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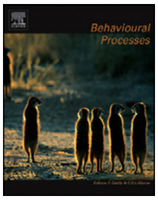

Resistance to change varies inversely with reinforcement context☆

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ABSTRACT

We report two experiments which test whether resistance to prefeeding and satiation for a variable-interval (VI) schedule that delivers a constant rate of reinforcement varies inversely with the reinforcement rate for an alternative schedule. In Experiment 1, eight pigeons responded in a multiple schedule in which the red key was always associated with a VI 90-s schedule and the green key with either a richer (VI 18 s) or leaner (VI 540 s) schedule in different conditions. After baseline training in each condition, prefeeding test sessions were conducted in which 10 g, 20 g, 30 g, 40 g, and 50 g food were provided one-hour prior to test. Additional baseline training was given between each test session. In Experiment 2, two groups of pigeons responded in a multiple schedule similar to Experiment 1. After baseline training, pigeons were exposed to a 5-h satiation test session in which the VI 90-s schedule was available continuously. Test sessions were conducted when pigeons were maintained at 85%, 95%, and 85% of their body weights in an ABA design. Results of both experiments showed that responding in the VI 90-s schedule that alternated with a leaner schedule during baseline was more resistant to prefeeding and satiation. These data rule out alternative explanations for results of previous studies, and confirm that resistance to change varies inversely with reinforcement context.

1. Introduction

A traditional assumption in the study of instrumental conditioning, embodied in Thorndike's (1911) law of effect, is that response strength increases with reinforcement. Response strength corresponds to our intuitions about learning, which according to a well-known definition is "a relatively permanent change in behavior *potentiality* which occurs as a result of *reinforced* practice" (Kimble, 1961, p. 6, italics in original). Implicit in Kimble's definition is the notion of transfer, that is, changes in behavior must be observed in a subsequent test for learning to be confirmed. The question posed by the present research is whether the effects of reinforcement on response strength, as assessed by transfer tests, are relativistic.

It is well-known that the effects of reinforcement on instrumental responding are relativistic. For example, Reynolds (1961) showed that response rate maintained by a variable-interval (VI) schedule in one component of a multiple schedule varied inversely with the reinforcement rate in an alternative component, a result known as behavioral contrast (see Williams, 2002, for review). The effectiveness of a given sucrose concentration as a reinforcer for rats depends on other sucrose concentrations the animal has been previously exposed to (incentive contrast; Flaherty, 1996). Such contrast effects are ubiquitous phenomena in the study of conditioning and learning, and may be related to basic perceptual and psychophysical processes (Lockhead, 2004).

We adopt the definition of response strength as resistance to change, according to behavioral momentum theory (Nevin and Grace, 2000). Behavioral momentum theory defines two separate aspects of behavior–response rate and resistance to change. Response rate is determined by the response–reinforcer relation and resistance to change is determined by the stimulus–reinforcer relation. Resistance to change is typically assessed by arranging a multiple schedule in which two stimuli are correlated with differential reinforcement schedules. After sufficient baseline training so that responding has stabilized, a disruptor such as homecage prefeeding, extinction or response-independent food is arranged. The usual result is that responding in the component associated with the relatively richer conditions of reinforcement (i.e. greater rate, magnitude, probability or immediacy of reinforcement) is more resistant to change (for review, see Nevin, 1992b, 2002; Nevin and Grace, 2000).

Does resistance to change depend on reinforcement context, similar to behavioral contrast for response rate? Several previous studies have investigated this question. Nevin (1992a) trained five

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pigeons in a multiple VI VI schedule in which a constant component provided 60 reinforcers per hour (rft/h) and alternated with either a richer (300 rft/h) or leaner (10 rft/h) component in different conditions. He found that both resistance to prefeeding and extinction were greater in the constant component when the alternative component was lean than when it was rich. Based on this result as well as previous studies, Nevin (1992b) proposed a model for behavioral momentum which assumed that resistance to change was determined by the rate of reinforcement in a signaled component relative to the reinforcement rate for the session as a whole, r_c/r_s, similar to Gibbon's (1981) contingency ratio for autoshaping.

Nevin and Grace (1999) tested whether resistance to change depends on reinforcement context by arranging two multiple schedules in each session, separated by a long blackout. Specifically, a constant component that arranged 40 rft/h alternated with a richer (160 rft/h) or leaner (10 rft/h) component. Nevin and Grace found that although resistance to extinction depended on reinforcement context, and was greater for the constant component paired with a leaner schedule, resistance to prefeeding was unaffected by the reinforcement rate in the alternative component. Nevin and Grace explained the differences in the extinction and prefeeding results by pointing out that extinction, in addition to eliminating the response–reinforcer contingency, is also associated with generalization decrement. That is, the omission of reinforcers during test constitutes a change in the overall stimulus situation, which could also act as a disruptor to reduce responding. Because generalization decrement would be greater for the multiple schedule in which the alternative component had a richer reinforcement rate, this could explain the lower resistance to extinction (see also Nevin et al., 2001). Nevin and Grace proposed a model in which resistance to change depended solely on the reinforcement rate signaled by a stimulus, but generalization decrement was included as a disruptor for extinction but not prefeeding. In this way, they attempted to reconcile the difference between their extinction and prefeeding results.

