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RATSKETBALL: USING LOW-COST 3D-PRINTED OPERANT CHAMBERS TO PROBE FOR GENERATIVE LEARNING

RATSKETBALL: UTILIZANDO CÁMARAS OPERANTES DE BAJO COSTO IMPRESAS EN 3D PARA PROBAR EL APRENDIZAJE GENERATIVO

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Abstract

The cost of operant chambers used to teach students basic concepts and principles of behavior analysis and learning has increased across time, adding a barrier for instructors who wish to incorporate animal models within their laboratory courses, instead using virtual and analog models. Researchers have begun to investigate the use of 3D-printed operant chambers in laboratory classes as a low-cost alternative to traditional operant chambers. The current paper extends the literature on low-cost alternatives and provides an overview of the methodology to create and use 3D-printed operant chambers designed to function as basketball courts. In addition to specific instructions to assemble these boxes, we present a rationale as to how instructors can use these chambers in assignments designed to teach concepts and principles of operant conditioning, while establishing novel topographies of behavior not commonly seen in rats (i.e., placing basketball in hoop). We present sample data from the course assignment to highlight the utility of these chambers. It is our hope that researchers and instructors can use these methods to replicate this novel extension of traditional operant conditioning procedures to behaviors not commonly established in operant conditioning laboratories.

Keywords: learning, operant conditioning, low-cost chambers, 3-D printed, rats

Resumen

El costo de las cámaras operantes utilizadas para enseñar a los estudiantes conceptos y principios básicos de análisis de la conducta y el aprendizaje ha aumentado con el tiempo, agregando una barrera para los instructores que desean incorporar modelos animales dentro de sus cursos de laboratorio, en lugar de utilizar modelos virtuales y analógicos. Los investigadores han comenzado a indagar el uso de cámaras operantes impresas en 3D en clases de

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laboratorio como una alternativa de bajo costo a las cámaras operantes tradicionales. El presente artículo amplía la literatura sobre alternativas de bajo costo y proporciona una descripción general de la metodología para crear y utilizar cámaras operantes impresas en 3D diseñadas para funcionar como canchas de baloncesto. Además de las instrucciones específicas para armar estas cajas, presentamos una justificación de cómo los instructores pueden usar estas cámaras en tareas diseñadas para enseñar conceptos y principios del condicionamiento operante, al mismo tiempo que establecemos topografías novedosas de comportamiento que no se ven comúnmente en ratas (es decir, colocar pelotas en un aro). Presentamos datos de muestra de la tarea usada en el curso para resaltar la utilidad de estas cámaras. Esperamos que los investigadores e instructores puedan utilizar estos métodos para replicar esta novedosa extensión de los procedimientos tradicionales de condicionamiento operante a conductas que no se establecen comúnmente en los laboratorios de condicionamiento operante.

Palabras clave: aprendizaje, condicionamiento operante, cámaras de bajo costo, impresión 3D, ratas

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Since inception and introduction by B.F. Skinner (1956), operant chambers have become ubiquitous in the study of animal behavior. While their high cost remains a barrier to entry for some as readily available commercial examples can reach a cost ranging from 2,000 – 10,000 USD, the closed ecosystem of many for profit designs further dissuades their adoption to novel experiments and setups by presenting further barriers to researchers. While virtual laboratories present an alternative to in-vivo animal laboratories, research has shown that certain benefits exist for in-vivo animal laboratories including increased test scores (Venneman & Knowles, 2005), preferences for in-vivo over virtual (Elcoro & Trundle, 2013), and increases in positive perceptions of science (Hummel & Randaler, 2010).

Open-source designs, the maker movement, and modern technologies and developments such as Python and 3D printing help overcome these issues by enabling the creation of purpose specific hardware and software at exponentially reduced costs. As early as 2013, researchers have begun exploring low-cost alternatives to traditional operant chambers (Chauvet & Cabrera, 2013), and multiple researchers have published resources to aid instructors in the adoption of low-cost 3D-printed operant chambers (e.g., Escobar, 2017; Escobar et al., 2022; Pérez-Herrera et al., 2018)

To highlight the use and impact of these technologies in the field of behavioral sciences and operant chambers, we present a case study showcasing the use of low-cost 3D-printed chambers and open-source technology. This project was part of a graduate-level course on the concepts and principles of behavior analysis and learning where students trained their rats to compete in basketball. We hope to add to the existing literature on low-cost options for animal laboratory experiences in undergraduate and graduate programs (e.g., Escobar, 2017; Escobar et al., 2022; Pérez-Herrera et al., 2018).

