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The Planaria Train-A-Tray Revisited: 3D Printer Schematics

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In the late 1950s through the 1960s, one of the most popular animals in behavioral neuroscience was the planarian. Over the succeeding 50 years, interest in these animals began to wane. Recently, planarians have been rediscovered by behavioral neuroscientists. One of the most popular apparatuses at the time for training planarians in the areas of learning and memory was the Train-A-Tray. The Train-A-Tray had sections for classical conditioning and for the study of instrumental learning using a Y maze. At the time, it was the only commercially available apparatus for invertebrates. As the popularity of planarians began to wane, the apparatus was discontinued. This article describes how to 3D print the device in anticipation that it will once again be used for student training in comparative psychology and behavioral neuroscience.

Keywords: apparatus, comparative psychology, learning, planaria, teaching

プラナリアのTrain-A-Trayの復活：3Dプリント設計図

1950年代後半から1960年代において、プラナリア類は行動神経科学における最も普及した動物種の1つであった。その後の50年間で、これらの種に対する関心は衰退していった。しかし近年、プラナリア類は行動神経科学者によって再発見されている。当時、学習および記憶の分野におけるプラナリアのトレーニングで最もよく使われた装置は、トレイ型実験装置（Train-A-Tray）であった。Train-A-Trayには古典的条件付けのための区画と、Y字迷路を使って道具的条件付けを研究する区画が備わっていた。当時、本装置は無脊椎動物を対象とした唯一の市販の実験装置であった。プラナリア類の人気の減衰に伴い、本装置も製造中止となった。本稿では、比較心理学および行動神経科学における学生実習で再び本装置が使用されることを期待して、3Dプリントによる装置の作製方法を解説する。

キーワード：装置、比較心理学、学習、プラナリア、教育

El *Train-A-Tray* para planarias: recuperación y esquemas para impresión 3D

Desde finales de la década de 1950 hasta la década de 1960, uno de los animales más utilizados en la neurociencia conductual fue la planaria. Durante los 50 años posteriores, el interés por estos organismos comenzó a disminuir. Recientemente, las planarias han vuelto a despertar el interés de los investigadores en neurociencia conductual. El *Train-A-Tray* fue uno de los dispositivos más populares durante ese tiempo para el entrenamiento de planarias en el estudio del aprendizaje y la memoria. Este dispositivo contaba con secciones destinadas al condicionamiento clásico y al estudio del aprendizaje instrumental mediante un laberinto en forma de Y. En aquel entonces, era el único dispositivo comercialmente disponible para el estudio de invertebrados. A medida que el interés por las planarias comenzó a disminuir, la comercialización de este dispositivo se interrumpió. El presente artículo describe el procedimiento para reproducirlo mediante impresión 3D, con la expectativa de que pueda volver a utilizarse en la formación de estudiantes en psicología comparada y neurociencia conductual.

Palabras clave: instrumento experimental, psicología comparada, aprendizaje, planarias, enseñanza.

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In the late 1950s through the 1960s, one of the most popular animals for neurobiological research on learning and memory was the planarian, commonly known as the flatworm. This popularity was stimulated by the initial experiment of Thompson and McConnell (1955), who demonstrated that planarians could learn to associate an increase in illumination with a brief electrical shock. While the procedure formally resembled classical conditioning, the fact that planarians would initially contract to the light before it was paired with shock cast doubt on whether the procedure was classical conditioning or some other phenomenon such as alpha conditioning (Abramson, 1994).

Despite this limitation, the planarian work captured the attention of both the scientific community and the general public. Especially so, when further research showed that learning can be transferred from a trained planarian to an untrained planarian through cannibalism. Moreover, as planarians have remarkable powers of regeneration, a trained planarian can be cut in half, and the regenerates will possess some of the learning from the original intact planarian. For a comprehensive review of this early literature, see Corning and Ratner (1967/2013) and Corning and Kelly (1973).

The popularity of the planarian experiments was so great that McConnell created the *Journal of Biological Psychology,* where some of the early studies were published. What was so unique about this journal was that it was designed in such a way that a companion journal called the "*Worm Runner's Digest*" was published on the reverse side of the "parent" journal. *The Worm Runner's Digest* provided researchers with tips and general information, along with cartoons about planarians.

