has been useful for examining how relative reinforcement conditions impact relative conditioned value. Concurrent chains are useful because preference and relative resistance to disruption can be assessed within the same experimental situation under almost identical conditions (Grace & Nevin, 1997). Nevin and Grace (2000b) arranged concurrent chains with initial links presenting two concurrently available interdependent VI 25-s schedules. Responding on one initial-link option resulted in 30 s of access to a terminal-link discriminative stimulus context presenting food reinforcement according to a VI schedule. Responding on the other initial link produced 30 s of access to a different, mutually exclusive terminal link presenting food reinforcement according to a different VI schedule. Relative response rates during the initial links provided a measure of preference for the terminal-link stimuli, while terminal-link stimuli were analogous to multiple-schedule components. Therefore, relative resistance to disruption was assessed across the terminal links by introducing disruptive operations like satiation, extinction, or response-independent food presentations during the initial links. Consistent with the idea that both preference and relative resistance to disruption reflect the conditioned value of discriminative stimuli, these measures were related positively as a function of relative reinforcement arranged in the terminal links (see Grace, Bedell, & Nevin, 2002, for a summary).

One factor strongly influencing preference, but not accounted for in the way that Equation 1 characterizes resistance to disruption, is the temporal context in which terminal-link stimuli signaling different rates of reinforcement are embedded. Although a general finding is that preference is greater for terminal links signaling richer schedules of reinforcement, the degree of preference for the richer terminal link decreases toward indifference as initial links become progressively longer (i.e., the initial-link effect). For example, Fantino (1969) arranged a constant 3:1 difference in VI-schedule reinforcement rate across terminal links while varying the initial links from concurrent VI 40-s schedules to concurrent VI 600-s schedules. Preference for the richer terminal link was more than ten-fold greater at the shortest initial links compared to the longest. Although the exact behavioral mechanisms governing the initial-link effect are controversial (see Fantino, 2000a; Grace & Savastano, 2000), preference is well described by a modification of Equation 2 that accounts for the effects of changes in initial-link duration on sensitivity to relative terminal-link food reinforcement rates (Grace, 1994):

$$\frac{B_1}{B_2} = b\left(\frac{r_{i1}}{r_{i2}}\right)^{a_i}\left[\left(\frac{r_{t1}}{r_{t2}}\right)^{a_t}\right]^{\left(\frac{T_t}{T_i}\right)}. \tag{3}$$

In the equation, B is initial-link responding, r_i is initial link reinforcement rate, and r_t is terminal link food reinforcement rate for two options denoted by the subscripts. The a_i and a_t parameters scale sensitivity of preference to changes in relative rate of transitioning to the terminal links and relative rate of primary reinforcement in the terminal links, respectively.

Time in the terminal link (T_t) relative to time in the initial link (T_i) scales the sensitivity of preference to relative terminal link reinforcement rates as a function of the temporal context. Because T_i is in the denominator, Equation 3 accurately predicts that longer initial links decrease sensitivity to relative terminal-link reinforcement rates.

One obvious difference between Equation 1 describing relative resistance to disruption and Equation 3 describing preference is that there are no terms in Equation 1 to account for changes in temporal context on relative resistance to disruption. Given the tendency to observe a positive relation between preference and relative resistance to disruption (Grace et al., 2002), one might predict that manipulating temporal context should similarly impact relative resistance to disruption. Existing data, however, suggest that temporal context does not impact relative resistance to disruption in the same way it affects choice. Just as increasing initial-link duration increases time between terminal-link stimulus contexts (e.g., Fantino, 1969), increasing timeout duration increases time between multiple-schedule components. Nevin (1992b) manipulated the intercomponent interval (ICI) from 2 s to 120 s when one component was a constant VI 60-s schedule of food reinforcement and a second component varied across conditions between a richer VI 12-s schedule and a leaner VI 360-s schedule. Both response rates and relative resistance to presession feeding and extinction tended to be greater in the currently richer component, regardless of ICI duration. Moreover, the shorter ICI produced greater differences in baseline response rates between richer and leaner components, consistent with behavioral contrast effects (see Williams, 1983). Conversely, no reliable effect of ICI duration was observed with relative resistance to disruption (see Nevin's, 1992b, Tables 1 and 2). These findings suggest that changes in temporal context might not impact relative resistance to disruption within discriminative stimulus contexts but do influence preference for one stimulus context over another.

The findings of Nevin (1992b) are limited with regard to understanding how temporal context impacts the relation between preference and relative resistance to disruption. First, no measure of preference was taken to indicate whether changes in preference might occur with changes in time between multiple-schedule components. Second, changing temporal context by increasing ICI timeout durations might not be analogous to changing initial-link duration in concurrent chains. In concurrent chains, introducing timeouts between the end of terminal links and initiation of initial links does not impact preference (e.g., Goldshmidt, Lattal, & Fantino, 1998; see Fantino, 2000b, for a relevant discussion). Therefore, a more direct test of how changes in temporal context impact preference and relative resistance to disruption would be to assess both measures within a concurrent-chains procedure at different initial-link durations.

Jimenez-Gomez, Podlesnik, and Shahan (2009) assessed whether temporal context impacts preference and resistance to disruption with rats responding in concurrent chains with terminal links maintained at VI 12-s and VI 48-s schedules of food reinforcement. Across conditions, both initial links were changed from 100 s to 20 s, and back to 100 s. To assess resistance to disruption, response-independent food was presented in the initial links for three consecutive sessions on a variable-time (VT) 15-s schedule. Consistent with previous findings of the initial-link effect (e.g., Fantino, 1969), preference for the VI 12-s terminal link became less extreme with the longer initial links. Surprisingly, relative resistance to disruption followed the opposite pattern. Resistance to disruption in the richer VI 12-s terminal link became relatively greater—more extreme—with longer initial links. Thus, preference and relative resistance to disruption were negatively correlated, counter to the assumptions of behavioral momentum theory that these measures are converging expressions of conditioned value.

The inverse relation between preference and relative resistance to disruption from Jimenez-Gomez et al. (2009) was clear and systematic, but what remains unclear is exactly what produced this inverse relation. For instance, relative resistance to disruption was consistently greater in the *leaner* terminal link for 2 out of 4 rats when initial links were short. Because the procedures were modeled after Nevin and Grace (2000b), in which preference and resistance to disruption were consistently a function of reinforcement rate, it is unclear why relative resistance to disruption should be greater in the terminal link arranging lower reinforcement rates. One possibility in the Jimenez-Gomez et al. study is that relative terminal-link response rates immediately prior to disruption influenced relative resistance to disruption; a clear negative relation existed between relative resistance to disruption and relative terminal-link response rates. Relatedly, resistance to disruption tends to be lower with higher response rates when reinforcement rates are equated (e.g., Lattal, 1989; Nevin, 1974; Nevin, Grace, Holland, & McLean, 2001). If relative terminal-link response rates were responsible for the inverse resistance to disruption relations in Jimenez-Gomez et al., then relative terminal-link response rates may have somehow overshadowed relative terminal-link reinforcement rates in that study. Establishing the generality of the effects reported by Jimenez-Gomez et al. is important because they are counter to assertions of behavioral momentum theory that (1) relative resistance to disruption is determined primarily by Pavlovian conditioned effects, and (2) preference and relative resistance to disruption both are quantitative expressions of a fundamental underlying behavioral process—conditioning value to discriminative stimuli (Nevin & Grace, 2000a).

The goal of the present experiments was to explore more systematically the role of temporal context in preference and resistance to disruption within a concurrent-chains procedure. In three experiments, we manipulated initial-link duration with different rates of food reinforcement presented between the terminal links. We used pigeons rather than rats to test the species generality of the inverse relation between preference and relative resistance to disruption found by Jimenez-Gomez et al. (2009). This allowed us to examine temporal-context effects in the species used by Nevin, Grace, and colleagues in their studies establishing a positive relation between preference and relative resistance to disruption (e.g., Grace et al., 2002; Nevin & Grace, 2000b).

EXPERIMENT 1

The use of rats as experimental subjects is one obvious difference between the Jimenez-Gomez et al. (2009) study and all previous studies assessing the relation between preference and relative resistance to disruption. Pigeons were used in all studies by Nevin, Grace, and colleagues (see Grace et al., 2002, for a summary). Given that Jimenez-Gomez et al. is the only published assessment of preference and relative resistance to disruption using rats, we systematically replicated their study using pigeons as experimental subjects in the present study. Mazur (2005, 2007) has reported differences in sensitivity to variations in procedures such as reinforcer rates and delays between pigeons and rats. Although it is difficult to distinguish between quantitative and qualitative differences between species, perhaps relative resistance to disruption in rats is differentially sensitive to relative terminal-link reinforcement and response rates compared to pigeons. Observing similar effects in another species would indicate the effects observed by Jimenez-Gomez et al. are not limited to rats. Therefore, the present study replicated the procedures used by Jimenez-Gomez et al. with pigeons.

METHOD

Subjects

Four homing pigeons participated in the experiment. They were maintained at approximately 80% of their free-feeding weights (±15 g) by postsession supplemental feeding of pigeon chow as necessary. The pigeons had experience with concurrent-chains schedules of reinforcement similar to those used in the present experiment and therefore did not require preliminary training. Pigeons were housed in a climate-controlled room with a 12:12 hr light/dark cycle with lights on at 7:00 a.m. Experimental sessions were conducted 7 days per week at approximately the same time every day. All pigeons had free access to water in their home cages. Animal care and housing was conducted in accordance to standards set by the Guide for the Care and Use of Laboratory Animals (National Research Council, 1996).

Apparatus

Four sound-attenuating chambers were used. The chambers were clear plastic and aluminum measuring 29 cm long × 26 cm wide × 29 cm high. Each chamber had two response keys located 2 cm from the side walls and 16 cm above the floor. Response keys

Table 1

Stimuli assigned across left and right keys for the 4 pigeons in all three experiments.

