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Behavioural Processes 71 (2006) 1–7
BEHAVIOURAL PROCESSES
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Responding for sucrose and wheel-running reinforcement: Effect of prerunning

Terry W. Belke *

Mount Allison University, Department of Psychology, 49A York St., Sackville, New Brunswick, Canada E4L 1C7

Received 19 March 2005; received in revised form 2 August 2005; accepted 2 August 2005

Abstract

Six male albino Wistar rats were placed in running wheels and exposed to a fixed interval 30-s schedule that produced either a drop of 15% sucrose solution or the opportunity to run for 15 s as reinforcing consequences for lever pressing. Each reinforcer type was signaled by a different stimulus. To assess the effect of prerunning, animals were allowed to run for 1 h prior to a session of responding for sucrose and running. Results showed that, after prerunning, response rates in the later segments of the 30-s schedule decreased in the presence of a wheel-running stimulus and increased in the presence of a sucrose stimulus. Wheel-running rates were not affected. Analysis of mean postreinforcement pauses (PRP) broken down by transitions between successive reinforcers revealed that prerunning lengthened pausing in the presence of the stimulus signaling wheel running and shortened pauses in the presence of the stimulus signaling sucrose. No effect was observed on local response rates. Changes in pausing in the presence of stimuli signaling the two reinforcers were consistent with a decrease in the reinforcing efficacy of wheel running and an increase in the reinforcing efficacy of sucrose. Prerunning decreased motivation to respond for running, but increased motivation to work for food.

Keywords: Wheel running; Sucrose; Reinforcement; Prerunning; Fixed interval; Lever press; Rats

Mueller et al. (1999) demonstrated that when rats are deprived of the opportunity to run for a short period of time (i.e., 1–3 h), animals increase their rate of running when subsequently given the opportunity to run. This effect is similar to the increase in food intake that occurs following a short-term period of food deprivation (Tagliaferro and Levitsky, 1982) and suggests that wheel running, like eating or drinking, is a regulated appetitive behavior. Depriving the animal of the behavior leads to a compensatory increase in that behavior. Conversely, satiating the animal for that behavior should lead to a compensatory decrease in that behavior. Deprivation increases, while satiation decreases, motivation to run.

Changes in motivation may also be reflected in changes in the efficacy of an opportunity to run as a reinforcer. When Belke and Heyman (1994) withheld the opportunity to run for 45 min, the rate of running and responding for the opportunity to run increased. Analysis of the changes in responding using Herrnstein's (1970) response-strength equation suggested that withholding the opportunity to run increased the reinforcing efficacy of wheel running. If withholding the opportunity to run increases the reinforcing efficacy of wheel running, then providing the opportunity to run prior to a session should have the opposite effect. Thus, the principle objective of the present study was to assess the effect of prerunning on subsequent running and responding reinforced by the opportunity to run. If preexposure to the opportunity to run functions like a "satiation" operation, then running and responding for the opportunity to run should diminish. This effect is referred to as "satiation-like" because, unlike food and water, wheel running does not involve the ingestion of a substance, nor is there an identified physiologically based satiety mechanism.

Previous research has also shown that running affects the intake of food. Lett et al. (1996, 1998) showed that food intake was higher in non-deprived rats following 30-min access to a running wheel than 30-min spent in their home cages. Based on these results, Lett et al. concluded that short durations of access to running facilitate food intake. This effect stands in contrast to the suppression of feeding that occurs with two or more hours access to running (Boakes and Dwyer, 1997; Lattanzio and Eikelboom, 2003). Boakes and Dwyer (1997) showed that allowing rats to run for 2 h was sufficient to reduce food intake during a 1.5 h period of access to food that followed wheel access.

* Tel.: +1 506 364 2459; fax: +1 506 364 2467.
E-mail address: TBELKE@MTA.CA.

0376-6357/$ – see front matter
doi:10.1016/j.beproc.2005.08.003

Suppression of food intake following long-term or chronic access has been demonstrated in a number of studies with both deprived (Dwyer and Boakes, 1997; Epling and Pierce, 1992, 1996) and non-deprived animals (Afonso and Eikelboom, 2003; Levitsky, 1970; Looy and Eikelboom, 1989; Mueller et al., 1997; Premack and Premack, 1963; Tokuyama et al., 1982). Long-term access has also been shown to reduce the reinforcing efficacy of food. Pierce et al. (1986) showed that breakpoints on progressive ratio schedules of food reinforcement were lower when sessions were preceded by 19 h in an unlocked wheel followed by 1 h in their home cage than when sessions were preceded by 19 h in a locked wheel followed by 1 h in their home cage.

