TECHNICAL REPORT

A RELATIVELY LOW-COST EQUIPMENT TO INVESTIGATE PHYSICAL EFFORT IN HUMANS

Raquel Fernanda Ferreira Lacerda[1]; André Luiz[1,2,3]; Carlos Eduardo Costa[1]

[1]UNIVERSIDADE ESTADUAL DE LONDRINA
[2]UNIVERSIDADE POSITIVO – FACULDADE LONDRINA
[3]INSTITUTO CONTINNUM

Response cost is a concept used to represent multiple relations among events (see Soares, Costa, Aló, Luiz, & Cunha, 2017 for a review of this literature). For example, Luce, Christian, Lipsker, and Hall (1981) have pointed out three procedures mainly called response-cost: (a) the increase in the physical effort required to respond (e.g., Alling & Poling, 1995, Experiment 1; Skinner & Morse, 1958; Solomon, 1948); (b) changes in the programmed contingency such as an increase in the ratio required to produce a consequence (e.g., Powell, 1968; Weiner, 1966; Winograd, 1965); (c) contingent reinforcement loss, such as point loss (e.g., Bolívar & Dallery, 2020; Cunha, Cordeiro, & Costa, 2018; Okouchi, 2015; Pietras & Hackenberg, 2005; Weiner, 1962, 1969). The current manuscript aims to describe relatively low-cost equipment that allows the investigation of the first response-cost procedure using humans as subjects.

The experimental analysis of human operant behavior can be seen as an intermediate field between non-human animal research and the development of solutions to social problems (Lattal & Perone, 1998). In this field, humans are frequently exposed to computer tasks controlled by software (Becker, 2011; Cabello et al., 2002, 2003; Costa & Banaco, 2002; Peirce et al., 2019; Roche & Dymond, 2003; Ruiz & Bermúdez, 2018) and touch on the computer's screen (e.g., Dube & McIlvane, 2001; Okouchi, 2007, 2015) or presses on the mouse button (e.g., Kestner, Romano, St. Peter, & Mesches, 2018; Lacerda, Suarez, & Costa, 2017) are often recorded as responses. Commonly, research software allows the investigation of the increase in the ratio required to produce a consequence and contingent reinforcement loss, two out of three response-cost procedures previously described. However, such software cannot directly require levels of physical effort (the first response-cost procedure) on responding. Therefore, aiming to study the effects of physical effort on human behavior, we build a spring button that can be used as a response button and allows the experimenter to manipulate levels of physical effort required to respond.

THE SPRING BUTTON

The Spring Button (Figure 1) consists of an 13 cm (height) X 13 cm (length) X 13 cm (wide) nylon box. Nevertheless, the button's material does not need to be nylon; wood or acrylic, for example, can replace it. At the inner bottom of the equipment, a mouse's circuit board with an optical system and a USB connection was fixed using Velcro tape (Figure 2).

At the top of the equipment, a cylinder with a diameter of 3.53 cm, that when pressed 3.5 cm down activated the microswitch, which, in turn, started the mouse's circuit board. We used a microswitch of 15A with three terminals (but only two terminals were used[1]).

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[1] We used the Normally Open (NO) and the Common (COM) terminals. These terminals were connected to the left mouse button connection in the mouse's circuit board using two 0.5 mm flexible copper wires. The yellow wire connected the COM terminal to the first left mouse button connection, and the black wire connected the NO terminal to the second left mouse button connection.