	Terminal link	
Pigeon	Rich	Lean
237	Red (left)	White (right)
858	Green (left)	White (right)
927	White (right)	Red (left)
1158	White (right)	Green (left)

measured 2.5 cm in diameter and required about 0.1 N to operate. Each peck produced a brief audible click as a result of the closing of a microswitch. The keys could be illuminated red, green, or white from behind with 28-V DC bulbs. A 28-V DC houselight centered above the keys and 33 cm from the floor of the chamber provided general illumination. A 6-cm × 5-cm aperture centered below the response keys and 5 cm from the chamber floor allowed access to a solenoid-operated hopper filled with pigeon chow. During 2-s hopper presentations, the hopper aperture was illuminated and the houselight and keylights were turned off. A ventilation fan masked extraneous sounds. Control of experimental events and data recording was conducted using Med Associates ® interfacing and programming.

Procedure

Responding in a concurrent-chains procedure with two concurrently available VI schedules provided access to two mutually exclusive terminal links. Terminal links presented food reinforcement according to different rates using VI schedules. Flashing keylights signaled initial links on the side keys and steady keylights signaled terminal links on the side keys. Table 1 shows the assignment of keylight stimuli during the initial links and corresponding high-reinforcement rate (i.e., Rich) and low-reinforcement rate (i.e., Lean) terminal links. Initial-link durations were 100 s in the first condition, 20 s in the second condition, and returned to 100 s in the final condition. Between conditions, initial-link durations were changed across 7–10 sessions until terminal values were reached. This was done to minimize the likelihood that initial-link responding would extinguish, particularly when initial-link durations increased. Two disruption tests were assessed in each condition by presenting response-independent food deliveries in the initial links.

Initial links began with the two keylights simultaneously flashed on and off every 0.5 s. Terminal-link entries were assigned randomly to left and right keys, with 12 entries per side in each session. An initial-link response produced access to a terminal link, provided it was made to the selected key and an interval from the VI schedule had elapsed. Timing of initial links began after a peck to either key. No changeover requirement was programmed. Access to terminal links was scheduled with two separate arithmetic VI schedules, both with 12 intervals. Interval progressions were as described by Grace and Nevin (2000): a, $a+d$, $a+2d$, …, with a equaling 1/12th and d equaling 1/6th of the initial-link schedule values (i.e., 100 s or 20 s). Separate lists of intervals were maintained for Rich and Lean terminal-link entries and intervals were sampled without replacement. In total, 24 cycles were arranged between the initial and terminal links, with each interval selected once per session.

Terminal links were a constant 30 s in duration, excluding reinforcement time. Thus, multiple food presentations or zero presentations could occur during each terminal link. Entries into terminal links were signaled by transitioning to a steady keylight on the selected key and turning off the other key. Food presentations in the Rich and Lean terminal links were scheduled by separate VI 12-s or VI 48-s schedules, respectively. Each interval progression included 13 intervals (Fleshler & Hoffman, 1962), sampled without replacement. At the end of a terminal link, initial links began immediately. Food presentations available but not collected at the end of a terminal link were available upon the first response the next time that terminal link was presented.

Disruption was assessed following the number of baseline sessions shown in the Appendix (for all experiments), along with obtained initial-link and terminal-link response rates. Stability was assessed visually; with baseline sessions continuing for all pigeons until no clear increasing or decreasing trends were present and response rates from the last six sessions appeared within the range of variability within that condition. During disruption tests, 2-s hopper presentations were arranged response independently during the initial links for five consecutive sessions according to a VT 15-s schedule with 13 intervals (Fleshler & Hoffman, 1962). Transitions into selected terminal links occurred response independently to prevent prolonged session times with low levels of responding during disruption (Grace & Nevin, 1997, 2000). Hopper time was included in timing of initial links. Two disruption tests were conducted per condition (i.e., at each initial-link duration). Baseline schedules were reestablished between all disruption tests when pigeons reached 80% of their free-feeding weights.

Dependent Measures

Baseline response rates were calculated as means of six sessions prior to disruption separately for both initial links and both Rich and Lean terminal links. Resistance to disruption was assessed as a proportion of baseline terminal-link response rates calculated separately for each terminal link by dividing mean response rates from five disruption sessions by the mean of the previous six predisruption sessions.

It is standard practice in studies of behavioral momentum to convert initial-link, terminal-link, and proportion of baseline response rates to relative measures when comparing Rich and Lean options (see Grace & Nevin, 1997). Relative measures were calculated using mean values described above. Preference was measured as the logarithmic (log) ratio of Rich-to-Lean initial-link response rates. Relative terminal-link response rates were measured as the log ratio of Rich-to-Lean response rates in the terminal links. Relative resistance to disruption was calculated as the difference between the log proportion of baseline response rates in the Rich terminal link and log proportion of baseline response rates in the Lean terminal link. Because disruption was arranged twice at each initial-link duration, preference, terminal-link response rates, and resistance to disruption were assessed twice per condition, with figures showing all assessments, except when noted otherwise.

RESULTS

Figure 1 shows initial-link response rates, terminal-link response rates, and proportion of baseline response rates during disruption across all conditions and assessments. The left column shows baseline response rates in the initial links leading to the Rich and Lean terminal links. In all cases, response rates were greater in the initial link leading to the Rich terminal link. In addition, shorter initial links typically increased response rates for the Rich and decreased response rates for the Lean (but see 1158, Condition 2). In the center column, terminal-link response rates did not differ systematically among the pigeons, either as a function of reinforcement rate or initial-link duration. In the right column, resistance to disruption, shown as a proportion of baseline response rates, consistently was greater in the Rich terminal link. Responding also tended to be more resistant to disruption in the Lean terminal link during the short, 20-s initial-link condition compared to long initial links—no systematic changes occurred across conditions in the Rich terminal link. Overall, decreasing initial-link duration increased differences in responding during the initial links but decreased differences in resistance to disruption in the terminal links.

Figure 2 shows relative measures of data shown in Figure 1. In the left column, preference consistently was greater for the Rich terminal link across all conditions. Moreover, preference became more extreme with the short, 20-s initial links. In the center column, no clear patterns of relative terminal-link responding were observed as a function of relative reinforcement rate or initial-link duration. In the right column, relative resistance to disruption was positive in all cases. Furthermore, resistance to disruption tended to be less extreme with short initial links, although there were clear exceptions. These include the transition from short to long initial links for Pigeon 858 and from long to short for Pigeon 1158. Overall, these relative measures indicate that decreasing initial links enhanced preference for a Rich terminal link, slightly increased relative response rates in that terminal link, but reduced relative resistance to disruption.

Figure 3 examines the relation among the relative measures shown in Figure 2. These data were examined in two ways. In the left column, all assessments across the three conditions are presented. In the right column, the two assessments from the short initial-link condition were averaged and the four assessments from the two long initial-link conditions

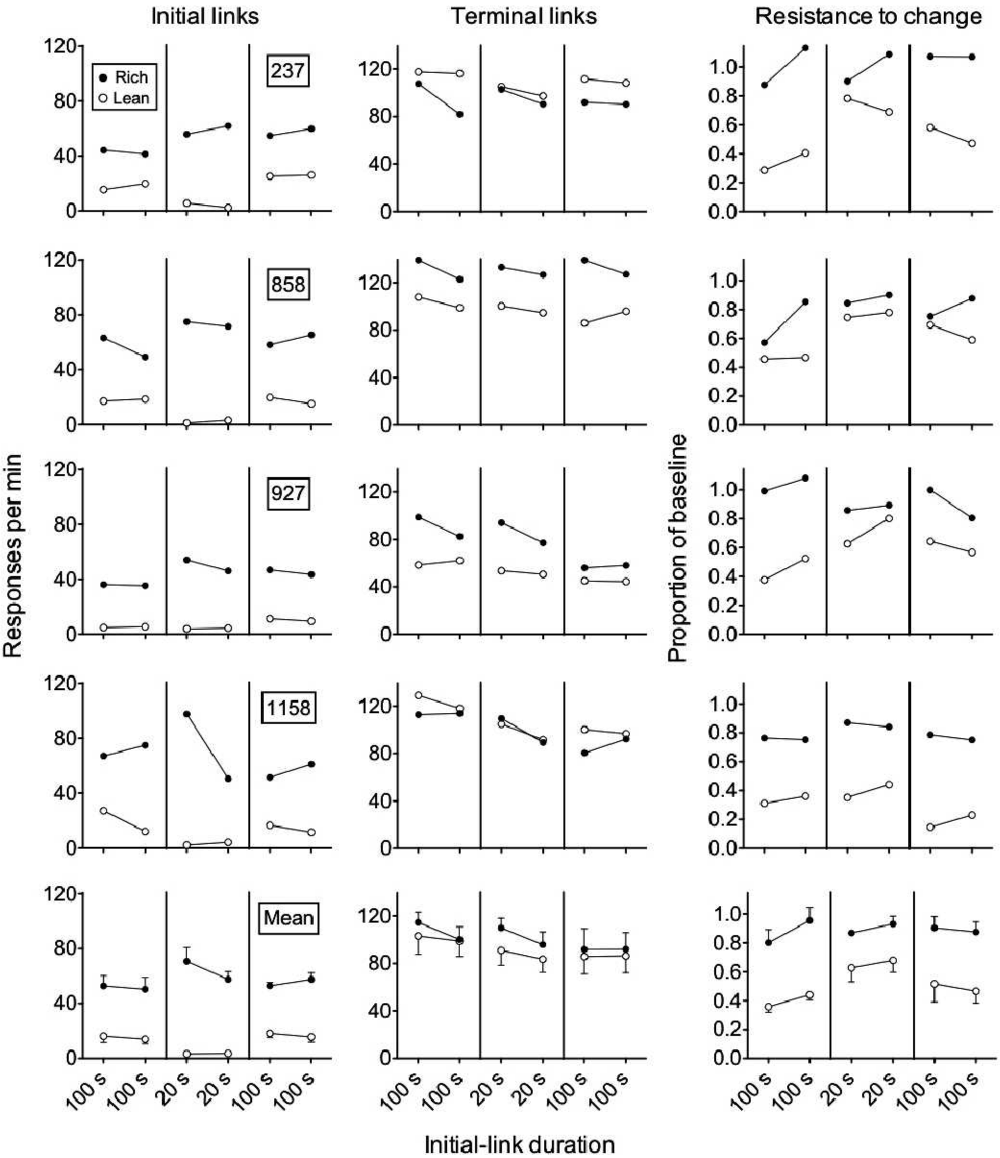

Fig. 1. Response rates in the initial links, response rates in the terminal links, and resistance to disruption as shown as proportion of baseline response rates in Experiment 1. The connected data points in each condition represent the two assessments of these measures per initial-link duration. Error bars represent SEM.

were averaged. This latter analysis provided a clearer picture of the overall effect of initial-link duration. In both columns, linear regression lines (see dashed lines) were fitted to reveal general relations between measures. In the right column, solid lines connect long- and short-initial link data points for each pigeon.