Rationale

Over the course of the semester, ten first-year graduate students participated in weekly three-hour lectures and two one-hour laboratory sessions. The overall course included three specific learning objectives: (1) Students will identify and describe elementary concepts and principles of behavior analysis, (2) Students will analyze the environmental variables that affect a variety of behaviors, and (3) Students will give examples of how behaviors are learned, shaped, and changed in human and non-human organisms. Pragmatically, the design of the course emphasized the extension of conditioning principles beyond direct training contexts to foster generative performance in the students. During the weekly lecture, students received direct instruction on the concepts and principles of behavior analysis, using Pierce and Cheney (2017) as their primary text.

The instructor devoted the laboratory sessions on the direct application of concepts and principles to animal models. Each student received a rat to train over the course of the semester and participated in seven assignments total. The assignments included handling and care of their rats, habituating the rat to the chamber, magazine training, shaping the lever press, discrimination training, chaining, and schedules of reinforcement. Students completed written laboratory reports on each of these assignments and received direct and explicit feedback from the first author. Each of these assignments functioned as component behaviors required for more difficult skills.

The final assignment in the course functioned as a probe for generative responding. Generative responding occurs when an organism engages in a novel instance of behavior without direct instruction (Johnson et al., 2020). This occurs when an organism engages in a learned response in a new context not directly taught (i.e., application), or the learner engages in a recombination of previously learned behaviors and engages in a new topography of behavior (i.e., adduction). In the present example, we conceptualized the laboratory assignments as learned behaviors that received reinforcement from the instructor. Students receive direct and explicit feedback to acquire these component skills under a controlled laboratory environment.

The use of the 3D-printed basketball chambers represented our probe of generative responding to evaluate whether the students could use the established skills in a new context without direct instruction to shape up novel responses in the rats. Namely, they had to teach the rats to pick up a ball, travel with it across some distance, and deposit the ball in a 3-D printed basketball hoop to produce reinforcement. This presents instructors with a benefit for student learning over standard operant chambers, as the specific topography of terminal behavior consists of complex chains of behavior that requires the rat's performance to occur in the presence of ever-changing variables (e.g., placement of the ball, the possession of the ball by another rat, etc.). While instructors can build competency in isolated conditioning processes with traditional operant chambers, arranging learning opportunities for novel re-combinations of the skills directly taught with traditional operant chambers allows the instructor to program for generative responding (Johnson et al., 2020).

Training animal models to engage in complex behavioral responses that resemble human performances has a long history in the field of behavior analysis. Skinner described his shaping endeavors with a rat in a Times article in 1937 where he elaborated on the steps taken to teach his rat Pliny how to complete a behavior chain consisting of pulling a string to drop a marble, picking up the marble, and putting it in a basket (Peterson, 2004). This represented one of the earliest accounts of shaping. It seems this tradition continues to live on with universities including this as part of undergraduate and graduate courses (e.g., Wofford College, 2009; UNAM Psicología UDEMAT, 2023). To assist instructors who wish to incorporate low-cost operant chambers to teach complex behavioral chains, we present a method for designing such an operandum, as well as the associated classroom assignment.

Method

Participants

Ten graduate students in the MS program in Behavior Analysis who were enrolled in PSYC 6480: Principles of Behavior Analysis course during the Fall 2023 semester at Georgia Southern University piloted the development of the 3D-printed operant basketball chambers. Students had varying backgrounds ranging from no experience with learning principles to having certification as a Board-Certified Assistant Behavior Analyst (BCaBA). Only one student had experience in an operant conditioning laboratory. This course served as their first experimental class in a master's program in behavior analysis.

Ten male *Long Evans* rats approximately 60 days old at the start of the study served as subjects in the current project. The first author and his graduate assistant handled the rats daily and provided daily enrichment in the form of exercise (i.e., wheel running 10 min a day) and socialization (i.e., 15 min a day of paired play in larger cages). The first author served as the instructor of the course and restricted the rats' weight to 80% of their free-feeding weight. The rats had exposure to a variety of conditioning procedures prior to being placed in the 3D-printed chambers. The laboratory component of the course operated in a non-linear way, where students progressed as their rats demonstrated performance criteria. Therefore, each rat had a different conditioning history prior to their exposure to the 3D-printed chambers.