A B

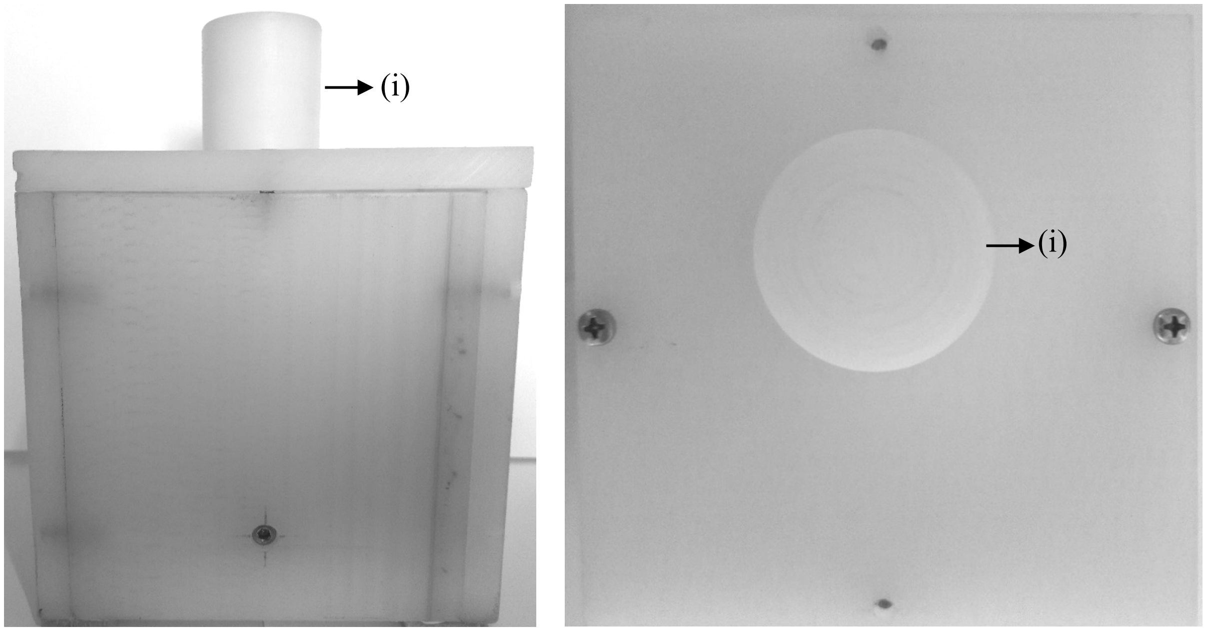

Figure 1. Spring button side view on Panel A and top view on Panel B. (i) cylinder.

C D

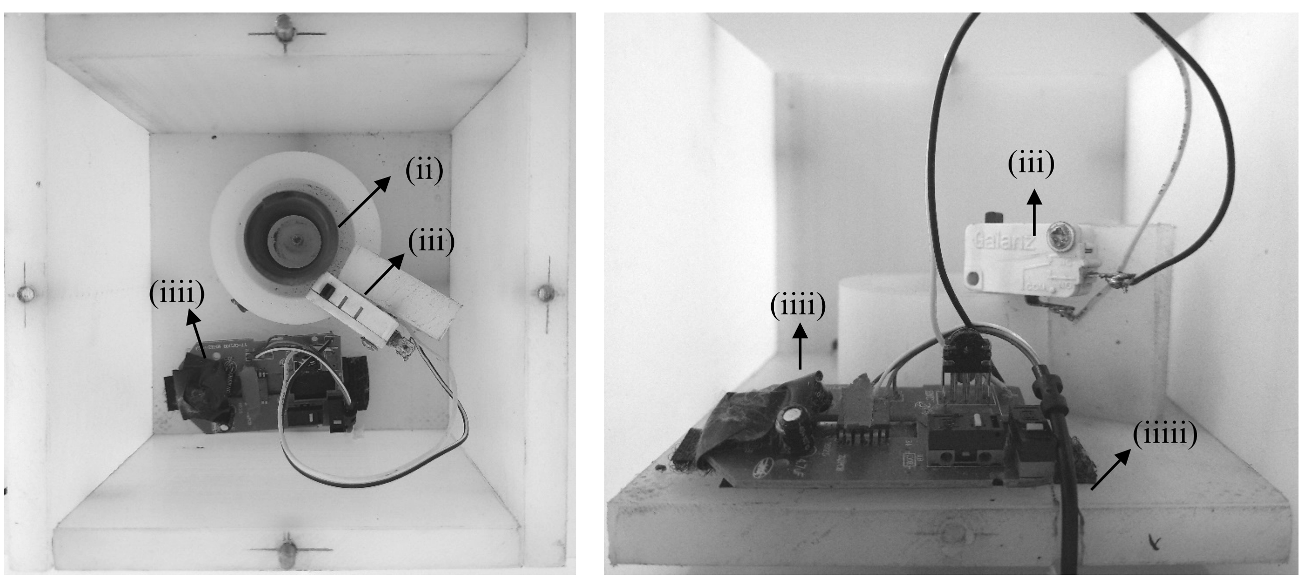

Figure 2. Spring Button interior top view on the Panel C and interior side view on the Panel D. (ii) steel spring (the spring is removable); (iii) microswitch; (iiii) mouse's circuit board; (iiiii) USB cable.

A steel spring placed between the cylinder and the mouse's circuit board required different levels of physical effort to press the button. The physical effort requirements imposed by the spring were measured according to Hooke's Law (Aranha et al., 2016). Different levels of physical effort can be required using other springs with different stiffness (e.g., 30, 50, 90, and 110 N, see Figure 3).

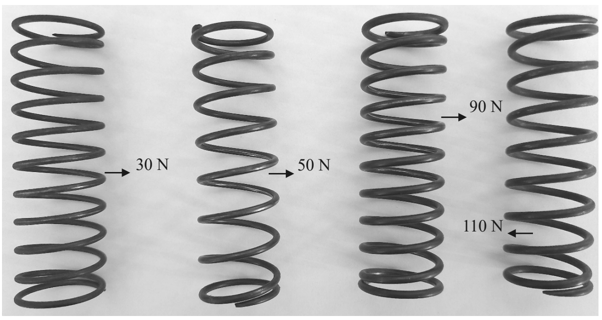

Figure 3. Steel springs.