The top panels of Figure 3 show preference as a function of relative resistance to disruption, measures typically correlated positively in the behavioral momentum literature (see Grace et al., 2002, for a summary). The overall relation indicated by the dashed lines in both columns, however, is negative. Although neither of these lines were statistically different from zero (see equations in figure), the top-right panel shows this effect was observed in all 4 pigeons. These findings suggest that changes in initial-link

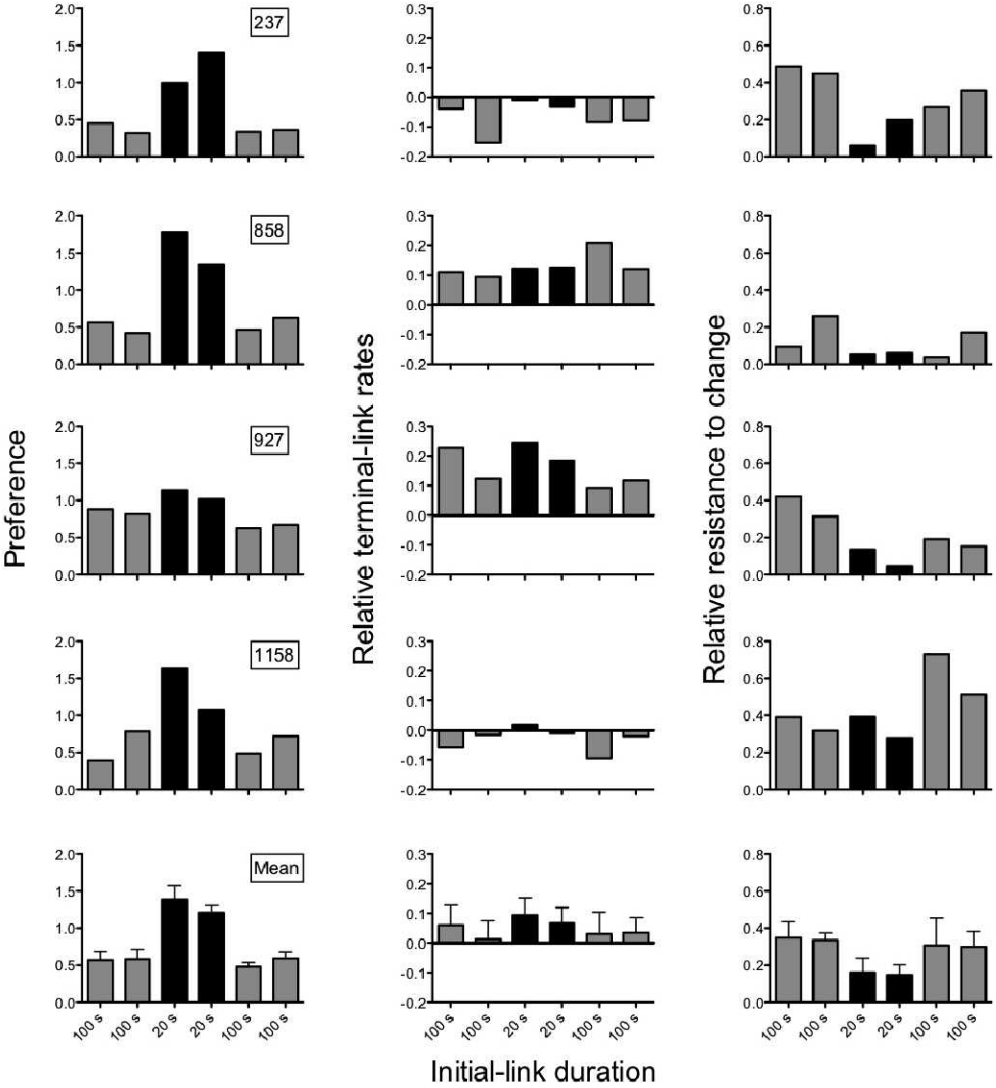

Fig. 2. Preference, relative terminal-link response rates, and relative resistance to disruption in Experiment 1. The two bars in each condition represent the two assessments of these measures per initial-link duration. Error bars represent SEM.

duration impacted preference and resistance to disruption differently: Longer initial links decreased preference for a rich terminal link but increased relative resistance to disruption.

The middle row of Figure 3 shows the relation between relative resistance to disruption and relative terminal-link response rates. The overall relation between relative resistance to disruption and relative terminal-link response rates was negative. Regression lines in both panels were statistically different from zero (see equations in figure). In the middle-right panel, these effects also were observed on the individual-subject level in 3 pigeons; little change in relative terminal-link response rates was observed for Pigeon 858.

The bottom row of Figure 3 shows the relation between preference and relative terminal-link response rates. A slight positive relation was observed at the overall level in the left panel, although the line does not differ statistically from zero. However, a positive relation also was observed in 3 pigeons in the right panel (again, Pigeon 858 was the exception). This positive relation in these 3 pigeons was not surprising given the negative

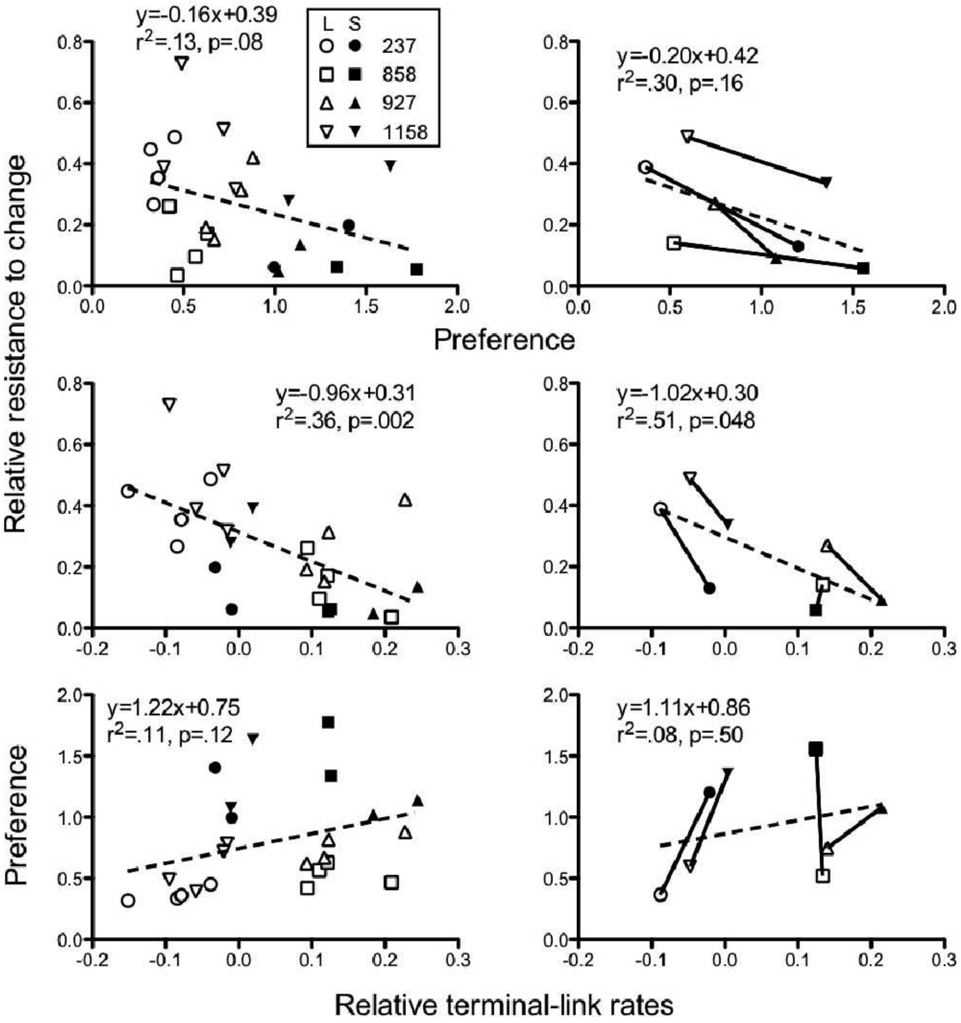

Fig. 3. Relations among relative measures from Experiment 1. The left column shows relations among all assessments and the right column shows averages of assessments from the long (L) and short (S) initial-link conditions. Linear regression lines are indicated by dashed lines and equations are shown in each panel.

relations between relative resistance to disruption and these two measures observed in the top and middle rows.