Another example of the popularity of the planarian experiments was the planarian Train-A-Tray. The Train-A-Tray was created by Dev-Coa, Inc. (83 Clover Avenue, Floral Park, New York) and included a Y maze, a holding area that could double as a runway, and a circular area that could be used to classically condition a planarian. The Tray could be hooked to a battery to provide an electric shock as an unconditioned stimulus for classical conditioning experiments or provide a stimulus to escape and/or avoid if the Y maze was used. The Y maze was unique in that the angles of the start box and arms were such that they could be used interchangeably without the planarian being handled between runs through the maze.

The tray is designed to use various glass filters when light is used as a conditioned or discriminative stimulus. The design was perhaps not "professional grade" but satisfied the needs of the intended audience – students at all levels of the educational system. The apparatus was also unique because it was the only commercially available invertebrate learning apparatus.

As the decades have passed since the initial Thompson and McConnell experiment, the interest in planarian learning waned and the apparatus was discontinued (Abramson, 1994; Rilling, 1996). Stimulated by the work of Michael Levin, there has been renewed interest in planarian behavior (Nicolas et al., 2008). The purpose of this article is to provide 3D printer instructions to duplicate the original Train-A-Tray. In an earlier article, we advocated for the use of 3D printing in comparative psychology and illustrated its use by creating a 3D-printed maze for honey bees (Hitesh & Abramson, 2020).

3D Printing Instructions

A digital 3D model of the original Train-A-Tray was constructed using Tinkercad, a free, web-based 3D modeling program (Abburi et al., 2021; https://www.tinkercad.com). All model dimensions were derived from direct measurements of a physical copy of the original Train-A-Tray. The digital model is provided as an electronic supplementary file in stereolithography format ("Train-A-Tray.stl"), a commonly supported format compatible with most 3D printing programs. Readers may also import and modify the model using Tinkercad or other 3D-modeling applications, such as FreeCAD (https://www.freecad.org).

Below, we provide a protocol for printing the model using the widely adopted commercially available Bambu Lab H2D 3D printer (Bambu Lab, Shenzhen, China). The H2D uses fused deposition modeling (FDM), in which thermoplastic filament is melted and deposited layer by layer onto a build platform to construct a physical object from a digital model. Although the settings described below were optimized for the Bambu Lab H2D, the STL file can be adapted for use with other 3D printers.

Install the Slicing Software

Install Bambu Studio, the slicing software (also known as "slicer") associated with the Bambu Lab H2D. A slicer program translates a digital 3D model into specific machine-readable instructions the 3D printer needs to build the object. The detailed installation and usage guide is available from the Bambu Lab Wiki: https://wiki.bambulab.com/en/bambu-studio/quick-start. The Bambu Studio version used in this protocol was V2.7.1.62.

Import the Digital Model

Import “Train-A-Tray.stl” into Bambu Studio. This creates a project in which the model orientation, dimensions, filament assignments, support structures, and other printing parameters can be configured.

Configure the Printing Parameters

The settings described below were used to obtain the best printing results in our tests and are summarized in Table 1.

Table 1

3D Printing Settings Used in Bambu Studio (V2.7.1.62) for the Train-A-Tray Model

Section	Parameter	Setting
Printer	Left/Right nozzle diameter	0.4 mm
	Flow	Standard
Project Filaments	Filament	Bambu PLA Basic (White) and Bambu PETG (Translucent), diameter: 1.75 mm
	Nozzle temperature (Other layers)	PLA: 200 °C; PETG: filament-profile default
Process (Strength)	Wall loops	≥ 3
	Top/bottom surface pattern	Monotonic
	Top shell layers	≥ 10
	Top shell thickness	0 mm
	Bottom shell layers	≥ 6
Process (Quality)	Bridge flow	0.9
Process (Speed)	Bridge	20 mm/s
Process (Support)	Enable support	On
	Support type	Normal (auto)
	Support/raft base	PLA
	Support/raft interface	PETG
	Top Z distance	0 mm
	Top interface layers	4 layers
	Interface pattern	Rectilinear interlaced
	Top interface spacing	0 mm
	Independent support layer height	Off
Other settings		Default

Note. PLA = polylactic acid; PETG = polyethylene terephthalate glycol.

