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Short report

Human choice under schedules of negative reinforcement

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ABSTRACT

The generalized matching equation provides a good description of response allocation in concurrent schedules of positive reinforcement in nonhumans as well as in humans. The present experiment was conducted to further investigate the allocation of responding under concurrent schedules of negative reinforcement (i.e., timeouts from pressing a force cell) in humans. Each of three participants was exposed to different reinforcement ratios (9:1, 1:1 and 1:9) in the terminal links of a concurrent-chains schedule of negative reinforcement. The allocation of responding under this schedule was well described by the generalized matching equation, for each participant. These results replicate previous findings obtained with nonhumans and humans under concurrent schedules of positive reinforcement. In addition, they extend the results reported by Alessandri and Rivière (2013) showing that human behavior maintained by timeouts from an effortful response is sensitive to changes in relative reinforcement ratios as well as relative delays of reinforcement.

1. Introduction

Response allocation in concurrent schedules of reinforcement has been well described by the generalized matching equation (Baum, 1974, 1979; Davison and McCarthy, 1988; de Villiers, 1977; Grace and Hucks, 2013; Horne and Lowe, 1993; Madden and Perone, 1999; Pierce and Epling, 1983). In its logarithmic form, the equation states that:

$$\log(B_L/B_R) = a\log(R_L/R_R) + \log b, \quad (1)$$

where B_L and B_R are response rates on the two alternatives (e.g., left and right response buttons), R_L and R_R are obtained reinforcement rates from the respective alternatives, and the free parameters a and b index sensitivity to reinforcement ratios and bias towards one alternative.

The majority of studies have been conducted to assess the effects of contingencies of positive reinforcement on response allocation (see Grace and Hucks, 2013, for a review). Although contingencies of negative reinforcement are ubiquitous in the environments of humans and nonhumans, their effects on response allocation has been studied less extensively (see Baum, 1973, for a study with pigeons using concurrent timeouts from electric shocks). In studies with humans, negative reinforcement contingencies often have been programmed as avoidance of point or money loss. Magoon and Critchfield (2008) used such a procedure to study human response allocation on a concurrent schedule of positive versus negative reinforcement.

Recently, Alessandri and Rivière (2013) described a laboratory procedure to study human behavior under negative reinforcement (escape) contingencies. In their procedure, responding was maintained consistently by timeouts from an effortful response (i.e., pressing a force cell). An advantage of this procedure to study human operant behavior is that it allows the programming of a biologically relevant consequence (i.e., reduction of effort) within a session that might be functionally equivalent to other consequences commonly programmed in studies of negative reinforcement with nonhumans (e.g., escape and avoidance of electric shocks; Baron, 1991).

Thus, the goals of the present experiment were: (a) to systematically replicate the study of Alessandri and Rivière (2013) by investigating human response allocation under different reinforcement ratios; and (b) to assess human response allocation under concurrent chain schedules of negative reinforcement of timeouts from an effortful response, extending previous studies which compared the allocation of responding on concurrent schedules of positive (money gain) versus negative reinforcement (avoidance of money loss; e.g., Magoon and Critchfield, 2008).

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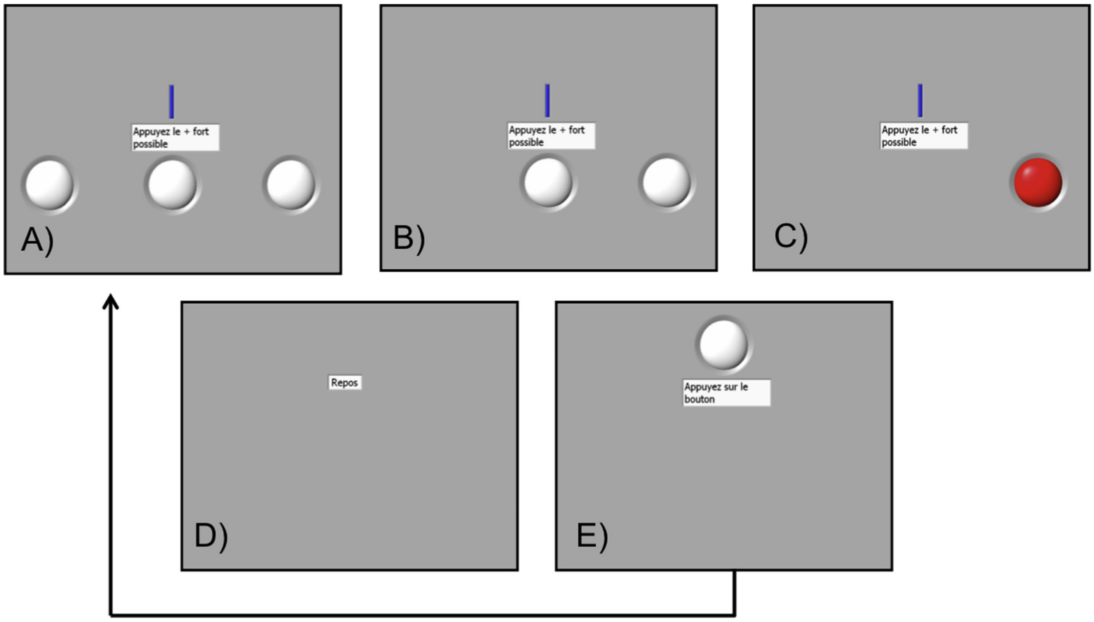

