



Short report

Resurgence of response duration in human participants[☆]

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ABSTRACT

Previously reinforced responses can reappear when reinforcement is withdrawn from current responding. This is known as resurgence. Although resurgence of response topography, spacing, and patterns over time has been demonstrated, there is no evidence of resurgence of response duration. This experiment explored resurgence of response duration in humans. In Phase 1 a multiple schedule of reinforcement with two components was used. In each component a chained variable-interval 30 s, variable-ratio 3 schedule was implemented. In the terminal link of the chained schedule, response durations between 0.1 and 0.5 s were reinforced during one component, and between 2 and 8 s in the other component. In Phase 2, response requirement during the terminal link of the chained schedule was inverted between components relative to Phase 1. In Phase 3 the chained schedule was changed to a variable-interval 30-s, extinction 30 s. Resurgence of the durations trained during Phase 1 was observed. It was concluded that duration is a response dimension that reappears during extinction.

1. Introduction

A previously reinforced response can reappear when current responses are exposed to extinction. This phenomenon is known as response resurgence. Commonly, resurgence is studied using a three-phase procedure. During Phase 1, a response is trained, during Phase 2 the response is exposed to extinction while an alternative response is reinforced, and during Phase 3 reinforcement is withheld (Lattal and Peter, 2009). Resurgence is observed, when in Phase 3, responses reinforced during Phase 1 are higher in frequency relative to their occurrence in Phase 2.

Aside from the finding of reoccurrence of responses during extinction, resurgence of specific response dimensions has also been observed. Cançado and Lattal (2011), for example, studied the resurgence of response patterns extended over time with pigeons as subjects. In a first experiment, they used a multiple schedule of reinforcement with two components in their Phase 1. In each component a variable-interval (VI) 15-s or a fixed-interval (FI) 5-s, were in effect. During the next phase, they extinguished responses on the response key and reinforced responses on a second key. When responses were exposed to extinction on both keys, the two temporal patterns of responding observed during the first phase of the experiment reappeared in the original key. In their next experiment, resurgence was assessed after the temporal patterns of responding were directly reinforced according to an algorithm-defined pattern.

Other studies provided evidence that spacing between responses

(Carey, 1951), topography (Lieving et al., 2004; Wacker et al., 2013) and response sequencing (Sánchez-Carrasco and Nieto, 2005), also resurge. There is no evidence, however, of resurgence of response duration, which is a fundamental property of behavior. Response duration or temporal extent is defined as the period of time during which behavior occurs. This dimension of responding can be reinforced to increase its rate of occurrence (e.g., Platt et al., 1973; Stevenson and Clayton, 1970), and is particularly important in applied scenarios in cases in which responding extends over long or brief periods of time and targeting response frequency could be inadequate. Therefore, the purpose of the present experiment was to provide evidence of resurgence of response duration in human participants.

2. Method

2.1. Participants

Four undergraduate students from the *Universidad Marista de Merida*, between 18 and 25 years old served as participants. Participants voluntarily consented to collaborate in an experiment described as “research regarding decision making and performance in which you have the opportunity to earn some money”. None of them had any experience with operant-conditioning research. They were informed that points obtained during sessions would be exchanged for money at the end of the experiment. Sessions were conducted in isolated cubicles at the University’s library, on a daily basis from Monday to Friday for

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9 days. Apart from one weekend break that occurred during Phase 2, there were no additional breaks. Before each session, the screen of a portable computer displayed the following instructions in Spanish: “You are in charge of working with the apparatus, you can do whatever you like but your payment depends on what you do. The buttons only work when the LEDs above them are on”. Participants received on average 31.67 Mexican pesos per session (ranging from 16 to 41), which was equivalent to 2.24 US dollars.

2.2. Apparatus

A portable computer and a custom controller (20-cm wide, 10-cm high, and 5 cm deep) were used to present stimuli and record responses. The controller was made of hard plastic, and was equipped with two standard push buttons (Steren, Model AU-105) that required a force of 5 N to operate: The buttons were located 5 cm apart from each other. This controller was designed to be held and operated using both hands. The controller could be moved around as long as the cable connecting it to the computer was not disconnected. The buttons were connected directly to an Arduino UNO board inside the controller, which recorded responses and was connected to the computer with a USB cable. Response duration was recorded from the moment participants pressed the button until the moment it was released. A red LED, located 1 cm above each button, signaled when buttons were operative. This controller was used to avoid history effects using a keyboard or a mouse. Experimental events were displayed on the screen of the computer by means of a Visual Basic program that communicated with the Arduino board (see Escobar and Perez-Herrera, 2015, for details). During sessions, participants had access only to the controller and the computer screen.

