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ScienceDirect
Behavioural Processes 78 (2008) 158–164
BEHAVIOURAL PROCESSES
www.elsevier.com/locate/behavproc

Signals, resistance to change, and conditioned reinforcement in a multiple schedule

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Received 31 August 2007; accepted 28 January 2008

Abstract

The effect of signals on resistance to change was evaluated using pigeons responding on a three-component multiple schedule. Each component contained a variable-interval initial link followed by a fixed-time terminal link. One component was an unsignaled-delay schedule, and two were equivalent signaled-delay schedules. After baseline training, resistance to change was assessed through (a) extinction and (b) adding free food to the intercomponent interval. During these tests, the signal stimulus from one of the signaled-delay components (SIG-T) was replaced with the initial-link stimulus from that component, converting it to an unsignaled-delay schedule. That signal stimulus was added to the delay period of the unsignaled-delay component (UNS), converting it to a signaled-delay schedule. The remaining signaled component remained unchanged (SIG-C). Resistance-to-change tests showed removing the signal had a minimal effect on resistance to change in the SIG-T component compared to the unchanged SIG-C component except for one block during free-food testing. Adding the signal to the UNS component significantly increased response rates suggesting that component had low response strength. Interestingly, the direction of the effect was in the opposite direction from what is typically observed. Results are consistent with the conclusion that the signal functioned as a conditioned reinforcer and inconsistent with a generalization-decrement explanation.

Keywords: Behavioral momentum theory; Resistance to change; Conditioned reinforcement; Key peck; Multiple schedules; Pigeons

1. Introduction

Behavioral momentum theory (BMT; Nevin, 1992; Nevin and Grace, 2000) is a general theory of behavior that accounts for both steady-state responding and responding under conditions where behavior is disrupted. BMT states that behavior is determined by two separate features: response rate and resistance to change. Response rate is used to portray steady-state behavior and is described by the matching law (Herrnstein, 1970). Resistance to change describes behavior when it is disrupted. It reflects a dynamic process and is associated with learning. Resistance to change is typically assessed with one of three methods of disrupting steady-state behavior: (a) pre-feeding subjects prior to experimental sessions, (b) adding response-independent (free) food during experimental sessions (e.g., using a variable-time (VT) schedule of reinforcement within the intercomponent intervals (ICI) during resistance-to-change tests), or (c) extinction. Responding during disruption is evaluated relative to baseline levels of responding to assess the degree of change and is a putative index of the relative strength of behavior, with larger changes in behavior indicating lower response strength.

A key feature of BMT (Nevin, 1992; Nevin and Grace, 2000) is the claim that resistance to change is at least partially determined by the Pavlovian, stimulus–reinforcer relationship (and not by the operant response–reinforcer relationship). It is known, however, that degrading operant contingencies (while maintaining constant Pavlovian contingencies) can reduce resistance to change. For example, Grace et al. (1998) presented pigeons with a concurrent chain schedule of reinforcement which gave subjects a choice between two different terminal link schedules. One was an immediate, no-delay schedule and the other was identical in length but delivered reinforcement following a 3-s unsignaled delay to reinforcement. Both schedules had different operant (response–reinforcer) contingencies but identical Pavlovian (stimulus–reinforcer) contingencies. After assessing preference in the concurrent chains procedure, resistance to

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doi:10.1016/j.beproc.2008.01.014

change was assessed in a second phase using a multiple schedule where the schedules used were identical to the terminal links of the concurrent chains procedure. Grace et al. showed that the unsignaled-delay schedule was both less preferred and less resistant to change compared to the no-delay schedule, which led them to conclude that the Pavlovian contingency could not be the sole determinant of preference or resistance to change.

Bell (1999) provides additional evidence showing that Pavlovian contingencies are not the sole determinants of resistance to change. In his study, pigeons responded to a three-component multiple schedule with equal VI components. One component employed a no-delay-to-reinforcement schedule. The second presented reinforcement according to an unsignaled delay-to-reinforcement schedule and the third component employed a signaled delay-to-reinforcement schedule. Resistance to change was greater for both the no-delay schedule and the signaled schedule compared to the unsignaled delay. The fact that the signaled schedule was comparable to the no-delay schedule in terms of resistance to change is somewhat surprising, as the signaled-delay procedure temporally separates the target stimulus from the delivery of the reinforcer, whereas in the no-delay component the target stimulus was directly paired with the reinforcer.

