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Effects of extinction on wheel running and lever pressing as operant behaviors within a multiple schedule of reinforcement

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ABSTRACT

Rats were exposed to a multiple schedule in which they pressed a lever on a variable-ratio schedule for wheel-running reinforcement in one component and pressed a lever or completed wheel revolutions on a fixed-ratio schedule for 15% sucrose solution reinforcement in the changed component. After 20 sessions, sucrose reinforcement was replaced with water (0% sucrose) and operant behavior (lever pressing or wheel running) placed on extinction in the changed component. Extinction markedly reduced lever-pressing rate and lengthened postreinforcement pause (PRP) duration in the changed component, but only modestly reduced wheel-running rate and actually shortened PRP duration. In the unchanged component, when either lever pressing or wheel running were placed on extinction in the changed component, wheel-running rate, lever-pressing rate, and wheel-running reinforcers decreased while PRP duration increased in the changed component. The effect of extinction differed in the changed component as a function of the type of operant, but not in the unchanged component. This ruled out the automatic reinforcement effect of wheel running as a bridge for transferring the extinction effect between components. Arousal, negative induction, and a shift from high to low valued reinforcement were considered as potential accounts for the effects in the unchanged component.

1. Introduction

Running in a wheel is a behavior that can function as reinforcement for another behavior (e.g., lever pressing) and as an operant behavior that produces another reinforcement (e.g., sucrose). To investigate these aspects of wheel running, Belke and Pierce (2015) recently developed a multiple schedule in which wheel running was arranged as reinforcement in one component and as an operant in another. When operant wheel running for a drop of sucrose was placed on extinction (drop of water), wheel-running rate decreased in the changed or operant component, as would be expected under extinction; however, the amount of decrease was limited due to the automatic reinforcement generated by wheel running. Wheel-running rate also decreased in the other, unchanged component. Rats ran at a lower rate, obtained fewer wheel-running reinforcements, and took longer to initiate lever pressing for wheel running in the unchanged component when operant wheel running was placed on extinction. Although initially assumed to be independent, the automatic reinforcement of

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wheel running in both components appeared to bridge the components, allowing sucrose extinction to affect behavior in the unchanged component.

To clarify this role of automatic reinforcement, the current study compared the effects of extinction when lever pressing or wheel running produced sucrose reinforcement in the changed component, and lever pressing for wheel running operated in the unchanged component. As noted, wheel running produces automatic reinforcement or reinforcement emanating from engaging in the operant behavior itself, not from any programmed experimental contingencies (Skinner, 1953, 1957; Vaughn & Michael, 1982), occurring at some level even after the removal of sucrose reinforcement. Lever pressing, unlike wheel running, is not maintained on its own and is mostly controlled by extrinsic, sucrose reinforcement. When placed on extinction, lever pressing in the changed component is expected to return to near zero operant level, in contrast to the high operant level of wheel running. Notice also that when lever pressing produces sucrose, the operant response during extinction is the same in both the changed and unchanged components, but automatic reinforcement from the behavior cannot link or bridge the components. This analysis suggests that extinction in the changed component should have different effects on wheel running and operant responding in the unchanged component, depending on the operant (wheel running or lever pressing) that produces sucrose reinforcement in the changed component (Belke & Pierce, 2015).

Belke and Pierce (2015) also suggested induction and arousal as alternative accounts for the changes in running and operant responding in the unchanged component. Induction, the opposite of behavioral contrast, refers to a cross-component effect in which changes in the reinforcement conditions in one component produce increases (positive induction) or decreases (negative induction) in responding in both components (Marcucella, 1976). In the Belke and Pierce experiment, following a baseline of wheel running for sucrose reinforcement, sucrose was removed (extinction); wheel-running rate decreased in the changed component and lever pressing for wheel running and wheel-running rate decreased in the unchanged component. These changes are consistent with a negative induction effect produced by extinction of wheel running for sucrose in this study.

Previous research suggests that negative induction occurs more commonly when reinforcement in the changed component is delivered independently of responding, as when a variable interval (VI) schedule is changed to variable time (VT) (Boakes, 1973; Powell, Kelly, & Palm, 1978; Sherman & Spitzner, 1975). Fewer studies have shown negative induction in a multiple schedule when reinforcement in the changed component is removed (Spealman, 1978; Westbrook, 1973). Complexity of operant behavior (Williams, 1983) and location of stimuli relative to the response manipulandum (Spealman, 1978) have been considered factors supporting the occurrence of negative induction.

Williams' (1983) account of behavior complexity may be relevant to the hypothesis that the automatic reinforcement common to wheel running bridges the extinction of sucrose reinforcement across components. According to Williams, complex behaviors are more likely to show negative induction due to the greater degree of stimulus control exerted by interoceptive relative to exteroceptive events. Interoceptive events refer to aspects of a complex response that control other parts of the response. Exteroceptive events refer to external stimuli that exert control over the behavior. When interoceptive events constitute relatively greater stimulus control over a behavior than exteroceptive, "the response-suppressive properties of extinction should be likely to produce negative induction due to the shared interoceptive stimuli" (Williams, 1983, p. 358).

Alternatively, for food-deprived rats, the presentation of sucrose as extrinsic reinforcement for operant wheel running may have enhanced general arousal while removal of sucrose reduced it (Killeen, Hansen, & Osborne, 1978). That is, arousal-related motor activity in the form of wheel running would be higher when sucrose is present than when absent. Additionally, as sucrose is delivered contingent upon wheel running, reduction of arousal-related wheel activity would occur in both components when the contingency switched from reinforcement to extinction in the changed component. Thus, wheel running in the unchanged component would covary with the presence and absence of sucrose in the changed component if arousal mediated the cross-component effects on wheel-running behavior.

The cross-component effect also may reflect the removal of high valued reinforcement. Qualitatively different reinforcers (wheel running and 15% sucrose), which also differed in value, were arranged for the two components. Previous research suggests that the value of wheel running is approximately equivalent to 2.5% sucrose (Belke & Hancock 2003; Belke, Pierce, & Duncan, 2006). In the Belke and Pierce (2015) study, the removal of 15% sucrose arranged weak, wheel-running reinforcement in both components. One implication is that withdrawal of higher valued sucrose reinforcement would have depressed responding for lower valued wheel-running reinforcement (Crespi, 1942; Gonzalez, Gleitman, & Bitterman, 1962).

In the current study, the operant behavior in one component of a multiple schedule was manipulated (wheel running or lever pressing) and the effect on responding in that component and the unchanged component was observed.

In the operant or changed component, the delivery of 0.1 ml of 15% sucrose solution as reinforcement was contingent upon either 15 lever presses or 15 wheel revolutions. In the unchanged component, the opportunity to run for 15 revolutions was contingent upon pressing a lever on an VR 10 schedule. After each operant in the changed component was established, it was subsequently placed on extinction.