Printer Settings

Nozzle Diameter. 0.4 mm for both the left and right nozzles. The nozzle diameter determines the diameter of the melted filament, affecting printing speed, structural strength, and the level of detail that can be reproduced. The standard 0.4 mm nozzle provided an effective balance between printing speed and model resolution.

Flow Setting: Standard. In Bambu Studio, the standard filament flow ratio is 1.0, corresponding to 100% of the nominal extrusion volume. This setting was used to maintain appropriate wall thickness, layer adhesion, and surface quality while avoiding substantial under- or over-extrusion.

Project Filament Settings

Model and Support Filaments. Bambu PLA Basic (white) and Bambu PETG (translucent) were used. In 3D printing, support structures are temporary scaffolds printed beneath unsupported portions of a model to prevent sagging or collapse during printing due to gravity. A support structure generally consists of two regions: a support base and a support interface. The support interface consists of the dense layers positioned directly beneath and in contact with the surface of the model, providing a continuous foundation on which unsupported model layers can be deposited. The support base is the remaining portion of the support structure, which does not directly contact the model. It forms the bulk of the scaffold and is typically printed more

sparsely to reduce printing time and material consumption. Additional information on support structures is available from the Bambu Lab Wiki: https://wiki.bambulab.com/en/software/bambu-studio/support.

In our configuration, PLA (polylactic acid) served as the primary model material and as the support-base material, whereas PETG (polyethylene terephthalate glycol) was used only for the support-interface layers. Both filaments had a diameter of 1.75 mm, which is compatible with the standard 0.4 mm nozzle. Because support structures are temporary and must be removed after printing, the support interface material should provide sufficient support while bonding only weakly to the model material. PLA and PETG generally adhere poorly to each other, allowing the PETG interface to be separated easily from the PLA model. Other combinations of model and support interface materials may be substituted, provided that they offer adequate support and can be readily separated after printing.

PLA Nozzle Temperature for Other Layers. 200 °C. Nozzle temperature affects filament flow, layer adhesion, mechanical strength, and surface quality. In our tests, 200 °C produced better results for Bambu PLA Basic than the lower or higher temperatures evaluated. The PETG temperature was retained at the filament-profile default.

Process Settings: Strength

Wall Loops. ≥3. Wall loops, or perimeters, are the continuous outlines printed around the exterior of the object. Increasing the number of wall loops generally improves lateral strength, rigidity, and impact resistance. At least three wall loops provided adequate structural integrity in our tests.

Top/Bottom Surface Pattern. Monotonic. This parameter determines the geometric design on the very top or bottom layers of a print. The monotonic pattern prints adjacent surface lines in a consistent direction and produced a more uniform and smoother surface than other tested patterns such as rectilinear and concentric.

Top Shell Layers. ≥10. These layers are deposited horizontally to seal the top of a print. At least 10 top shell layers were used to produce a continuous upper surface without visible gaps.

Top Shell Thickness. 0 mm. In Bambu Studio, a value of 0 mm disables the independent thickness requirement, such that top-shell thickness is determined by the specified number of top shell layers.

