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Resistance to extinction of lever-pressing rates maintained by different wheel-running reinforcement durations

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ABSTRACT

Previous research using resistance to extinction to assess response strength has shown slower attenuation of responding maintained by larger than smaller reinforcement magnitudes. The current study sought to generalize this reinforcement-magnitude effect to extinction of lever-pressing rates maintained by wheel-running reinforcement of different durations. Rats responded on a response-initiated variable interval 20-s schedule for the opportunity to run in a wheel for 5 s, 30 s, and 90 s. Following training on each reinforcement duration, lever pressing for wheel running was placed on extinction. Results showed that responding maintained by 5 s of wheel-running reinforcement declined slower in extinction than for the 90-s duration, while 30 s of wheel-running reinforcement produced inconsistent effects on attenuation of response rates. These results suggest that shorter periods of wheel-running reinforcement have higher reinforcement value than longer durations—findings incompatible with the earlier research showing more resistance to extinction with large reinforcement magnitudes. We offer an interpretation based on response deprivation arising from restriction of the wheel-access interval and its motivational impact on wheel running as a reinforcing consequence and on responding for wheel-running reinforcement. An alternative analysis proposes that discrimination of the shift to extinction is more salient for the long wheel-running duration—accounting for the rapid attenuation of responding in extinction with the long periods of wheel-running reinforcement.

1. Introduction

What is the relationship between wheel-running reinforcement duration and reinforcement value? Does longer access to wheel running with more revolutions produce higher reinforcement value than shorter access with fewer wheel turns? Previous research that focused on absolute response rates (Belke, 1997; Belke & Dunbar, 1998; Belke & Hancock, 2003) generated by different wheel-running reinforcement durations showed that brief durations of wheel running have higher reinforcement value than long durations. The current study assessed the reinforcement value of different wheel-running durations based on resistance to extinction. Resistance to extinction involves attenuation of reinforced responding and is not equivalent to steady-state response rate measures of reinforcement value (Nevin, Tota, Torquato, & Shull, 1990), thereby,

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having the potential to contribute new insights about the nature of wheel-running reinforcement. Additionally, this is the first study to use resistance to extinction to assess the reinforcing properties of wheel running.

Initially, wheel-running reinforcement duration was viewed as a manipulation of reinforcement magnitude, similar in effect to more conventional reinforcers such as food (Belke, 1997). That is, long durations of wheel running functioned like long periods of food access, enabling high consumption of the reinforcement (Epstein, 1981). Assuming that the unit of value is measured by the wheel revolution, longer bouts of wheel running would be of greater reinforcement value than shorter intervals of access to wheel running.

To test the analysis, Belke (1997) investigated the effect of 30-s, 60-s, and 120-s durations of wheel-running reinforcement on the operant lever-pressing rates of rats responding on a response-initiated variable-interval (VI) 30-s schedule. Response-initiated VI schedules were used because wheel running generates longer postreinforcement pauses (PRP) than more conventional reinforcers like food pellets; in addition, these long PRPs fundamentally alter how an interval schedule is experienced. For example, if the average PRP following the termination of a wheel-running interval is longer than the average value of a VI schedule, then the schedule may be experienced more like a CRF than an intermittent schedule.

On these response-initiated VI schedules, Belke (1997) found that local lever-pressing rates were inversely, not directly, related to duration of wheel-running reinforcement. Shorter bouts of wheel running generated higher lever-pressing rates than longer durations. From a response-strength perspective, short durations were of greater reinforcement value than longer durations. Furthermore, rate of wheel running within the reinforcement interval also varied inversely with the wheel-access duration. Based on this observation, Belke (1997) speculated that the reinforcement value of running-wheel activity varies with rate rather than number of wheel revolutions. Similar findings were produced on fixed-interval reinforcement schedules over different ranges of wheel-running reinforcement durations (Belke & Dunbar, 1998; Belke & Hancock, 2003).

Resistance of reinforced responding to attenuation in extinction is an alternative way to measure response strength (Nevin, 1974, 1992, 2002, 2012; Nevin & Grace, 2000; Smith, 1974). A response that attenuates slowly is considered stronger than one that attenuates more rapidly, reflecting its previous history of reinforcement. Strength of responding measured as resistance to extinction also varies with reinforcement rate, delay, and magnitude, but is not equivalent to steady-state response rate measures (Nevin et al., 1990). With respect to reinforcement magnitude and resistance to extinction, prior research using multiple (Shettleworth & Nevin, 1965) and single operant schedules (Shull & Grimes, 2006) has shown that responding maintained by a large reinforcement magnitude shows greater resistance to extinction than responding for reinforcement of low magnitude. In Shettleworth and Nevin (1965), pigeons responded on a multiple VI 2 min VI 2 min schedule with different durations of access to grain in the two components. Response rates in extinction decreased more slowly in the presence of a stimulus previously associated with 9 s of hopper time than in the presence of another stimulus associated with 1 s of access to the hopper.

Shull and Grimes (2006), in their second experiment, assessed the attenuation of operant responding in extinction for two groups of four rats: one trained on a single VI 120-s schedule and the other on a single VI 240-s schedule with either one or four food pellets delivered as reinforcement. Results showed, with the exception of one rat trained on the VI 120-s schedule, that responding in extinction decreased more slowly with four food pellets compared to one pellet as reinforcement. Thus, operant responding previously maintained by the large amount of food was more resistant to extinction than behavior maintained by the small magnitude of reinforcement.

In the current study, we assessed the relation between the duration of wheel-running reinforcement and resistance to extinction on a single operant schedule. We used a single operant, rather than a multiple, schedule as there is a paucity of research on duration of wheel-running reinforcement using multiple schedules. Rats were trained to respond on a single response-initiated VI schedule for the opportunity to run for 5-s, 30-s, and 90-s durations. Following completion of 25 sessions of reinforced responding at each duration, the operant response was placed on extinction for 10 sessions to assess attenuation of responding in extinction. Our previous research indicates that response rates are higher with short bouts of wheel running, which generate elevated rates of running for the reinforcement interval. One possibility is that responding for short bouts of high-intensity wheel running (5-s duration) would result in high resistance to extinction while responding for long bouts of low intensity (90-s duration) would engender low resistance. If, however, the duration of wheel-running reinforcement is analogous to amount of reinforcement, prior research indicates more resistance to extinction after training with long bouts of wheel-running reinforcement compared to bouts of short duration.

2. Method

2.1. Participants

Eleven female Long- Evans rats obtained from Charles River in Saint Constant, Quebec served as subjects. The rats were approximately one year of age and had previously participated in classical and operant conditioning exercises in a Conditioning course. In the colony room, the rats were individually housed in polycarbonate cages (48.3 cm by 26.7 cm by 20.3 cm). Heat-treated beta chips and paper towel were used for bedding. Lighting in the colony room was on a 12-h light dark cycle (lights on at 0730). Rats were fed Prolab R-M-H 3000 lab chow. Distilled water was available at all times in their cage. Daily food allotment was restricted to maintain the rats at a target body weight of 260($\pm$10) g – a weight that was approximately 87% of the free-feeding adult female body weight for this strain. This research was conducted in accord with the guidelines