In summary, relative resistance to disruption was related negatively both to preference and relative terminal-link response rates, while preference and relative terminal-link response rates tended to be positively related.

DISCUSSION

According to behavioral momentum theory, relative resistance to disruption and preference are converging measures of the conditioned value of a discriminative stimulus (see Nevin & Grace, 2000a). Consistent with behavioral momentum theory, preference and resistance to disruption in the present experiment consistently were greater for a terminal link presenting a higher reinforcement rate (Nevin & Grace, 2000a). Changing initial-link duration, however, produced opposite effects on preference and relative resistance to disruption. Specifically, longer initial-link durations decreased preference for a rich terminal link (i.e., the initial-link effect; see also Fantino, 1969) but relative resistance to disruption tended to be greater in the rich terminal link when initial links were long. Although inconsistent with assumptions of behavioral momentum theory, this negative relation is consistent with data from rats responding under almost identical conditions (Jimenez-Gomez et al., 2009). Moreover, in both the present experiment and Jimenez-Gomez et al., there was a strong negative relation between relative resistance to disruption and relative terminal-link response rates. Therefore, these findings eliminate species differences as an account for the negative relation between relative resistance to disruption and preference.

Although relative resistance to disruption and preference were not positively related, it is premature to suggest these measures are not controlled uniformly and therefore cannot be expressions of the same behavioral constructs. In the present study and in Jimenez-Gomez et al. (2009), presenting food response-independently during the initial links was used to assess resistance to disruption, procedures used frequently when assessing relations between relative resistance to disruption and preference (see Grace et al., 2002). When initial-link duration changes across conditions, however, more food presentations occur response-independently during sessions in which initial links are long than when they are short. Therefore, the magnitude of the disrupter might be greater with long initial links if the cumulative number of food deliveries rather than rate of food delivery is the relevant disrupter. Moreover, larger magnitude disrupters produce greater differences in resistance to disruption between rich and lean stimulus contexts than smaller magnitude disrupters, indicating that the effects of disruption on the difference measure for relative resistance to disruption used herein is additive (see Nevin, 2002). Consistent with this interpretation, Figure 1 shows that responding in the Lean terminal link was more disrupted when initial links were long, while responding in the Rich terminal link remained high across both initial-link durations during disruption. Therefore, the present findings and those of Jimenez-Gomez et al. might be consistent with predictions of behavioral momentum theory.

To eliminate any confounding effects of presenting disrupters of different magnitude, Experiment 2 arranged a disrupter that could be applied equally across long and short initial-link conditions. With baseline conditions identical to those arranged in Experiment 1, disruption of responding in the terminal links was assessed by feeding pigeons prior to experimental sessions. If relative resistance to disruption again was negatively related to preference, these findings would suggest that initial-link duration impacts preference and relative resistance to disruption differently.

EXPERIMENT 2

METHOD

Subjects and Apparatus

The pigeons and operant chambers were identical to those used in Experiment 1.

Procedure

The experimental procedures were identical to those used in Experiment 1 with the exception that presession feeding was used as a disrupter. During presession feeding, pigeons were fed 12% of their free-feeding weights 1 hr prior to five consecutive experimental sessions. Transitions to terminal links occurred response independently during disruption, as previously described. Baseline conditions were reestablished between determinations of presession feeding. Dependent measures were the same as those described for Experiment 1.

RESULTS

Figure 4 shows initial-link response rates (left column), terminal-link response rates (center column), and resistance to disruption as a proportion of baseline response rates (right column) across all conditions and assessments. Response rates were greater in the initial link leading to the Rich terminal link, and shorter initial links typically increased response rates for the Rich and decreased response rates for the Lean. In the center column, terminal-link response rates did not differ systematically as a function of reinforcement rate or initial-link duration. In the right column, resistance to disruption also did not differ systematically as a function of reinforcement rate or initial-link duration, even though responding was disrupted to approximately 50% of baseline on average. Thus, decreasing initial-link duration increased differences in responding during the initial links but had no clear effects on terminal-link response rates or resistance to disruption.

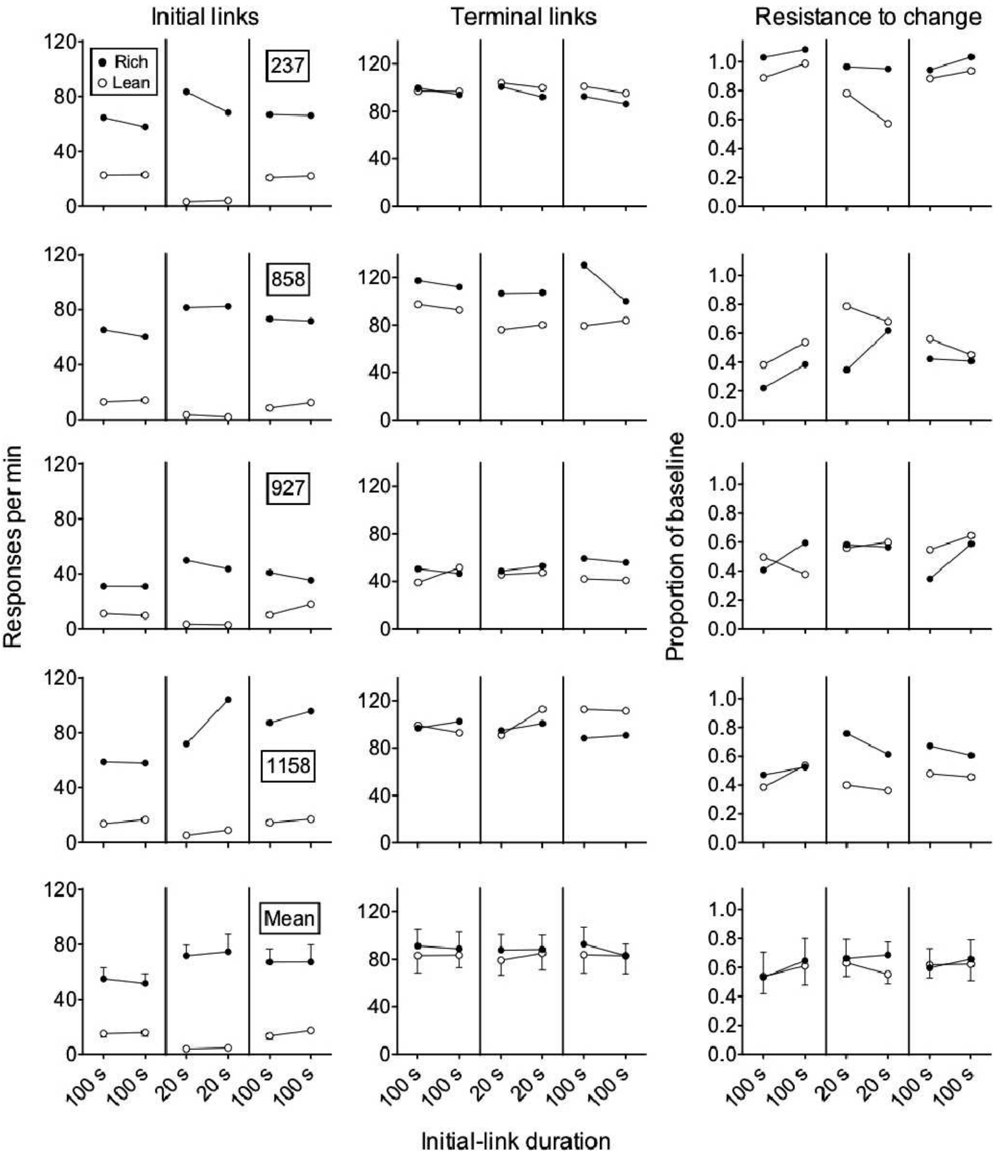

Fig. 4. Response rates in the initial links, response rates in the terminal links, and resistance to disruption as shown as proportion of baseline response rates in Experiment 2. The connected data points in each condition represent the two assessments of these measures per initial-link duration. Error bars represent SEM.

Figure 5 shows relative measures of data shown in Figure 4. The left column shows that preference consistently was greater for the Rich terminal link across all conditions and this effect became more extreme with the short initial-link condition. In the center and right columns, no clear patterns of relative terminal-link responding or relative resistance to disruption were observed as a function of relative reinforcement rate or initial-link duration.

Figure 6 examines the relation among the relative measures shown in Figure 5. The top row shows no clear relation between relative resistance to disruption and preference, although there is a slightly positive relation in 3 out of 4 pigeons in the top-right panel (858 is the exception). The middle row shows that relative resistance to disruption and relative terminal link response rates were related negatively, a finding supported statistically in