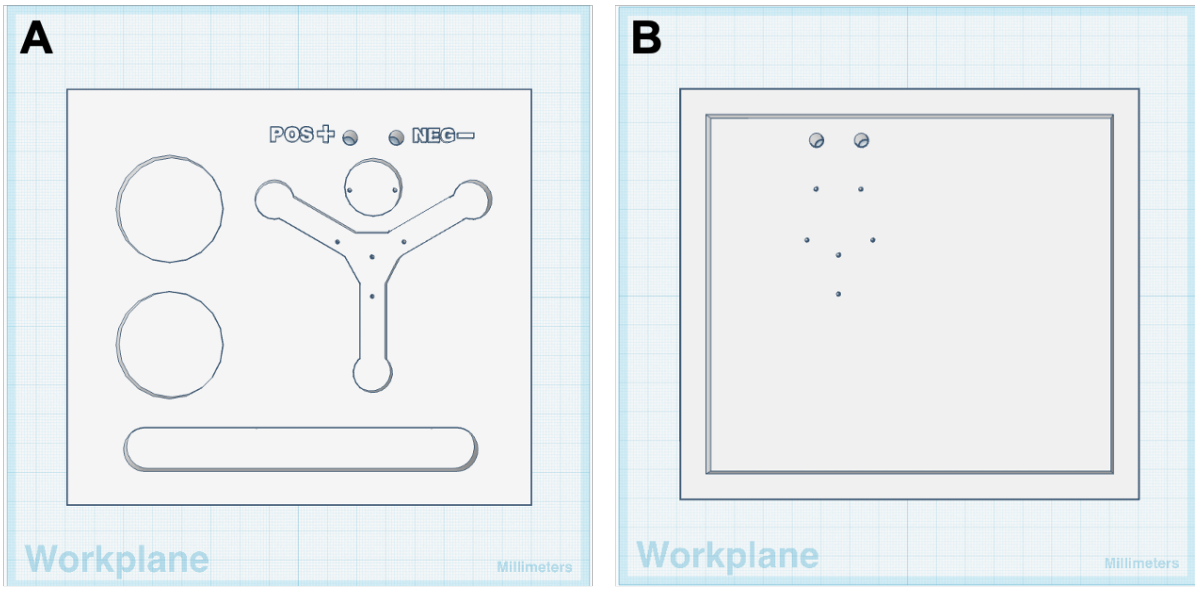
Bottom Shell Layers. ≥6. Similar to top shell layers, six or more bottom shell layers were used to ensure that the lower surface was fully sealed.

Process Settings: Quality

Bridge Flow. 0.90. In 3D printing, bridging occurs when filament is extruded across an unsupported horizontal gap between two supported regions. Bridging was a major concern for the Train-A-Tray because the lower structure spans a large hollow region (Figures 1B and 2B). Reducing the bridge flow from the default value of 1.0 decreased excess material deposition and reduced filament accumulation and sagging during bridge formation.

Figure 1

A Diagram of the Digital Model



Note. Diagram of the digital 3D model constructed with Tinkercad. (A) Top view of the model; (B) bottom view of the model.

Process Settings: Speed

Bridge Speed. 20 mm/s. Bridge speed controls the movement of the nozzle while filament is deposited across an unsupported span. Reducing the speed from the default 50 mm/s to 20 mm/s produced cleaner bridges with less sagging in our tests.

Process Settings: Support

Enable Support. On. Because of the broad hollow region in the model, adjusting the bridging settings alone proved insufficient. Without temporary support beneath the large unsupported spans, the extruded filament tended to sag, curl, or detach before forming a stable surface. Enabling support provided a temporary foundation for these layers, improving adhesion, dimensional accuracy, and surface quality.

Support Type. Normal (auto). Bambu Studio offers both normal and tree-style support structures, each available in automatic or manual mode. Normal supports consist of lattice-like structures extending vertically from the build plate or model, whereas tree supports use branching structures designed primarily for localized or irregular overhangs. Because the Train-A-Tray contains a broad, flat unsupported region, normal supports provided more uniform support than tree supports. Automatic mode was enabled so that the slicer could generate supports automatically rather than requiring manual placement.

Support/Raft Base. PLA. Although both PLA and PETG can be used for the support base, PLA was selected to reduce PETG consumption and overall material cost.

Support/Raft Interface. PETG. PETG was assigned to the support interface because its weak adhesion to PLA facilitated clean separation of the temporary support structure from the printed model.

Top Z Distance. 0 mm. This setting controls the vertical separation between the upper support interface and the lower surface of the model. Larger distances generally facilitate support removal but may allow the supported layer to sag or adhere poorly. Because PLA and PETG bond weakly, a 0 mm top Z distance produced a well-supported surface while still permitting easy separation of the support interface from the model.

Top Interface Layers. 4. Four dense interface layers were deposited immediately beneath the supported portion of the model. These layers prevented the unsupported model surface from sagging into the more widely spaced support base structure.