Fig. 1. Display of the computer screen at different times in the experiment. In Panels A–C, the message "Press with the + force possible" (in French, "Appuyez le + fort possible") was presented below the vertical gauge. In Panels D and E, respectively, the messages "Break" (in French, "Repos") and "Press the button" (in French, "Appuyez sur le bouton") were presented. See text for details. (For interpretation of the references to colour in the text, the reader is referred to the web version of this article.)

2. Materials and methods

2.1. Participants

Three undergraduate students (one male and two females, 20–25 years old, all right-handed; hereafter P1, P2 and P3) from the University of Lille participated. Participants had no experience in courses or experiments on learning and were not compensated (e.g., extra-course credit or money) for participation. Each signed an informed consent before the study and was debriefed after participation.

2.2. Apparatus

Sessions were conducted individually with each participant. Before entering the experimental room, participants were asked to leave all personal belongings (including electronic devices and computers) with the experimenter. Participants sat at a desk containing a Novatech Mini40 ATi force cell (Tatem Industrial Automation Ltd., Derby, U.K.), a computer monitor, a mouse, and a keyboard (not used). The force cell (40 mm in diameter and 12 mm high) was mounted on the left side, and the mouse on the right side of the keyboard, which was placed in front of the participant. Programming of conditions and data recording (resolution of 0.1 s) were accomplished by using a program written in Labview 8.6 (National Instruments Corporation, Austin, TX).

2.3. Procedure

2.3.1. Force-criterion assessment

To establish the timeouts from pressing the force cell as reinforcers, a force criterion was set for each participant before the first session. Participants were asked to press the force cell with their left thumbs (i.e., of their nondominant hand) continuously with the maximum force possible for three, 10-s intervals, which were separated by 3-s timeouts during which they did not press the force cell. The force criterion for each participant was equal to 75% of the maximum force he or she exhibited during these three 10-s intervals (respectively, 27 N, 23 N and 26 N for P1, P2 and P3).

2.3.2. Experimental task

Fig. 1 (Panels A through E) shows the computer screen presented to the participant at different times in the experiment. Each participant was exposed to a concurrent chains schedule of reinforcement (so that participants pressed the force cell also during the initial links and before a timeout from pressing the cell could be produced in the terminal links; this helped ensure the reinforcing function of the timeouts). The background color of the computer screen was gray at all times and a vertical gauge (updated every 0.1 s) displayed at the center of the computer screen above a message stating "Press with the + force possible" indicated the proportion of the force criterion exhibited by the participant (Fig. 1, Panels A–C). Before the first session, the following instructions to press the force cell were given vocally to each participant (references to Fig. 1 panels were not part of the instructions given to the participants):

Please try to achieve and maintain the indicator at the top of the gauge as much as possible. At no times are you allowed to stop pressing except when the message "break" appears on the screen (Fig. 1, Panel D). Please follow these recommendations because it is highly important for the sake of the experiment.

The following instructions, related to the concurrent-chains schedule, also were given vocally to each participant:

This is a situation in which you can earn breaks by clicking the left button of the computer mouse on any side circles (Fig. 1, Panel A) with you right hand (while you keep pressing the force cell with your left hand). You can choose between two side circles by clicking on either of them. When you click on one side circle, the other disappears and becomes inactive (Fig. 1, Panel B). You can change the circle you are responding at any time by clicking only once on the center circle (Fig. 1, Panel B*)* and waiting a while for the alternative side circle to appear. Sometimes when you press on the side circle, the circle will change color (Fig. 1, Panel C) and sometimes you will earn a break following a press on this latter circle (Fig. 1, Panel D). After the break, you will see a white circle on the screen and should press it once to continue. Please pay attention to the colors displayed and their locations, which may change over blocks of 10 min (you will have 5 min breaks after 10 min). Your task is to earn a break as fast as possible.