A USB connection cable connected the button to the computer; thus, the computer records pressures on the Spring Button as pressures on the left mouse button, and the spring directly imposes a physical force requirement on responding (Figure 4). More than one Spring Button can be used simultaneously in computers with more than one USB connection (see Luiz et al., 2020 for an example of it).

USING THE SPRING BUTTON

In our laboratory, Luiz (2017) used two Spring Buttons to examine the effects of two levels of physical effort on resistance to change in humans. Each button served as the response button for one component of a two-component multiple schedule of reinforcement. Below we present the data from the last four Baseline (BL) 30-min sessions of two participants of Luiz's experiment. We chose the sessions used by Luiz to calculate response-rate stability. His BL consisted of a two-component multiple variable interval (VI) VI schedule with equal reinforcement rates. In one component, the physical effort required was 10 N for both participants (Low-Effort Component), and in the other, the physical effort required was 50 N for Participant 1 and 30 N for Participant 2 (High-Effort Component).

E F

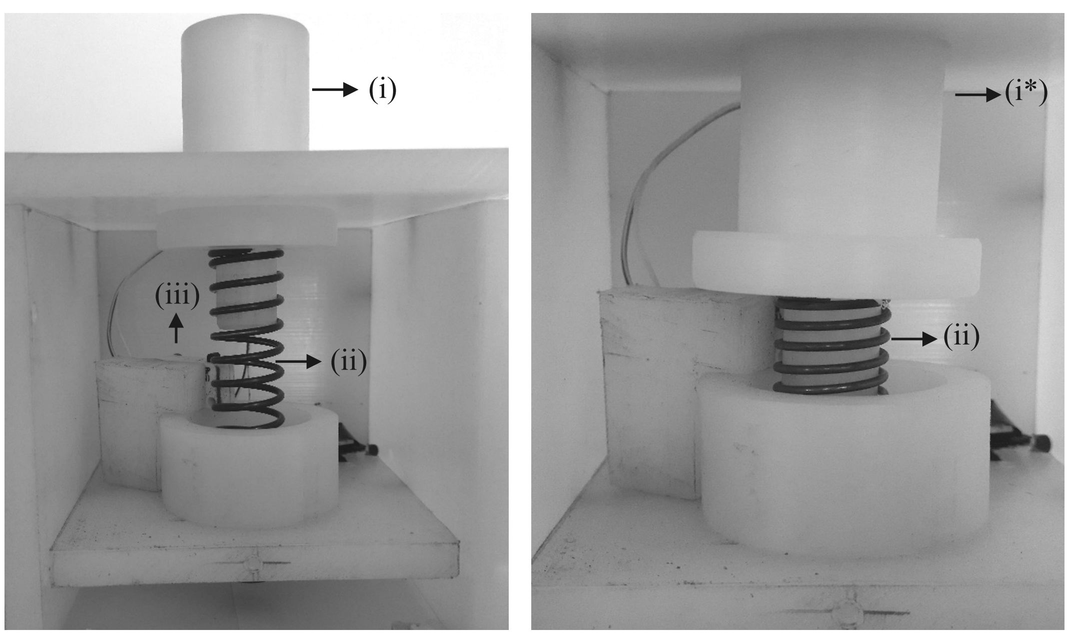

Figure 4. Spring Button's interior side view on Panel E and interior side view with the cylinder pressed down on Panel F. (i) cylinder; (i*) cylinder pressed down; (ii) steel spring; (iii) microswitch.

Figure 5 shows the response rates (responses per min) in the Low-Effort and the High-Effort Components for P1 and P2 during the last four BL sessions of Luiz's (2017) experiment. For both participants, response rates were always higher in the Low-Effort Component.

Figure 6 shows the proportional differences between the response rate during Low-Effort and the High-Effort Components for Participants 1 and 2. We obtained these proportional differences by dividing the response rate during Low-Effort Component by the response rate during the High-Effort Component in each session for both participants. Thus, data above or below 1.0 indicates higher response rates in the Low-Effort and High-Effort Component, respectively. In addition, response rates were always higher during the Low-Effort Component, and the 50 N vs. 10 N produced a greater difference between the response rates than the 30 N vs. 10 N.

Corroborating experiments with non-humans (e.g., Alling & Poling, 1995; Chung, 1965) data from Figure 5 show that the greater the physical-force requirement, the lower is the response rate. Additionally, Figure 6 suggests that the greater the difference between two physical-force requirements, the greater the proportional differences between response rates. These data indicate that the spring button is a viable alternative for researchers aiming to study the effects of physical effort on human responding.