Materials

Materials for the study included two 3D-printed operant chambers, as described below. In addition to that, commercially available plastic golf balls served as the basketball for the rats. The balls contained holes that allowed the rats to grasp and travel with the ball throughout the chamber. Students had the option to use the dustless reinforcement pellets used in the traditional operant chambers, freeze-dried yogurt bites, or pieces of cereal as the reinforcers in the study. The instructor provided multiple reinforcers to allow students to explore different parameters of reinforcement as part of the assignment (e.g., quality, magnitude, etc.). Students also used data collection sheets to record the behaviors of the rats, however the students had the choice of creating their own or using the data sheets provided in class.

***Hardware for 3D-printed operant chambers*.** Table 1 presents a list and associated cost of each piece of hardware used in the design and creation of the operant chambers. Hardware includes a Raspberry Pi single-board computer (SBC). We recommend a Pi 3 or up to ensure adequate performance with the Pygame packages. The Raspberry Pi's GPIO pins and related hardware provide connection points for optical sensors and relays to power the lights. The Raspberry Pi's GPIO pins are incapable of supplying the current required to power brighter lights and higher load devices directly, necessitating the use of a relay. A relay provides a low current switching method for a larger load and/or voltage. The relay provides isolation between the Raspberry Pi's 3.3V logic level pins and the electrical load of the 5V light, allowing the use of our 5 VDC LED light panel. The relay used incorporates a flyback diode to protect the raspberry pi from the sudden voltage spike when the inductive load of the relay coil is switched off and the electromagnetic field collapses.

Table 1

Materials for Basketball Chambers

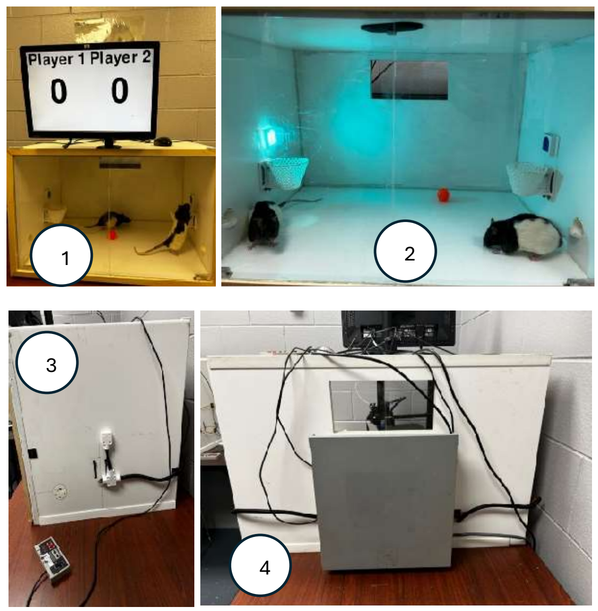
Quantity	Component	Total in USD
1	Raspberry Pi	45
2	Optical sensors	10
2	Relays	12
1	5V Power Supply	15
1 (Pack)	Gel Light Filters	12
1	Pack Zip Ties	10
4	Bearings (684AZZ)	12
10	M4X25 Socket Cap Screws	5
2	M4 Nylock nuts	1
2	NES Controllers	20
	Total	**$142**

We printed the basketball hoops from white PLA, while the arm that interrupts the optical switch required black PLA to ensure insufficient light permeation through the plastic to allow proper detection of a scoring event. PLA, or poly lactic acid-based filament, is a material created from a carbohydrate source, often corn, prints very easily at lower temperatures, and is not commonly associated with the toxic off-gassing and particulate emissions possible with other filaments such as ABS. We assembled these hoops with the 3D printed parts, M4 lock nuts, M4X25 Socket Cap Screws, and 684AZZ bearings. LED light panels are enclosed in 3D-printed gel light filter holders that incorporate a slot to place a gel light filter. We affixed the hoops and gel light filter holders to the box using zip ties. Additionally, we selected a 5VDC (volts dc) 5A (amp) power supply based on the electrical requirements of the Raspberry Pi, ancillary electronics, and desired headroom.