Interface Pattern. Rectilinear interlaced. This pattern produced a dense, interlocking support surface and yielded a smoother underside in our tests.

Top Interface Spacing. 0 mm. This setting determines the spacing between adjacent lines in the top support interface. If the spacing is too narrow, the support interface may fuse with the model's bottom layer, producing a rough, difficult-to-remove mass of material. Conversely, if the spacing is too wide, the supported layer may sag into the gaps, resulting in a rough or ribbed underside. In our tests, a spacing of 0 mm produced a continuous support interface that prevented sagging while remaining readily removable because of the weak adhesion between PLA and PETG.

Independent Support Layer Height. Off. This option allows support structures to print at a different layer height from the model. Although it may reduce printing time or material use in some applications, it was disabled because no clear improvement was detected in our tests with PETG used as the support interface material.

All settings not specified above were retained at their default values.

Save the Project File

Before proceeding, save the project as a 3MF (3D Manufacturing Format) file. The 3MF is an advanced 3D printing format that can store complete model data, including model geometry, multiple objects, material assignments, and slicer settings. Saving the project in this format facilitates subsequent modification or reprinting. The project file containing the model and the settings described above is provided as "Train-A-Tray_BambuH2D.3mf."

Slice the Model

Select "Slice plate", choose the desired slicing options, and then confirm the filament grouping when prompted. The filament-grouping window allows the user to assign PLA and PETG to the same nozzle or to separate nozzles. When a dual-nozzle printer such as Bambu Lab H2D is available, assigning one material to each nozzle is recommended because it reduces filament-purging and material-switching time. In our configuration, use of separate nozzles reduced the estimated printing time by approximately 1 h 30 min.

Slicing digitally divides the 3D geometry into a series of horizontal two-dimensional layers and generates the corresponding printer toolpaths. The resulting machine-readable geometric code (G-code) consists of commands specifying nozzle movement along the X, Y, and Z axes, material extrusion, temperature, and filament changes.

Transfer and Print the Sliced Model

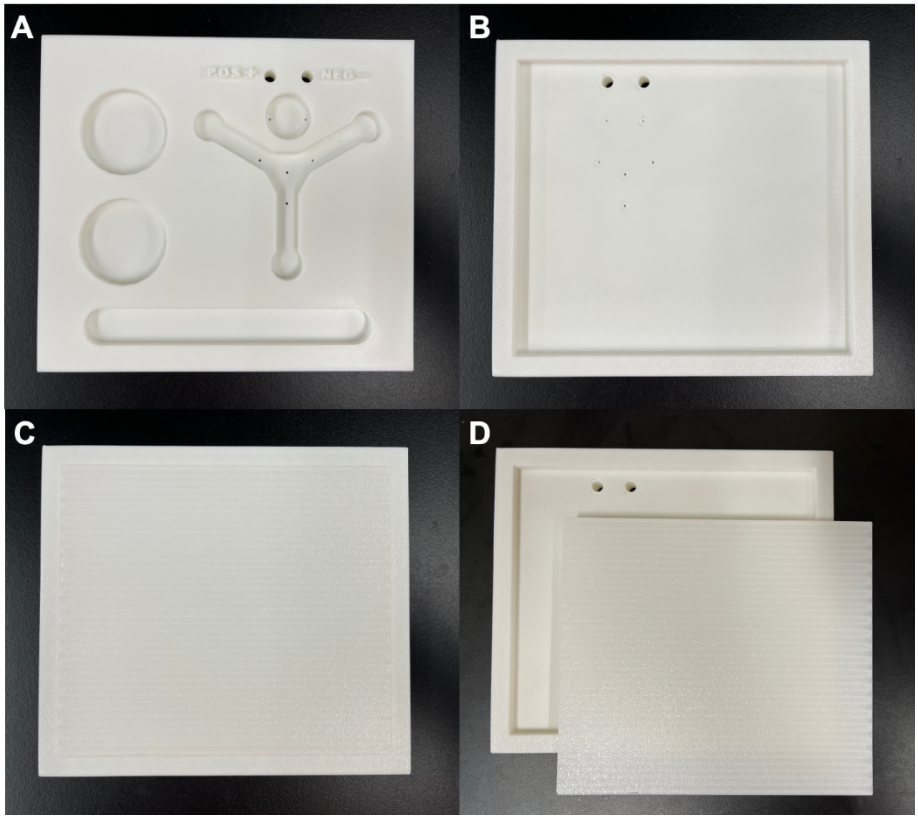
After slicing, the model can be printed directly through Bambu Studio when the software is connected to the Bambu Lab H2D. Alternatively, the sliced file can be exported to removable storage (e.g., a flash drive) and transferred to the printer. For the H2D, we exported the project as a ".gcode.3mf" file, which retains both the sliced machine instructions and project-related information required for printer-specific features, including multi-material assignment. This file is provided as "Train-A-Tray_BambuH2D.gcode.3mf." Because printer-ready G-code is generally machine-specific, users of other printer models should import "Train-A-Tray.stl" into the slicing software appropriate for their printer and generate new G-code using settings calibrated for that machine. A generic G-code file (".gcode") can also be exported from the slicer but should not be assumed to be compatible with printers that differ in build volume, firmware, nozzle arrangement, coordinate system, or material-handling configuration.