[2] Figures 5 and 6 were made for the present manuscript based on data from Luiz (2017).

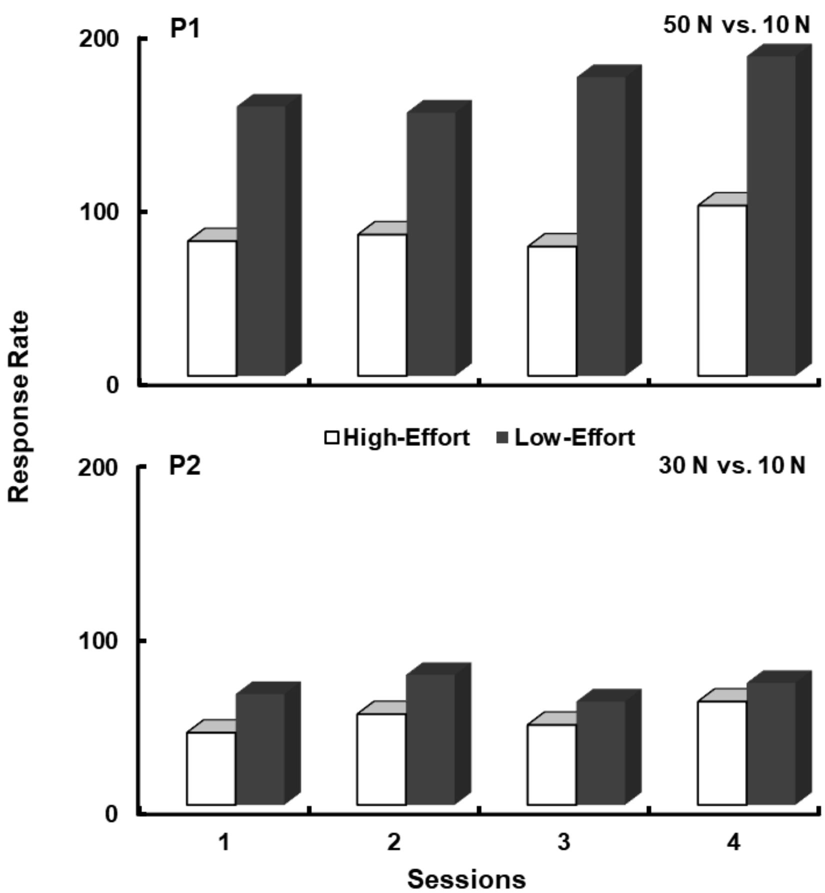

Figure 5. Response rates (responses per min) in the Low-Effort (white bars) and the High-Effort (gray bars) Components for P1 and P2 during the last four BL sessions of Luiz's (2017) experiment.

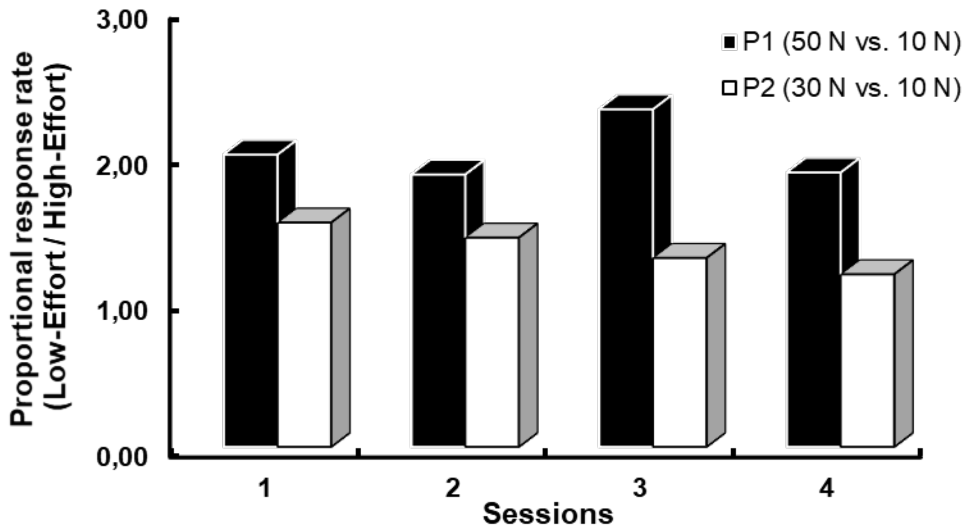

Figure 6. Proportional differences between the response rate during Low-Effort and the High-Effort Components for Participants 1 (black bars) and 2 (white bars) from Luiz's (2017) experiment. Data above or below 1.0 indicates higher response rates in the Low-Effort and High-Effort Component, respectively.

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