Assembly of 3D-Printed Operant Chambers. Figure 1 shows photographs of the assembled operant chamber. Researchers created two operant chambers out of repurposed foam core boxes, with polycarbonate clear windows to view the rats, and outfitted with 3D-printed parts and electronics including a raspberry pi. 3D-printed parts consisted of the basketball hoop and associated sensing equipment, along with lamp holders and gel filter slots to select colors for each respective rat. Figure 2 presents a computer-rendered model of the basketball hoop. Autodesk Inventor, a 3D design software available for free to colleges and universities, was used to design and render all components. During design, careful consideration was given to create

Figure 1

Photographs of the 3D Printed Operant Chamber

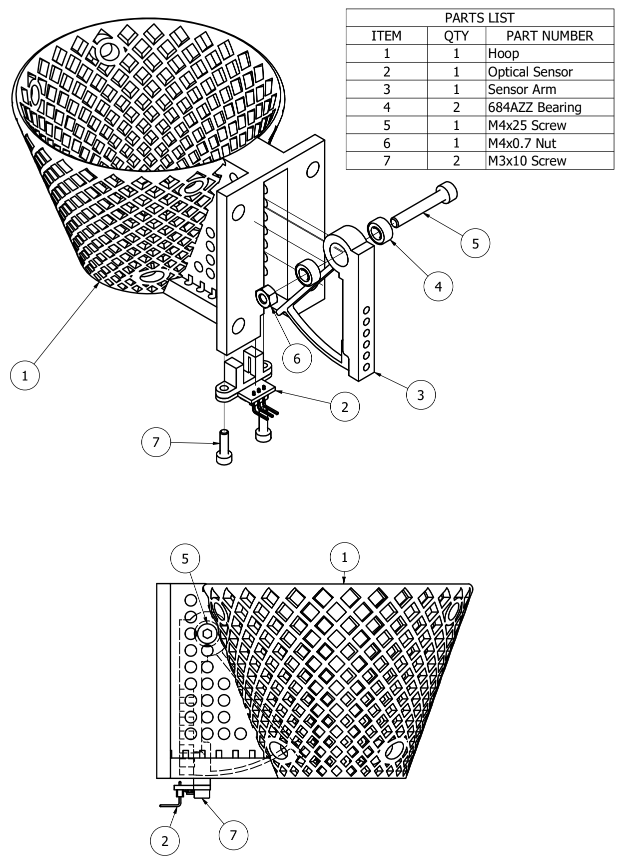


Note. Photograph 1 displays the monitor that records each instance of activation of the switch located inside the hoop. Photograph 2 shows each rat on their associated side, with two different colored lights assigned to each rat. Photograph 3 shows the side profile of the chamber, with the controller to manually shape response, and the 3D-printed magazine for students to deliver food reinforcers. Photograph 4 shows the back of the chamber, with all wiring and hardware protected by an electrical enclosure.

larger flat surfaces on the parts to allow for the best bed adhesion. The angles of any part walls or sides were kept as vertical as possible in order to reduce and eliminate overhangs, and consequently the need for 3D print supports. The parts require 250g (grams) of filament and can be printed in under 30 hours with most hobby grade 3D printers.

Figure 2

Isometric and Side View of 3D Printed Hoop Assembly



PARTS LIST		
ITEM	QTY	PART NUMBER
1	1	Hoop
2	1	Optical Sensor
3	1	Sensor Arm
4	2	684AZZ Bearing
5	1	M4x25 Screw
6	1	M4x0.7 Nut
7	2	M3x10 Screw

Researchers used the colors blue and green, to make them easily discernible and to function as both a conditioned reinforcer and discriminative stimulus. The boxes had exterior dimensions of 505mm length, 785mm length, and a height of 505mm. The foam core panels measured 25mm thick and reduced the interior dimensions respectively.

The pellet ducts (i.e., magazine) that functioned to deliver the reinforcers measured 42mm in diameter and mounted with the centerline 47mm from the bottom of the chamber. Although these pellet ducts provided some ventilation, we added an additional ventilation hole centered on the upper rear of the box measuring 260mm wide, 125mm tall, and with the bottom of the opening residing 330mm from the bottom of the box.