Printing Time and Material Consumption

Using the Bambu Lab H2D configuration described above, printing required approximately 4 h 7 min and consumed an estimated 158.90 g of filament, consisting of 143.93 g of PLA and 14.97 g of PETG.

Figure 2 shows the completed Train-A-Tray printed with the Bambu Lab H2D using the "Train-A-Tray_BambuH2D.gcode.3mf" file.

Figure 2
Images of the 3D-printed Train-A-Tray



Note. Images of the 3D-printed Train-A-Tray. (A-B) Top and bottom views of the model; (C-D) before- and after-detachment of the support structure.

Instructions on How to Use the Train-A-Tray

Detailed instructions on how to use the Train-A-Tray are available in Abramson (1990). This book, which is no longer in print, is freely available upon request from the corresponding author. Briefly, an individual planarian is selected from the home tank and placed into the classical conditioning or Y maze section depending on the goals of the experimenter. Prior to placing the planarian into one of these two sections, the section is filled with water from the home container. Alternatively, several planaria can be placed in the "holding" or "runway" section if several planaria are to be conditioned during a training session. Detailed experimental designs, troubleshooting, and where to procure the planarians are available in Abramson (1990). It has been the experience of the corresponding author that the best stock animals come from Carolina Biological Supply Company. Experiments with other invertebrates are also described in the same book.

Representative Data

Classical Conditioning

In this sample experiment, the conditioned stimulus (CS) was an increase in background light levels produced by a standard desk lamp. The unconditioned stimulus (US) was a 2-sec electric shock. The time between the CS and US (i.e., the ISI) was 5-min. The response was observed manually and classified as either a partial (PC) or full contraction (FC). Each of the 10 subjects was given 10 pairings of light and shock. The animals were obtained from Carolina Biological Supply, as we have had excellent results in terms of longevity. For example, the corresponding author has routinely kept colonies through an entire 16-week semester. The data are shown in Table 2 and show quite clearly the problems faced by Thompson and McConnell in their initial experiments – the light stimulus elicited a partial contraction (PC) before its pairing with shock. One must consider that a light stimulus can itself be a variable to be manipulated, in addition to simply being presented or not (Paskin et al., 2014). Planarians display differing behavioral responses across a range of wavelengths. These responses occur in a hierarchy, with the shortest wavelengths, ultraviolet (UV), eliciting the most intense photophobic responses while longer wavelengths produce no effect (red) or an apparent attraction to infrared (IR) (Paskin et al., 2014).

This simple demonstration can stimulate many discussions about experimental design, the generality and importance of learning, the misuse of the term "cognition", and of course, why a comparative psychology is needed (d'Isa & Abramson, 2023). The Train-A-Tray can also be used for student independent projects. The student and professor are only limited by their imagination and enthusiasm when working with these fascinating animals. If it is not possible to print enough devices for a mid-size to large classroom, one device can be printed and shown to an entire class by placing it on a document camera found in most classrooms. As mentioned earlier, many details on how to use the Train-A-Tray are found in Abramson (1990).