A white 10 × 10 cm square at the center of the screen displayed messages signaling whenever points were available or obtained. Aligned on the center of the screen, below the white square, the total amount of points earned during the session was displayed.

2.3. Resurgence procedure

2.3.1. Phase 1: training

A two-component multiple schedule of reinforcement was used during every phase of the experiment. Each multiple schedule component lasted 180 s, including reinforcement time, they appeared in strict alternation, and were signaled with blue (BB) and gray (GB) background colors on the computer screen. The first component presented during each session was always grey. A 5-s inter-component interval, during which the screen was black and responses were not recorded, separated successive components. The multiple schedule of reinforcement was used to obtain data of resurgence of two response durations simultaneously for each participant (see Cançado and Lattal, 2011, for a similar procedure).

In each component, responding was reinforced on a chained VI 30-s, variable-ratio (VR) 3 schedule. A requirement of response duration was in effect only during the terminal VR link. The first link, without a duration requirement, was added to reduce variations in reinforcement frequency between components and to increase the probability of responding during the terminal link. The VI and VR values were generated by selecting randomly integer values between 15 and 45 for the VI, and between 1 and 5 for the VR (see Dixon and MacLin, 2003). If, for example, in a terminal link during the long response component, VR value was 4, emitting 4 long, although not necessarily consecutive, responses fulfilled the criterion for reinforcement. One button was operative during the VI initial link, and the other during the VR terminal link.

When the VI criterion in the initial link was met, the LED above the left button was turned off, the LED above the right button was turned on, and the message “You can collect” was presented on the screen. This message signaled the terminal VR link. During this link in one

component (BB) of the multiple schedule, only button presses between 0.1 and 0.5 s (short response [SR]) fulfilled the requirement for reinforcement and were counted as short target responses. In previous tests with a requirement of a relatively long response (4–8 s), we noted that participants consistently failed to reach the criterion for reinforcement. To address this issue, we set the requirement of long responses to 2–8 s. Therefore, during the other component (GB), when the button remained pressed for a minimum of 2 s and a maximum of 8, a long response that fulfilled the requirement for reinforcement was counted (long response [LR]). When the VR 3 requirement in either component was met, the message “You earned 1 point” was presented for 3 s. A 30-s limited-hold contingency was added to this terminal link in both components, such that if the criterion for reinforcement was not met within 30 s, the chained schedule returned to the initial VI link. If participants were pressing the button while the limited hold ended, the duration for that specific button press was not recorded. The chained schedule reset at the end of every component, such that every component started with the initial link. Sessions lasted a total of 8 components, 4 for SRs and 4 for LR. Training Phase 1 was in effect for 4 sessions.

2.3.2. Phase 2: reinforcement of an alternative response

During this phase the response duration requirement was inverted in relation to background colors. SRs were reinforced during the GB component, and LR were reinforced during the BB component, every other detail of the procedure was kept the same as in Phase 1. This phase was in effect for 4 sessions.

2.3.3. Phase 3: resurgence test

The components of the multiple schedule alternated as in previous phases but the chained VI 30 s VR 3 schedule was replaced with a VI–30 s extinction 30-s schedule. When participants reached the terminal link and the message “You can collect” appeared on the screen responses were recorded but had no programmed consequences. After 30 s in the terminal link, the initial VI link was presented again. Only one session was conducted.

3. Results

Data from the first link of the chained schedule did not vary systematically across phases or components, therefore, only data from the terminal link, in which the criterion for reinforcement was dependent on response duration, will be described. Table 1 shows reinforcement rates for the 8 participants during training (Phase 1) and alternative reinforcement (Phase 2). Reinforcement rate was low for all participants during the first two sessions of Phase 1, afterwards, it increased and remained relatively stable and close to 1 and 2 reinforcers per minute during the rest of the experiment. The exception was participant

Table 1
Reinforcers per minute for each participant.

	SR Component				LR Component			
	Session				Session			
	1	2	3	4	1	2	3	4
Participant	Training phase							
P1	1.16	1.66	1.75	1.75	0.16	0.16	1.33	1.33
P2	1.66	1.08	1.66	1.83	0.25	0.91	1.41	1.58
P3	1.58	1.91	1.33	1.75	0	0	1.08	0.58
P4	2	1.83	1.66	1.91	0.25	1.16	1.08	1.25
	Alternative response phase							
P1	1.58	1.83	1.58	1.75	1.58	1.5	1.5	1.41
P2	1.33	1.58	1.66	1.58	1.41	1.41	1.25	1.5
P3	1.58	1.66	1.66	1.75	1	1.33	1.41	1.41
P4	1.91	1.83	1.25	1.58	1.16	1.16	0.75	1.33

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