In the present study, animals will respond on a schedule of reinforcement that provides either an opportunity to run or a drop of sucrose solution. If the facilitation of food intake following running observed by Lett et al. (1996) is related to a change in the reinforcing efficacy of food, then one would expect that the reinforcing value of sucrose would increase. Alternatively, if the suppression of food intake following running observed by Boakes and Dwyer (1997) is related to a change in the reinforcing efficacy of food, then one would expect that the reinforcing value of sucrose would decrease.

The effect of prerunning on responding reinforced by wheel running and sucrose solution was assessed using a procedure developed by Perone and Courtney (1992). In this procedure, both types of reinforcers are delivered on a schedule of reinforcement and each reinforcer type is differentially signaled. Postreinforcement pauses (PRP) and local lever-pressing rates under different conditions are broken down in terms of transitions defined by the type of previous and upcoming reinforcer (i.e., wheel followed by wheel, wheel followed by sucrose, sucrose followed by sucrose, sucrose followed by wheel). Analysis of the data in this way allows one to assess the effects of a manipulated variable on pauses and local rates as a function of the prior and upcoming reinforcer type. Belke (2004) used this procedure to assess the effect of body weight manipulation on responding for sucrose and wheel-running reinforcement.

1. Method

1.1. Subjects

Six male Wistar rats obtained from Charles River Breeding Laboratories, Quebec, served as subjects. All animals had extensive experience in operant investigations of wheel-running and sucrose reinforcement prior to participating in the present study. The animals were approximately 18 months old at the start of the prerunning manipulation. When not running in experimental sessions, the rats were individually housed in polycarbonate cages (48 cm × 27 cm × 22 cm) in a holding room on a 12 h light/12 h dark cycle (lights on 0800). Immediately after each experimental session, each rat was given an amount of food sufficient to maintain its weight at approximately 85% of a free-feeding body weight determined when each animal had reached an adult weight of approximately 400 g. Target weights varied between 330 and 340 g. Distilled water was freely available in the home cage.

1.2. Apparatus

Sessions occurred in two activity wheels (Lafayette Instruments) with diameters of 35 cm. Each wheel was located in a sound-attenuating shell with a fan for ventilation and to mask extraneous noise. Wheel revolutions were recorded by a microswitch attached to the wheel frame. 24 V dc lights mounted on the sides of the wheel frame illuminated the interior of the wheel chamber. A solenoid-operated brake was attached to the base of the wheel frame. When the solenoid was operated, a rubber tip attached to a metal shaft contacted the wheel and caused the wheel to stop.

A Plexiglas panel (16 cm × 16.5 cm × 4 mm) with a lever, two stimulus lights, and a liquid receptacle, was mounted at the opening of each wheel (7 cm × 9 cm). The lever was located 10 cm from the base of each panel. The lever was 3.3 cm wide and extended 2 cm from the face of the panel into the wheel chamber. The force required to activate the lever microswitch in each wheel was approximately 30 g. Located 1.25 cm above the lever were red and white 28 V dc 40 MA stimulus lights (Dialco 507–3917). The diameter of each light was 7 mm and the center to center distance between the two lights was 1.4 cm. In one wheel, the lights were arranged so that the white light was to the left of the red. In the other, this arrangement was reversed. Adjacent to each lever was a liquid receptacle. The area of each receptacle into which sucrose solution was dispensed was 5.5 cm × 6 cm × 3.2 cm. The base of each receptacle was located 5.7 cm from the base of each panel. Behind the top of each receptacle was a metal clamp into which a clear plastic cylinder (10.5 cm long, 3.8 cm diameter) and a 24 V dc General Valve Co. solenoid could be placed. A Lafayette Instruments Co. Model 80201 liquid dispenser operated the solenoid valve. Each Plexiglas panel was attached to the wheel frame by Velcro strips. Control of experimental events and recording of data was handled by a Borland Turbo Pascal 4.0 program run on an IBM PC computer interfaced to the wheel through the parallel port.

1.3. Procedure

The training procedure is described in detail in Belke and Hancock (2003). What follows is a briefer version. Seventeen rats were given the opportunity to run for 30 min each day over 15 days in running wheels equipped with a retractable lever. After 15 days, the highest rate runners were selected for further training. In the next phase, after the 30-min running period, animals were placed in standard operant conditioning chambers and shaped to press a lever using the method of successive approximations. Each lever press produced .1 ml of a 15% (w/v) sucrose solution. When subjects reliably pressed the lever, the reinforcement schedule was shifted from fixed ratio (FR) 1 to variable ratio (VR) 3. Each session terminated when 50 sucrose reinforcers were obtained.

After four sessions on the VR 3 schedule, sessions in the operant conditioning chamber ceased. At this point, the retractable lever in each wheel chamber was extended during the wheel-running sessions and the opportunity to run for 60 s was made contingent upon a single lever press. Retraction of the