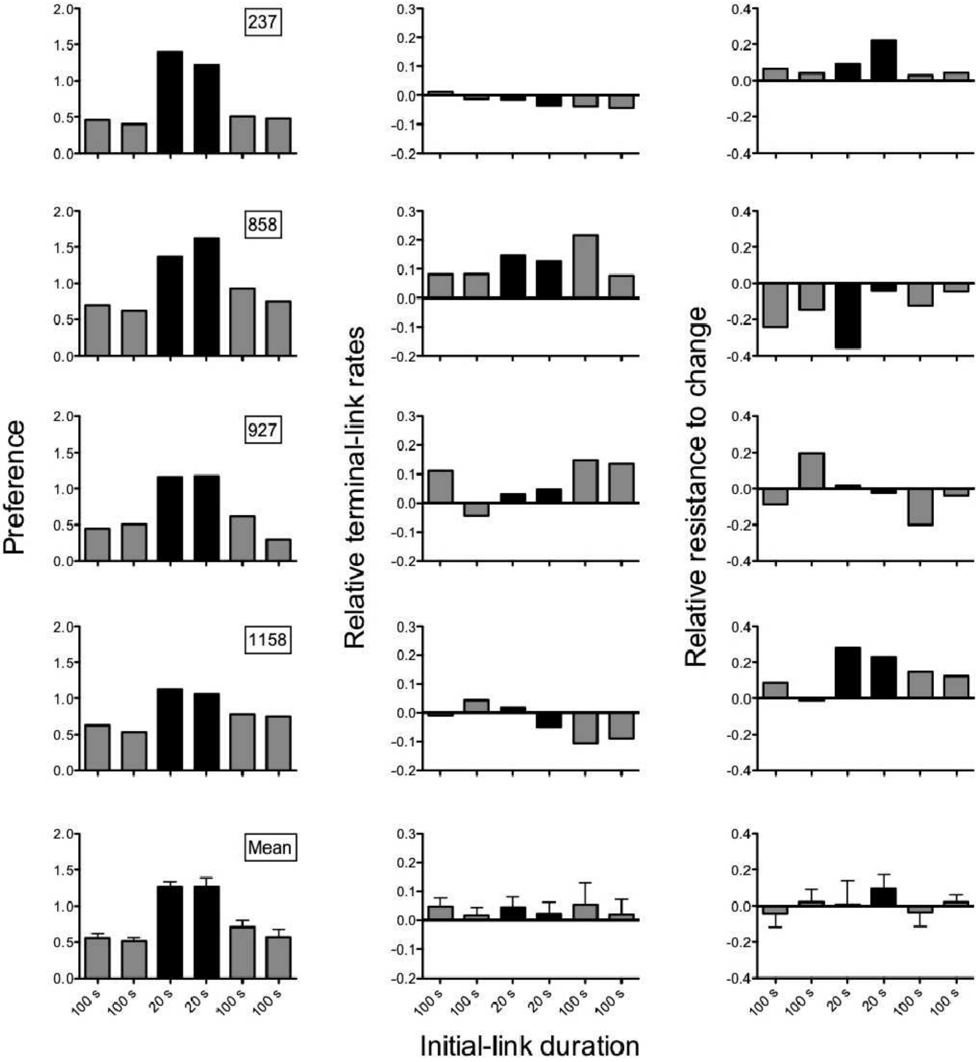

Fig. 5. Preference, relative terminal-link response rates, and relative resistance to disruption in Experiment 2. The two bars in each condition represent the two assessments of these measures per initial-link duration. Error bars represent SEM.

both the middle-left and middle-right panels. However, comparing long and short initial-link conditions, there was no clear within-subject relation as a function of condition. Finally, the bottom row shows that preference and relative terminal-link response rates were not related at an overall or individual-subject level.

In summary, there was some indication of a positive relation between relative resistance to disruption and preference at the individual-subject level. However, the strongest relation was that between relative resistance to disruption and relative terminal-link response rates.

DISCUSSION

In Experiment 1, a negative relation between relative resistance to disruption and preference was observed when responding in the terminal links was disrupted by response-independent food presentations during initial links. Because the magnitude of disruption might have been greater with longer initial links, the present experiment equated disruption across short and long initial-link conditions by feeding animals prior to sessions. This change in disruption reduced the negative

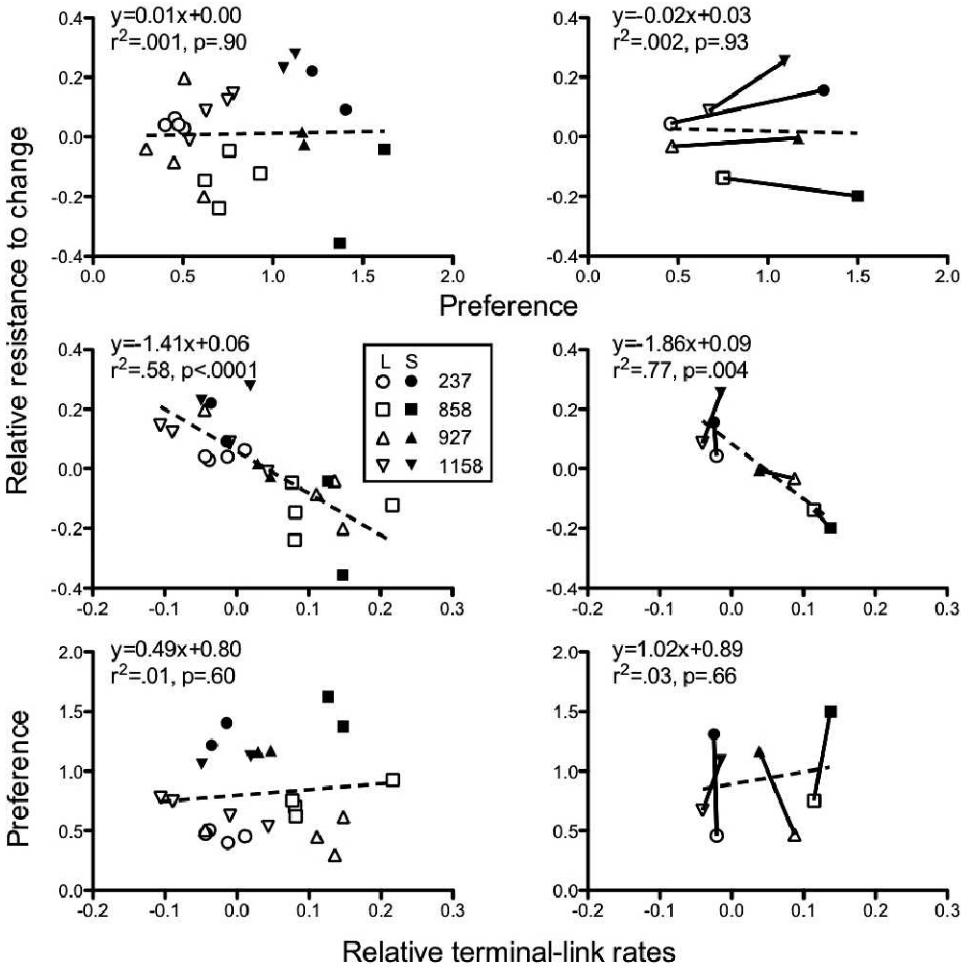

Fig. 6. Relations among relative measures from Experiment 2. The left column shows relations among all assessments and the right column shows averages of assessments from the long (L) and short (S) initial-link conditions. Linear regression lines are indicated by dashed lines and equations are shown in each panel. Note that y-axes in top two rows have different values but span the same range as in Figure 3.

relation between relative resistance to disruption and preference, compared to Experiment 1. However, unlike in Experiment 1, relative resistance to disruption in the present experiment was not related consistently to differences in reinforcement rate across terminal links in any condition. Nonetheless, preference remained sensitive to differences in terminal-link reinforcement rates and changes in initial-link duration.

Preference consistently is more sensitive to terminal-link reinforcement rates than is relative resistance to disruption (e.g., Grace & Nevin, 1997). In addition, sensitivity of relative resistance to disruption differs among disrupter types (e.g., Nevin & Grace, 2000a; Nevin et al., 2001). Resistance to extinction generally is less sensitive to relative reinforcement rate than resistance to response-independent food presentations. Unfortunately, no direct comparisons of presession feeding to other disrupters have been conducted in concurrent-chains procedures. As indicated by Grace and Nevin (1997), it is important to note that differences among different disrupter types could be due to differences in disrupter magnitude and/or qualitative differences among behavioral processes impacted during disruption.

If relative resistance to disruption was insensitive to the arranged reinforcement rates, arranging more extreme reinforcement rates between terminal links should improve the likelihood of observing differences in resistance to disruption. In Experiment 3, the terminal-link intervals were set to VI 10 s (Rich) and VI 60 s (Lean), a 6:1 ratio compared to the 4:1 ratios used in Experiments 1 and 2. In addition, initial links were manipulated from 140 s to 28 s, and back to 140 s. According to delay reduction theory (Squires & Fantino, 1971), these schedule values should have kept the conditioned reinforcing value of the Rich and Lean terminal links equal between Experiment 3 and Experiments 1 and 2, Thus, preference should be impacted as in Experiments 1 and 2 both by relative terminal-link reinforcement rates and changes in initial-link duration. The question is whether relative resistance to presession feeding is impacted similarly by the relative terminal-link reinforcement rates and initial-link duration.

EXPERIMENT 3

Method

Subjects and Apparatus

The pigeons and operant chambers were identical to those used in Experiments 1 and 2.

Procedure

The experimental procedures were identical to those used in Experiment 2 with the exception that initial-link and terminal-link reinforcement schedules differed. In Conditions 1 and 3, initial-links schedules were VI 140 s. In Condition 2, initial-link schedules were VI 28 s. In all conditions, terminal-link schedules were VI 10 s in the Rich terminal link and VI 60 s in the Lean terminal link. The Rich and Lean links were counterbalanced across sides among pigeons. All pigeons were exposed to these conditions in the same order baseline was reestablished prior to all disruption tests. As in Experiment 2, disrupters consisted of feeding pigeons 12% of their free-feeding weights 1 hr prior to five consecutive experimental sessions.

Results

Figure 7 shows initial-link response rates (left column), terminal-link response rates (center column), and resistance to disruption as proportion of baseline response rates (right column) across all conditions and assessments. Preference findings generally were consistent with those of Experiments 1 and 2. Response rates were greater in the initial link leading to the Rich terminal link. Shorter initial links typically increased response rates for the Rich and decreased response rates for the Lean. In the center column, terminal-link response rates did not differ systematically as a function of reinforcement rate or initial-link duration. In the right column, resistance to disruption did not differ systematically as a function of reinforcement rate when initial links were long; however, resistance to disruption was greater in the Rich terminal link for all 4 pigeons when initial links were short. This primarily resulted from decreases in resistance to disruption in the Lean terminal link when the initial links were short. Thus, decreasing initial-link duration produced similar effects on responding in the initial links and resistance to disruption in the terminal links.