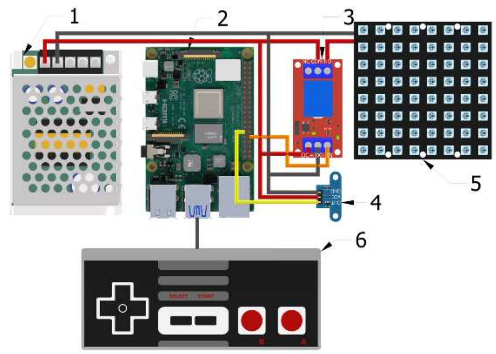
The basketball hoops were mounted with the top 125mm from the bottom of the chamber and had a diameter of 96mm at the top and approximately 44mm at the bottom. The hoop axis measured 65mm from the wall of the chamber and was mounted on the centerline of the wall. The hoops contain an arm that moved when a ball entered the hoop which then breaks a photosensor beam, signaling to the raspberry pi that a response occurred (i.e., basket made). One must ensure to print the arm in black or dark colored filament to ensure correct optical sensor operation, as the photosensor beam does not reliably detect a break from white filament. In addition to the optical sensor placed inside the hoop, the researchers used commercially available replicas of NES Nintendo controllers to allow the students to manually deliver reinforcers, as well as adjust the scores on the program. The chambers also contained a PC monitor mounted atop the box to display the scores during the game. Researchers mounted all possible wires and electrical components externally to prevent ingestion by rats and routed electrical wires in a corrugated wire sleeve with 3D-printed elbows, unions, and tees for increased durability.

Electronic connections. Figure 3 displays the diagram of the wired connections for the operant chamber. The raspberry pi (i.e., Figure 3, component 2) uses general purpose input and output pins (GPIO) to provide a hardware interface. These pins provide digital input and output to the raspberry pi and the respective program. During program execution, the raspberry pi constantly monitors the status of the input pins using the RPi.GPIO python library to check if an event has occurred. By requiring that the ball both activates and deactivates the switch before the score updates, the software is setup in such a way that the ball must travel completely through the hoop to trigger an event. This is intended to help reduce false positives in the event the ball gets lodged in the hoop.

Activating the LED light (i.e., Figure 3, component 5) is relatively straightforward with the use of a relay and a digital output pin. A relay (i.e., Figure 3, component 3) is required if intending to drive any significant load from the raspberry pi. One must carefully consider the hardware used to avoid confounding variables in experiments. For example, relays create an audible click upon activation and deactivation, whereas mosfets do not produce a sound. Open-source designs lend themselves particularly well to modification in this regard. The mechanical operation of a relay provides more salient feedback.

Figure 3

Simplified Diagram of Wired Connections



Note. Instructors will Need to Replicate the Lights and Control for a Second Player. Components include: (1) 5 VDC 5A power supply, (2) raspberry pi, (3) the relay, (4) optical sensor, (5) LED light panel, and (6) controller.

Software

Running on Raspberry PiOS (Legacy, 64-Bit Debian Bullseye). Our Python code, developed using Microsoft VS Code as the IDE, relies on Pygame and RPi.GPIO packages to handle game logic, controllers, and the GUI/Scoreboard. Required functions are minimal and include basics like text and time. Python and its available libraries facilitate incorporating a large scoreboard with an optional game timer. As an interpreted, high-level programming language, Python affords great readability to the programmer, clearly communicating code intent and enabling adaptability to future changes for varying circumstances. A while loop handles indefinite iterations and the Python code checks GPIO status in near real-time, as permitted by your hardware, and upon any changes on pins assigned to optical sensors, updates the scoreboard, and activates the relevant GPIO pin to trigger the light relay. USB connected NES game controllers provide a human interface to navigate the menu, manually adjust score, and activate the lights to serve as a conditioned reinforcer and discriminative stimulus indicating the availability of a reward.

Python, an interpreted language, requires more processing time to complete the same tasks compared to lower level programming languages like C, but these increased processing times, and subsequent read speed is not notable when running on a Pi 3B+ or newer as they have sufficiently high clock speeds and the processing times are negligible in relation to the time it takes for the ball to traverse the hoop.