The finding that responding was maintained in the signaled-delay schedule about as well as the no-delay schedule suggests that primary reinforcement is not solely responsible for maintaining responding and that the signal may also enhance resistance to change. Bell et al. (2007) employed a multiple schedule with VI components to further test this notion. The critical feature of their study was a component that contained a signaled delay-to-reinforcement schedule and, during resistance-to-change tests, the signal continued to be presented in some tests while in other tests it was removed. They reported that the absence of the signal resulted in lower resistance to change compared to the component in which the signal continued to be presented.

However, what remains unclear is how the signal affected resistance to change. While both Bell (1999) and Bell et al. (2007) suggested that the signal stimulus may function as a conditioned reinforcer for responding to the preceding stimulus (i.e., the terminal link functions as a conditioned reinforcer for responding to the initial link), neither provides unambiguous evidence supporting the hypothesis that the signal functions as a conditioned reinforcer. In fact, Bell et al. acknowledged generalization decrement as an alternative interpretation of their findings. In other words, removal of the signal could have served as an additional cue that indicated a change in contingencies, thus, causing an increase in generalization decrement. Therefore, it is possible that the resistance-to-change results reflect increased generalization decrement caused by the removal of the signal. This conclusion is consistent with revised models of BMT (Nevin et al., 2001) that explicitly included a term to account for generalization-decrement effects. Although there have been developments to include additional factors affecting resistance to change, it remains unclear precisely what determines response strength. In fact, Nevin and Grace (2005) suggest that the theoretical construct of behavioral mass, and not resistance to change, may be a more general and appropriate measure of response strength.

Additional evidence supporting generalization decrement as an explanation for the differential resistance-to-change results was provided by Bell and Gomez (2008) who presented pigeons with a two-component multiple schedule consisting of signaled delay-to-reinforcement schedules. One component presented a two-link chain schedule with a VI 120-s initial link followed by a fixed-time (FT) 5-s terminal link. The second component was similar except that a 5-s unsignaled delay occurred between the initial link and the terminal link. Two resistance-to-change tests (extinction and adding a VT 20-s schedule of reinforcement to the ICI) showed lower baseline responding with the unsignaled delay, but resistance to change for the initial link was unaffected. The findings and conclusions of Bell and Gomez lead to the preliminary conclusion that the data reported by Bell et al. (2007) may reflect generalization-decrement effects and not conditioned-reinforcement effects, but not enough evidence exists to clearly differentiate between generalization-decrement effects and conditioned-reinforcement effects.

If stimuli acquire some conditioned-reinforcement value (regardless of the precise mechanism), then responding to an initial link of a chain schedule should be influenced by the conditioned value of the terminal link stimulus. If conditioned reinforcers play a role in resistance to change, direct manipulations of signal stimuli presented in chain schedules should affect resistance to change. The purpose of the present study was to test this hypothesis using a three-component multiple schedule. During baseline training, two of the components were equivalent two-link chain schedules, each with VI initial links followed by FT terminal links (signals). The final component was a comparable VI FT tandem schedule. During resistance-to-change tests, the signal stimulus from one of the signaled-delay components (SIG-T) was removed and replaced with the initial-link stimulus from that component, effectively converting that component to an unsignaled-delay (tandem) schedule. That signal stimulus was added to the FT delay period of the unsignaled-delay component (UNS), converting it to a signaled-delay (chain) schedule. The final signaled component remained unchanged, serving as a control (SIG-C) (see Fig. 1). If generalization decrement is the only factor affecting resistance to change, then responding in the SIG-T and UNS components should be equal as the absolute number of changes in stimuli was constant across those components. Any effects due to generalization decrement would be equated. However, if the signal functions as a conditioned reinforcer, then removing the signal from one component (SIG-T) should result in lower resistance to change, and adding the signal to another component (UNS) should result in higher resistance to change.

2. Method

2.1. Subjects

Twelve adult White Carneau pigeons (Palmetto Pigeon Plant, Sumter, SC) served as subjects and were maintained at 80% of their free-feeding body weight ($M = 496$ g, S.D. = 34). Sub-