Figure 8 shows relative measures of data shown in Figure 7. In the left column, preference consistently was greater for the Rich terminal link across all conditions and this effect became more extreme with the short initial-link condition. In the center column, no clear patterns of relative terminal-link responding were observed as a function of relative reinforcement rate or initial-link duration. In the right column, relative resistance to disruption typically was greater when initial links were short compared to when initial links were long (last bar for Pigeon 1158 was the exception).

Figure 9 examines the relation among the relative measures shown in Figure 8. The top row shows a positive relation between relative resistance to disruption and preference. Although the linear regression lines are not statistically greater than zero (see figure caption), the top-right panel shows this relation was positive in all 4 pigeons. In the middle row, relative resistance to disruption and relative terminal-link response rates are related negatively, a finding supported statistically in both the middle-left and middle-right panels. However, comparing long and short initial-link conditions, there was no clear within-subject relation as a function of condition. Finally, in the bottom row, preference and relative

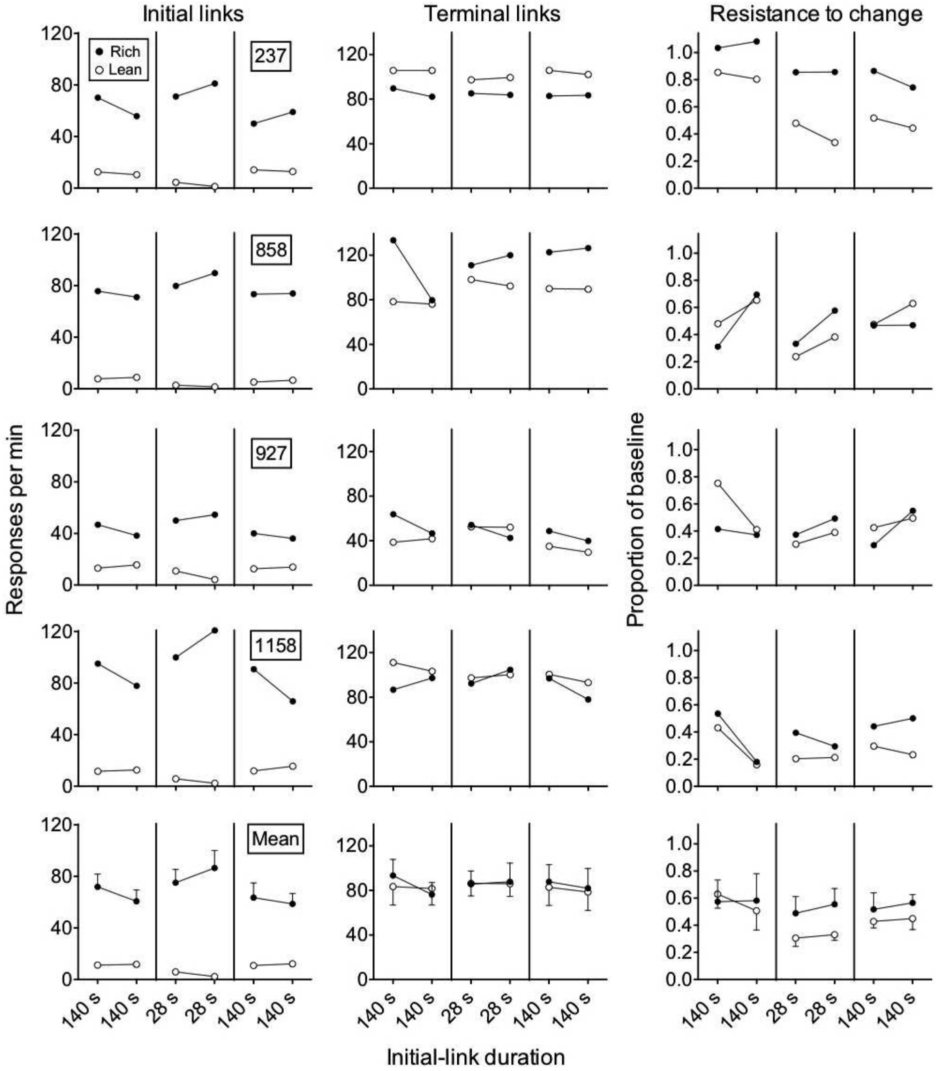

Fig. 7. Response rates in the initial links, response rates in the terminal links, and resistance to disruption as shown as proportion of baseline response rates in Experiment 3. The connected data points in each condition represent the two assessments of these measures per initial-link duration. Error bars represent SEM.

terminal-link response rates were not related at an overall or individual-subject level.

In summary, there was a positive relation between relative resistance to disruption and preference, most clearly represented at the individual-subject level. In addition, relative resistance to disruption and relative terminal-link response rates were related negatively at the overall level of analysis.

Discussion

Increasing differences in terminal-link reinforcement rates in Experiment 3 produced greater resistance to disruption in the Rich terminal link when initial links were short; resistance to disruption did not differ between terminal links when initial links were long. These findings suggest at least three points: (1) The absence of an effect in Experiment 2 likely was a result of a lack of sensitivity to the terminal-link reinforcer ratio with the presession-feeding disrupter; (2) Decreasing initial-link duration increases sensitivity of both relative resistance to disruption and preference to relative terminal-link reinforcement rate; and (3) Relative resistance to disruption

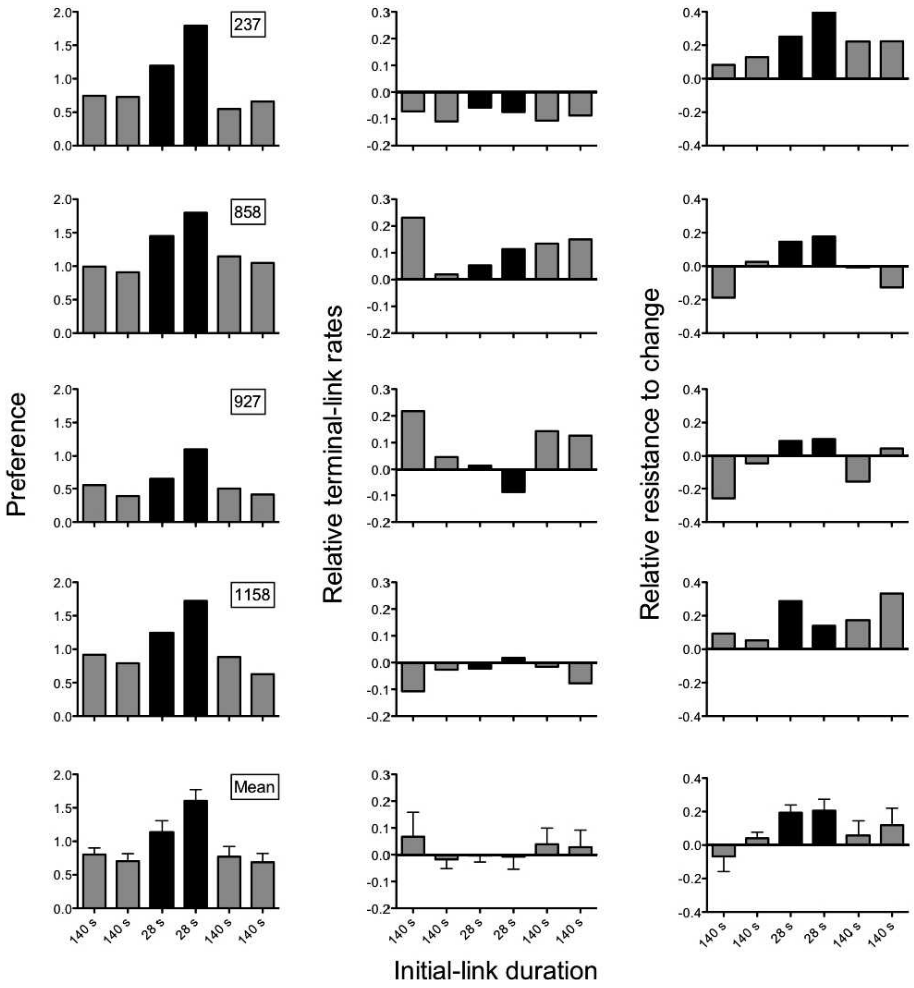

Fig. 8. Preference, relative terminal-link response rates, and relative resistance to disruption in Experiment 3. The two bars in each condition represent the two assessments of these measures per initial-link duration. Error bars represent SEM.

and preference are impacted similarly by changes in initial-link duration, consistent with the suggestion of behavioral momentum theory that both measures express relative conditioned value of terminal-link stimuli.

Consistent with findings from Experiments 1 and 2, as well as Jimenez-Gomez et al. (2009), relative resistance to disruption was negatively related to relative terminal-link response rates. This negative relation was obtained regardless of the pattern of resistance to disruption findings: Resistance to disruption in the richer terminal link was greater with long initial links in Experiment 1 and Jimenez-Gomez et al. (2009), undifferentiated in Experiment 2, and greater with short initial links in the present experiment. Given the complexity but apparent generality of these findings, they are addressed in greater detail below in the General Discussion.