Description of the Project

Appendix A presents the project description given to the students. Students received instruction on the assignment after they completed their shaping assignment in class. The instructor and graduate assistant of the class demonstrated how to use the 3D-printed operant chambers. Students could use two chambers both configured in an identical manner. The students would not receive any feedback on their shaping procedures. Instead, they made decisions about their rats' performance based on the data they collected. Students collected frequency data as a requirement but could collect other dimensional measures of behavior including duration, latency, and inter-trial-interval data if they wished. Students had to graph data on the graphical display of their choices. Options consisted of an equal-interval graph, a standard celeration chart, or a cumulative record.

The goal of the project consisted of the students shaping the response of a rat placing a ball inside the basketball hoop. Because the students' rats would compete against one another at the end of the semester, they also had to plan for the contextual variables associated with competing for the basketball in the chamber (e.g., the presence of another rat, noise from an audience, lights on, etc.).

At the end of the semester, students turned in a written document specifying the methodology they used to shape their rat's performance. Each document had to include an introduction section with a minimum of two peer-reviewed articles, a methodology section, a result section describing their data, and a discussion and reflection section. Because the student had not received direct training on single-case design methodology, the instructor provided most of the feedback based on their ability to make decisions based on the data they collected.

In addition to the written document, all students competed in a March Madness style competition at the end of the semester. Undergraduate students, faculty, and staff received an invitation to attend. The showcase featured a free-throw competition to start where students placed their rats in the chamber, and the rat had 3 min to engage in the behavior as many times as they could. The rats who made at least one correct response (i.e., places the ball in the hoop) progressed onto the 1:1 competition. A total of four rats progressed out of the ten.

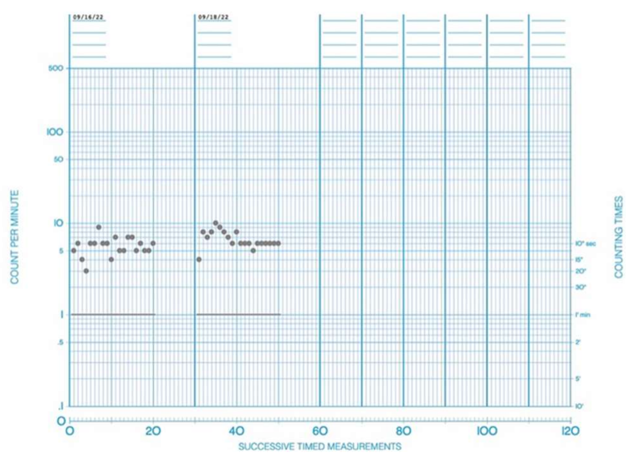
The instructor created a 2x2 bracket where the winner of each game progressed onto the next level of the tournament. A total of three games occurred. The student whose rat won the championship did not have to write up their final lab report and instead received an A for the assignment.

Sample data

Figures 4-7 present the data collected by graduate student Erykah Spriggs (consent obtained to use her name) to inform her shaping process during the assignment. All figures present data on the students preferred graphing convention, the standard celebration chart. A full appraisal of the charting conventions for the chart extends beyond the scope of the paper. The x-axis represents consecutive minutes, the dark horizontal lines indicate a new session, and the y-axis represents the frequency of behaviors per minute on a logarithmic scale.

Figure 4

Sample Data for Magazine Training

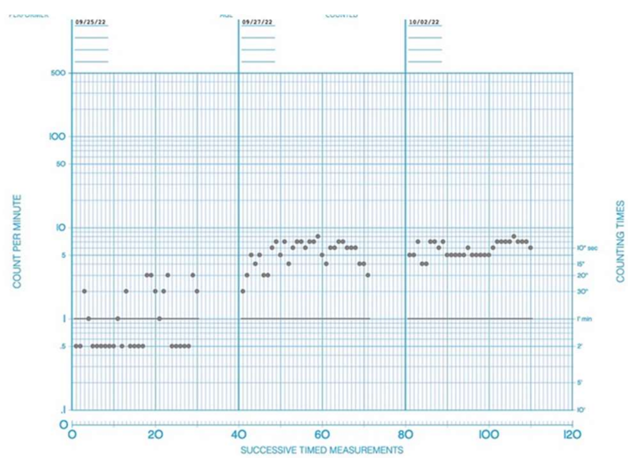


Note. The standard celeration chart below depicts successive minutes on the x-axis and count per minute on the y-axis. Dark horizontal lines indicate different training days. A total of two sessions occurred before the rat reliably retrieved the reinforcer when the blue light turned on.