However, a puzzle remains as to why Nevin (1992a) observed that resistance to prefeeding depended on reinforcement context whereas Nevin and Grace (1999) did not. Prefeeding is particularly important as a disruptor for tests of resistance to change because, unlike other disruptors like extinction or response-independent food, the testing contingencies are unchanged from baseline. Thus the discrepancy between prefeeding results of Nevin (1992a) and Nevin and Grace (1999) remains an important unresolved issue.

Grace et al. (2003) noted that Nevin (1992a) had not counterbalanced the order of conditions, and replicated his study using a larger number of pigeons (eight) and a fully counterbalanced design. They found that resistance to prefeeding varied inversely with the reinforcement rate in the alternative component. Although this suggests that resistance to prefeeding does depend on reinforcement context, there still some potential confounds. Grace et al. (2003) arranged the prefeeding tests as five consecutive sessions in which pigeons were fed 10 g, 20 g, 30 g, 40 g, and 50 g in their homecage one hour prior to session time. Responding decreased relatively more in the VI 90-s paired with the richer schedule (VI 90R) than the VI 90-s paired with the leaner schedule (VI 90L), but the difference in resistance to change was only noticeable for the last 3 prefeeding sessions (see Grace et al., Fig. 2). Because reinforcement was maintained in the alternative component during these sessions, pigeons received more total food in the rich condition compared with the lean condition. This additional reinforcement – 58 scheduled 3.5-s food presentations per session – might have had a cumulative effect on satiety in the rich condition, and contributed to the difference observed between VI 90-s schedules in the later prefeeding sessions.

Thus the goal of the present research was to test whether resistance to change of responding in a target component with constant reinforcement rate (VI 90 s) varied inversely with the reinforcement rate in an alternative component, while controlling for potential confounds in Grace et al. (2003). Experiment 1 used a design similar to Grace et al. (2003) except that different prefeeding amounts (10 g, 20 g, 30 g, 40 g, 50 g) were studied in individual test sessions, with 85% body weights recovered and additional baseline training given between each test. In this way, any cumulative effect on satiety of additional reinforcers provided in the rich condition over sessions would be eliminated. The critical question was whether we would still observe greater resistance to prefeeding for the VI 90-s schedule in the lean condition (VI 90L), particularly with larger prefeeding amounts. In Experiment 2, we eliminated the alternative schedule altogether and evaluated resistance to change during 5-h satiation test sessions in which only the VI 90-s schedule was available. This satiation test is unique in the literature on resistance to change because as the stimulus signaling the alternative schedule is never presented, target responding can only be affected by the prior historical context.

2. Experiment 1

2.1. Method

2.1.1. Subjects

Subjects were eight pigeons of mixed breed, numbered 001–008, and were maintained at 85% of their free-feeding weight plus or minus 15 g through appropriate post-session feeding. Subjects were housed individually in a vivarium with a 12 h:12 h light/dark cycle (lights on at 06.00), with water and grit freely available in the home cages. The pigeons were the same as had previously served in Grace et al. (2003).

2.1.2. Apparatus

Eight standard three-key operant chambers, 32 cm deep × 34 cm wide × 34 cm high, were used. The keys were 21 cm above the floor and arranged in a row 10 cm apart. Only the center key was used, and could be illuminated red or green. In each chamber a houselight that provided general illumination was located above the center key, and a grain magazine with a 5 cm × 5.5 cm aperture was centered 6 cm above the floor. The magazine contained wheat and was illuminated when wheat was made available. A force of approximately 0.15 N was necessary to operate the center key. Each chamber was enclosed in a sound-attenuating box, and ventilation and white noise were provided by an attached fan. Experimental events were controlled and data recorded through a microcomputer and MEDPC® interface located in an adjacent room.

2.1.3. Procedure

Because subjects were experienced, they were exposed directly to a multiple VI VI schedule. With few exceptions, sessions were conducted 7 days a week at approximately the same time of day (11.00 h). The details of the procedure were the same as Grace et al. (2003). Each session consisted of 36 components that were 1-min duration and signaled by red or green illumination of the center key. Components were arranged pseudorandomly, with the restriction that out of every 6 components, there were three of each color. Components were separated by a 10-s intercomponent interval (ICI) during which the chamber was dark and responses had no effect. The houselight was illuminated during components but extinguished during reinforcement and the ICI. In each component, center-key responses produced 3.5-s access to grain according to VI schedules. The VI schedules contained 12 intervals obtained from an exponential progression (Fleshler and Hoffman, 1962) and were sampled without replacement.

There were two conditions in the experiment, which were conducted in a counterbalanced order across pigeons.