GENERAL DISCUSSION

According to behavioral momentum theory, preference and relative resistance to disruption are converging expressions of relative conditioned value and should be positively related (Nevin & Grace, 2000a). The goal of the present experiments was to explore the effects of temporal context on preference and relative resistance to change. A previous study arranging concurrent chains with rats suggested that

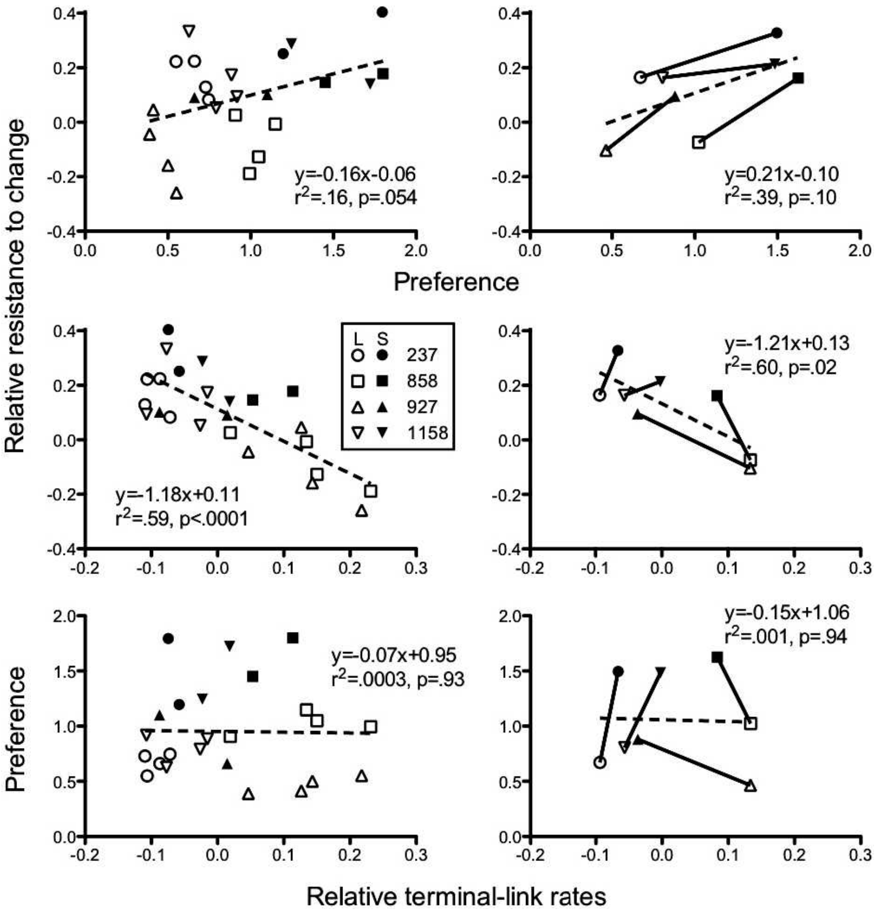

Fig. 9. Relations among relative measures from Experiment 3. The left column shows relations among all assessments and the right column shows averages of assessments from the long (L) and short (S) initial-link conditions. Linear regression lines are indicated by dashed lines and equations are shown in each panel. Note that y-axes in top two rows have different values but span the same range as in Figure 3.

manipulating temporal context by changing initial-link duration impacted preference and relative resistance to change in opposite directions. Jimenez-Gomez et al. (2009) found that preference for a terminal link presenting a higher reinforcement rate *decreased* with increases in initial-link duration. Conversely, resistance to disruption by response-independent food presentations during the initial links in that richer terminal link *increased* with increases in initial-link duration, relative to resistance to disruption in a leaner terminal link. Experiment 1 of the present study replicated these findings with pigeons, ruling out differences in species as a potential explanation.

A confound existed in Jimenez-Gomez et al. (2009) and Experiment 1. Disrupting with response-independent food presentations during initial links resulted in a greater number of food presentations within a session in longer than in shorter initial links. This likely resulted in a greater magnitude disrupter with longer initial links. Thus, Experiments 2 and 3 equalized the magnitude of disruption by providing access to equal amounts of food prior to sessions with long and short initial links. Experiment 2 replicated the changes in preference with changes in initial-link duration of Experiment 1 but relative resistance to presession feeding was not consistently a function of relative reinforcement rate at either initial-link duration. To increase the likelihood of impacting resistance to disruption, relative rates of reinforcement in the terminal links were made more extreme in Experiment 3. Preference and relative resistance to change both were greater for the richer terminal link with short initial links and decreased with longer time in initial links. The findings from Experiment 3 indicate that, when confounds of disruption are eliminated and are assessed under appropriate conditions of reinforcement, initial-link duration impacts relative resistance to disruption and preference in the same direction.

Findings from the present study speak broadly to relative resistance to disruption and preference being converging expressions of the relative conditioned value of discriminative stimuli, a fundamental assumption of behavioral momentum theory (see Nevin & Grace, 2000a). Though changes in initial-link duration impacted relative resistance to disruption and preference in the same direction, questions remain as to whether changing temporal context directly impacted relative conditioned value itself or merely the sensitivity of these measures to the prevailing relative conditioned value. The present findings suggest that sensitivity to relative conditioned value, not relative conditioned value itself, changed with manipulations to the temporal context (see also Grace & Savastano, 1997, 2000). In Experiment 2, the different terminal-link reinforcement rates did not differentially impact resistance to disruption at either initial-link duration. For this reason, in Experiment 3, we increased short and long initial-link durations and enhanced differences in terminal-link reinforcement rates to keep relative conditioned value equal, in accordance with delay reduction theory (see Squires & Fantino, 1971). If conditioned values remained the same with these changes between Experiments 2 and 3, patterns of relative resistance to disruption should have been identical between experiments. Instead, relative resistance to disruption in the richer terminal link was greater in Experiment 3 with shorter initial links. Thus, relative resistance to disruption became sensitive to relative terminal-link reinforcement rates by enhancing the difference in terminal-link reinforcement rates in Experiment 3. These findings suggest relative terminal-link reinforcement rate, not temporal context, impacts relative conditioned value. Changing temporal context, conversely, influences only the sensitivity of dependent measures to the differences in terminal-link reinforcement rates (see Grace & Savastano, 2000, for a detailed discussion).

The present finding that temporal context similarly impacts preference and relative resistance to change is generally consistent with the notion that these measures are converging expressions of relative conditioned value (see Nevin & Grace, 2000a). However, these findings also indicate the need for further theoretical development within behavioral momentum theory. Comparing the equations relating relative resistance to change (Equation 1) and preference (Equation 3) to relative rate of reinforcement, only Equation 3 can account for the effects of changing in temporal context (through the exponent T_t/T_i, which scales sensitivity of preference to relative duration of terminal and initial links). Equation 1, therefore, requires modification to account for the effects of temporal context on sensitivity of relative resistance to change to variations in relative terminal-link reinforcement rates. A reasonable first step would be to extend Equation 1 in a manner similar to the extension of the generalized matching equation (Equation 2) embodied by the contextual-choice model (Equation 3). Regardless of how such modeling is developed, testing modifications of Equation 1 will require a larger data set than that obtained in the present experiments.

Although the present findings showed that temporal context impacted both preference and relative resistance to change, it is important to note that only changes to specific aspects of the temporal context appear to impact these measures. For instance, changes in timeout duration between cycles of concurrent chains do not influence preference (Goldschmidt et al., 1998). In addition, changes in timeout duration between multiple-schedule components do not influence relative resistance to change (Nevin, 1992b). Future studies might assess whether resistance to change is impacted by changes in (1) timeouts between concurrent-chain cycles (see Fantino, 2000b) or (2) terminal-link duration. Preference is positively related to terminal-link duration (MacEwan, 1972; Williams & Fantino, 1978), and according to Equation 3, terminal-link duration impacts preference through the same mechanism as changes in initial-link duration (i.e., the exponent T_t/T_i). Such studies would provide important tests to explore the generality of the relation between preference and relative resistance to change, as well as further define the role of temporal context within behavioral momentum theory.

Although the present study was designed to examine how temporal context impacts preference and relative resistance to change, the present findings join others suggesting that relative resistance to change likely is determined by multiple factors (see Podlesnik & Shahan, 2008, for a discussion). The strongest relation observed in all three of the present experiments and in Jimenez-Gomez et al. (2009) was the negative relation between relative resistance to disruption and relative terminal-link response rates[2]. Several previous studies explicitly examined the role of response rates in relative resistance to disruption by arranging differential reinforcement of high versus low rate schedules or with ratio versus interval schedules (e.g., Nevin, 1974; Nevin et al., 2001; see also Lattal, 1989). When reinforcement rates were controlled, lower baseline response rates typically were more resistant to disruption (see Nevin, 2003, for a review). In the present studies, however, we obtained a negative relation between relative resistance to disruption and relative response rates despite arranging different reinforcement rates across terminal links. At the same time, no clear relation existed between relative terminal-link response rates and relative terminal-link reinforcement rates (see also Grace & Nevin, 2000; Herrnstein, 1964). These findings imply that, with regard to relative resistance to disruption, relative response rates might have influenced responding to a greater extent than relative reinforcement rates. Perhaps when sensitivity of relative resistance to disruption to relative terminal-link reinforcement rate is low, relative terminal-link response rates might exert a stronger influence.

What additional evidence exists for relative response rates influencing relative resistance to disruption? In Jimenez-Gomez et al. (2009) and Experiments 2 and 3, when response rates differed to the greatest extent, relative resistance to response-independent food presentations and presession feeding reached negative values, i.e., greater resistance to disruption in leaner terminal links. Under most conditions, relative resistance to these disrupter types should not reach negative values[3]. One exception would be the existence of a location or color bias for the lean terminal link. However, neither preference nor relative terminal-link response rates were greater for the lean terminal link when relative resistance to disruption reached negative values. This leaves plausible the explanation that relative terminal-link response rates produced the negative relative resistance to disruption values. Unfortunately, the behavioral processes underlying the effects of response rates on resistance to disruption remain unclear (see Nevin et al., 2001, for a discussion). Not only is behavioral momentum theory unable to account for such effects, other leading theories of operant behavior also cannot account a priori for such findings (see Nevin, 2003, for a relevant discussion).