Figure 4 presents the initial training procedure to establish the blue light as a conditioned reinforcer that also served as a discriminative stimulus for retrieving the food pellet in the magazine. A total of two sessions occurred for consistent pellet consumption in the presence of the blue light. Figure 5 presents the shaping data for the behavior of picking up the ball. It took the rat three sessions before consistent responding occurred. Figure 6 represents the next step the student chose to reinforce during the project, placing the ball into a stationary cup. Two sessions occurred before the rat reliably placed the ball in the cup. Finally, Figure 7 presents the final topography of behavior before the rat could place the ball independently in the hoop: Touches the hoop with the ball. Two sessions occurred for this response. Eventually, rats placed the ball into the hoop after the rat experienced extinction conditions for the final response identified by the student in the response hierarchy. Now, when the rat placed the ball in the hoop, the light automatically activated independent of the student activating the switch.

Figure 5

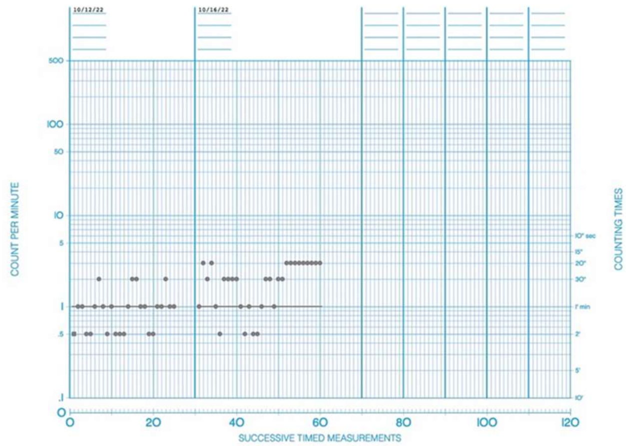
Sample Data for a Sample Behavioral Topography Reinforced: The Rat Picking up the Ball



Note. The standard celeration chart below depicts successive minutes on the x-axis and count per minute on the y-axis. Dark horizontal lines indicate different training days. A total of three sessions occurred before the rat reliably picked up the ball.

Figure 6

Sample Data for a Sample Behavioral Topography Reinforced: The Rat Placing the Ball in a Cup



Note. The standard celeration chart below depicts successive minutes on the x-axis and count per minute on the y-axis. Dark horizontal lines indicate different training days. A total of two sessions occurred before the rat reliably placed the ball inside of a cup.

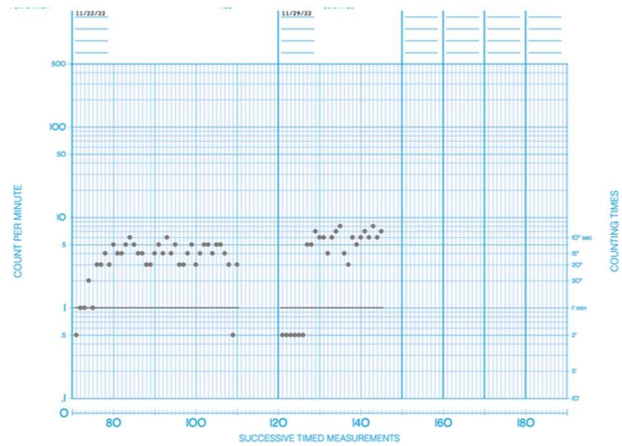
Discussion

Our case study illustrates the successful implementation of low-cost 3D printed operant chambers to promote generative responding in behavior analysis students. The results demonstrate the students' ability to apply learned behaviors in a new context, emphasizing the pedagogical value of this approach. Additionally, we present researchers, instructors, and any other interested party with the materials, coding, and methods for assembling low-cost 3D-printed operant chambers. This paper adds to the existing literature on low-cost operant conditioning apparatuses (Escobar, 2017; Pérez-Herrera et al., 2018). Given the benefits of in-vivo animal laboratory experiences compared to virtual (Elcoro & Trundle, 2013), we hope these methods provide a blueprint for instructors to incorporate animal laboratory experiences in their existing courses in behavior analysis and learning.