Although relative terminal link response rates appear to have influenced relative resistance to disruption, they were not the only factor influencing relative resistance to disruption. For instance, the relation between relative resistance to disruption and preference changed from negative to positive across experiments seemingly independently from the consistently negative relation between relative resistance to disruption and relative terminal-link response rates. If relative terminal-link response rates solely impacted relative resistance to disruption, patterns of disruption should not have changed with changes in disrupter type (Experiment 2) or terminal-link

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[2] We have examined alternative methods to assess relations between resistance to disruption and baseline response rates. We have compared resistance to disruption as log proportion of baseline response rates in each terminal link as a function of log baseline response rate in each terminal link. We also have examined relative resistance to disruption (difference of log proportion of baseline response rates) as a function of the log sum response rates across both terminal links. Neither method indicated a reliable relation between resistance to disruption and baseline terminal-link response rates.

[3] Relative resistance to disruption theoretically could reach indifference under conditions of complete insensitivity to relative reinforcement rates, such as when discriminative stimuli signaling different reinforcement rates are separated by large amounts of time (e.g., Cohen, 1998). In addition, resistance to extinction might not differ when different reinforcement rates are arranged across components (see Nevin & Grace, 2000a). Such findings are instances of the partial reinforcement extinction effect (PREE).

reinforcement rates (Experiment 3). Moreover, relative response rates also should have impacted preference because preference and relative resistance to disruption typically are correlated, with preference being more sensitive to terminal-link conditions (e.g., Grace et al., 2002). Importantly, previous studies have shown that differential responding in terminal links affects preference (e.g., Moore & Fantino, 1975, Nevin, 1979). Nonetheless, we observed no relation between preference and relative terminal-link response rates across the three present experiments. For these reasons, it is difficult to conclude that relative response rates primarily influenced relative resistance to disruption. Instead, it is more likely that relative response rates, along with other factors (e.g., relative reinforcement rate, initial-link duration, type of disrupter), combined in impacting relative resistance to disruption. Given the complexity, generality, and theoretical relevance of the present findings, additional research is warranted in exploring how relative resistance to disruption might be influenced simultaneously by multiple factors. Future studies might explore a broader range of initial-link durations and parametrically assess changes in terminal-link reinforcement rates to control for the potential impact of inherent biases.

Finally, despite the positive relation between preference and relative resistance to disruption in Experiment 3, the present experiments suggest limitations to this relation, even when disrupters are equated at different initial-link durations. Longer duration initial links decrease the effect of a given relative terminal-link reinforcement rate on preference and relative resistance to disruption. Therefore, a positive relation between these measures and their relation to relative terminal-link reinforcement rates theoretically should be eliminated with sufficiently long initial-link durations. Thus, the impact of relative reinforcement rates on the positive relation between relative resistance to disruption and preference is limited to conditions in which initial links are relatively short.

It is conceivable that diminished influence of relative reinforcement rate among stimulus contexts on preference and relative resistance to disruption could influence behavior in natural conditions, for good and bad. For instance, exceedingly long temporal distances from sources of reinforcement for problem behavior might improve treatment outcomes by reducing the preference for that source of undesirable reinforcement and resistance to disruption of that behavior. Conversely, arranging conditions in which the temporal relations with contexts of positive reinforcement for desirable behavior should be as brief as possible.

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Appendix

Conditions, baseline or disrupter assessments, sessions per assessment, initial-link response rates, and terminal-link response rates in all three experiments.

				Initial-link response rates							
				237		585		927		1158	
Experiment	Condition	Assessment	Sessions	Rich	Lean	Rich	Lean	Rich	Lean	Rich	Lean
1	100 s	BL	30	44.35	15.71	63.33	17.26	36.14	4.77	67.22	27.28
		VT	5	0.61	0.71	0.49	0.17	0.27	1.46	1.57	0.04
		BL	20	41.53	19.97	49.49	18.75	35.35	5.41	74.95	12.30
		VT	5	0.28	0.28	1.35	0.15	0.55	1.34	0.62	0.03
	20 s	BL	30	56.04	5.65	75.12	1.26	53.96	3.91	97.62	2.27
		VT	5	0.70	0.15	0.80	0.02	0.66	0.32	1.11	0.02
		BL	20	61.94	2.44	71.62	3.28	46.07	4.42	50.59	4.25
		VT	5	0.90	0.06	1.05	0.04	0.55	0.20	0.91	0.10
	100 s	BL	20	54.95	25.36	58.38	19.95	46.73	11.13	51.54	16.68
		VT	5	0.78	0.19	1.13	0.03	0.59	0.69	0.43	0.07
		BL	20	59.96	26.16	65.62	15.42	43.41	9.32	61.17	11.67
		VT	5	0.50	0.12	1.92	0.00	0.51	0.64	0.25	0.11
2	100 s	BL	25	64.47	22.62	65.38	13.02	30.79	10.93	58.80	13.88
		PF	5	1.64	0.30	0.61	0.21	0.04	0.07	0.24	0.02
		BL	20	57.68	22.92	60.23	14.38	30.66	9.55	57.88	16.83
		PF	5	1.80	0.11	0.50	0.24	0.03	0.05	0.46	0.05
	20 s	BL	25	83.31	3.29	81.63	3.46	49.78	3.42	72.06	5.41
		PF	5	0.91	0.03	0.18	0.04	0.15	0.02	0.22	0.01
		BL	20	68.13	4.13	82.53	1.98	43.50	2.92	104.45	9.13
		PF	5	1.42	0.02	0.74	0.02	0.17	0.01	0.33	0.02
	100 s	BL	25	66.71	20.85	73.34	8.65	40.87	9.89	87.34	14.55
		PF	5	2.04	0.12	0.90	0.11	0.13	0.05	0.18	0.01
		BL	20	65.97	22.02	71.86	12.60	35.26	17.89	95.88	17.16
		PF	5	2.57	0.18	0.63	0.13	0.14	0.09	0.06	0.01
3	140 s	BL	20	70.10	12.58	75.66	7.66	46.86	13.15	95.07	11.50
		PF	5	2.63	0.07	0.96	0.09	0.22	0.25	0.24	0.02
		BL	20	55.86	10.43	71.03	8.80	38.35	15.64	77.77	12.59
		PF	5	1.57	0.10	1.45	0.06	0.09	0.04	0.00	0.00
	28 s	BL	20	70.99	4.52	79.71	2.82	50.07	10.95	99.83	5.67
		PF	5	1.37	0.02	0.49	0.00	0.02	0.01	0.07	0.01
		BL	20	81.17	1.30	89.72	1.42	54.56	4.33	120.73	2.29
		PF	5	1.40	0.01	0.84	0.01	0.03	0.01	0.16	0.00
	140 s	BL	20	50.08	14.13	73.31	5.21	40.05	12.65	90.73	11.84
		PF	5	1.09	0.05	1.60	0.04	0.06	0.03	0.33	0.03
		BL	20	59.06	12.90	73.85	6.61	36.13	14.00	65.79	15.52
		PF	5	0.72	0.04	1.55	0.04	0.05	0.02	0.13	0.01

Appendix

(*Extended*)

Terminal-link response rates							
237		585		927		1158	
Rich	Lean	Rich	Lean	Rich	Lean	Rich	Lean
107.70	117.68	139.16	107.90	98.76	58.49	112.70	128.93
94.43	33.61	79.43	49.35	98.00	22.04	86.16	40.25
82.00	116.21	122.85	98.84	82.56	62.19	113.84	118.04
92.86	47.02	104.80	46.25	89.26	32.64	85.66	42.75
102.90	105.23	133.07	100.37	94.11	53.57	109.56	104.84
92.73	82.29	112.27	74.82	80.73	33.61	95.43	37.05
90.42	97.37	126.63	94.64	77.16	50.52	89.34	91.61
98.40	67.16	114.04	73.79	68.99	40.51	75.16	40.55
92.00	111.68	139.02	85.95	56.05	45.27	80.47	100.14
98.70	64.89	104.63	59.55	56.02	29.11	63.25	14.70
90.36	108.27	127.04	96.00	58.21	44.46	92.23	96.70
96.67	51.15	111.34	56.65	46.92	25.24	69.29	22.31
99.70	97.14	117.40	97.34	50.57	39.15	96.81	98.98
102.77	86.46	25.74	37.05	20.64	19.47	45.68	38.15
94.14	96.95	111.90	92.61	46.65	51.66	102.53	92.78
102.27	95.97	42.98	49.75	27.78	19.54	53.75	49.82
100.76	104.12	106.67	75.91	48.88	45.65	94.84	90.78
97.37	81.43	36.91	59.69	28.51	25.61	71.82	36.28
92.20	99.95	107.23	80.08	53.02	47.57	100.78	112.73
87.76	57.22	66.29	54.52	30.01	28.54	61.89	40.81
92.67	101.14	130.49	79.25	59.27	42.15	88.22	112.62
87.56	89.40	55.12	44.38	20.51	23.14	59.29	54.08
86.31	95.37	100.06	83.78	55.99	40.93	90.75	111.40
89.20	89.56	40.68	37.81	32.98	26.44	54.98	50.85
89.61	105.70	133.38	78.30	63.74	38.62	86.78	111.09
92.73	90.33	41.55	37.61	26.44	29.04	46.52	47.98
82.17	105.73	79.61	76.16	46.60	41.88	97.23	103.31
88.96	85.06	55.39	49.85	17.31	17.21	17.54	16.51
85.17	97.34	110.98	98.17	54.21	52.43	92.39	97.39
72.86	46.65	36.95	23.34	20.24	15.91	36.51	19.84
83.83	99.48	120.04	92.36	42.57	52.07	104.59	100.28
71.82	33.61	69.26	35.38	20.94	20.27	30.78	21.37
82.92	105.92	122.71	90.06	48.74	35.04	96.95	100.48
71.69	54.88	57.42	42.81	14.40	14.90	42.85	29.78
83.53	102.09	126.43	89.50	39.79	29.73	77.97	93.11
62.09	45.32	59.45	56.39	21.87	14.70	39.15	21.71