Several unexpected pragmatic benefits occurred as a result of this project. While researchers did not measure these data directly, future studies may wish to investigate these findings as individual research questions. First, given the performances of the rats, students opted to

Figure 7

Sample Data for the Sample Behavioral Topography Reinforced: The Rat Raising the Ball to the Hoop



Note. The standard celeration chart below depicts successive minutes on the x-axis and count per minute on the y-axis. Dark horizontal lines indicate different training days. A total of two sessions occurred before the rat reliably touched the hoop with the ball.

adopt their rats following the course, which decreased the euthanasia rates for the laboratory rats. The university had procedures already established that allowed for adoption of the animals as an alternative to euthanasia. We conducted the adoption process in accordance with our institutional review committee and ensured all students had proper training and resources to provide care to the animals.

Second, the department opened up the final showcase to the general public, which attracted non-psychology student majors. This may have positively affected the number of students enrolled in the psychology major. Lastly, we broadcasted the event via zoom to the general public outside of the university. Attendees made many positive comments, and one might assume this event has the potential to increase positive attitudes surrounding the use of animals in laboratory classes. Again, these findings are anecdotal at best but function as an interesting area to investigate.

In summary, we believe the current apparatus presents an exciting extension of operant conditioning techniques that instructors can use inside of the classroom to teach and extend basic concepts and principles of behavior analysis and learning.

Open Practice Statement

The data and materials for all experiments are available and none of the experiments were preregistered.

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Appendix A

Final Lab Report: Ratsketball

Andrew. J. Bulla, Ph.D., BCBA

Description and Rationale

Often, behavior analysts must program for the transfer of skills taught in a controlled setting to different stimulus arrangements and contexts. Principles and strategies from instructional design provide us with methods to do so. Component-composite analysis represents a behavioral analysis that allows us to program for generative responding. Generative responding is a type of responding in which the organism engages in novel occurrences of behavior. Researchers have identified two kinds of generative responding thus far: (1) a taught behavior occurs in a novel context/stimulus situation, and (2) a new, untaught, behavior occurs because of the environmental configurations. For this project, I will present you with a novel situation for which component repertoires taught in class (e.g., magazine training, shaping, schedules of reinforcement, etc.) can be used to teach a new behavior: a rat picking up a ball and placing it inside of a hoop. This project functions as a probe of generative behavior to see if the component skills you learned in isolation can be combined to teach a novel topography of behavior.

Requirements

For your project, you will spend time outside of class shaping behaviors until your rat can reliably place the ball inside of the hoop. You can use any resources from the class, but you must also identify at least two peer-reviewed papers to assist in your training. I will not offer any feedback on your training. Instead, I will look at your decision-making and analytic skills used throughout. The project will culminate in a final basketball match, in which rats will compete against each other in a tournament. The student of the winning rat will receive an A on this final assignment.

Introduction

For your introduction, you should provide 3-5 paragraphs on the concepts and principles of behavior analysis used in this project. You should also include a minimum of two peer-reviewed papers not covered in class on techniques you researched for how to train your rat. You can have additional references that are not peer reviewed, as well. The purpose of this section is to familiarize the reader with the concepts and principles of behavior analysis used in this assignment. You should not focus on describing the procedures you used, instead you should focus on the research supporting those procedures.

Methods

In this section you will include (1) Subject, (2) Setting and Materials, (3) Measurement and Data Collection, and (4) Procedures. Each section should include relevant information about your project. The procedures should clearly describe how you went about teaching and training your rats to engage in the behavior. A complete, technological, description of the procedures must be included, as well any interventions you implemented. Upon reading your procedures, I should be able to replicate your teaching.

Results

The results sections should describe any graphs/charts used during the teaching process. You should describe what the data told you throughout the project, and within-condition analyses you learned about in your Measurement Course. This may include, but not be limited to, celeration, bounce, level, range, etc. This project does not require you to "test" or "prove" a hypothesis. Instead, what did you learn from your data.

Discussion and Reflection

In the final part of the paper, you should describe how your results mapped on to the research you did in your introduction section. Only 2-3 paragraphs should do this. The majority of this section should be a reflection on what you learned during this project, and what your rat taught you about the concepts and principles of behavior analysis. This section can include your feelings, discoveries, frustrations, things you would have done differently, and breakthrough moments.

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