Table 2

Raw Data for 10 Animals Across 10 Training Trials

	Animal									
Trials	1	2	3	4	5	6	7	8	9	10
1	PC	PC	PC	FC	PC	PC	FC	PC	PC	PC
2	PC	FC	PC	FC	PC	PC	PC	FC	PC	PC
3	PC	FC	FC	FC	FC	FC	FC	FC	FC	FC
4	FC	FC	FC	FC	FC	FC	FC	PC	PC	PC
5	FC	FC	FC	FC	FC	PC	PC	FC	FC	FC
6	FC	FC	FC	FC	FC	FC	FC	FC	FC	FC
7	PC	FC	FC	FC	FC	FC	FC	FC	FC	FC
8	FC	FC	FC	FC	FC	FC	FC	FC	FC	FC
9	FC	FC	FC	FC	FC	FC	FC	FC	FC	FC
10	FC	FC	FC	FC	FC	FC	FC	FC	FC	FC

Note. PC = partial contraction; FC = full contraction.

Discussion

For several decades, the corresponding author has advocated the use of invertebrates in the classroom as the preferred alternative to computer simulations such as "Sniffy the rat" (Abramson, 1986). While we may not be voicing the popular opinion, computer simulations, which may be convenient for the instructor, teach the student little in the way of learning the nuances of behavioral experimentation – especially from the comparative psychological perspective (Abramson, 2015; 2023). In the only study we know of directly comparing a computer demonstration with a live animal demonstration, students considered the computer simulation more as a game than a nuanced learning activity (Abramson et al., 1996).

The Laboratory of Comparative Psychology and Behavioral Biology of the corresponding author has spent considerable effort in designing practical, inquiry-based teaching activities on a variety of topics, including planarians in the classroom (Abramson, 2020). Of special interest is a novel planarian technique in which planarians are trained to travel distances to seek out water (Chicas-Mosier & Abramson, 2015). It should also be mentioned that the situation can be automated with a low-cost observation system and microcontrollers (Tscheulin & Abramson, 2023; Varnon & Abramson, 2013, 2018).

In conclusion, given the renewed interest of behavioral neuroscientists in the learning of planarians, we hope that more psychology professors will begin to use planarians in the classroom. One of the potential stumbling blocks is the lack of a commercially available planarian training apparatus. This article eliminates this impediment by providing instructions on how to 3D print the original Train-A-Tray.

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References

Abburi, R., Praveena, M., & Priyakanth, R. (2021). Tinkercad – a web based application for virtual labs to help learners think, create and make. *Journal of Engineering Education Transformations*, *31*, 535–541. https://doi.org/10.16920/jeet/2021/v34i0/157209

Abramson, C. I. (1986). Invertebrates in the classroom. *Teaching of Psychology*, *13*(1), 24–29. https://doi.org/10.1207/s15328023top1301_6

Abramson, C. I. (1990). *Invertebrate learning: A laboratory manual and source book.* American Psychological Association. https://doi.org/10.1037/10078-000

Abramson, C. I. (1994). *A primer of invertebrate learning: The behavioral perspective*. American Psychological Association.

Abramson, C. I. (2004). Planarians in the psychology classroom: Habituation and instrumental conditioning demonstrations. In M. Bekoff (Ed.), *Encyclopedia of animal behavior*, (pp. 539–547). Greenwood Publishing Group.

Abramson, C. I. (2015). A crisis in comparative psychology: Where have all the undergraduates gone? *Frontiers in Psychology*, *6,* 1500. doi.org/10.3389/fpsyg.2015.01500.

Abramson, C. I. (2020). From flatworms to humans: Demonstration of learning principles using activities developed by the laboratory of comparative psychology and behavioral biology – Additional exercises. *International Journal of Comparative Psychology*, *33*. https://doi.org/10.46867/ijcp.2020.33.05.04

Abramson, C. I. (2023). Research methods in comparative psychology: A tutorial. *Journal of Mind and Behavior*, *44*, 111–134. https://jmb-online.com/pdf/03/JMB-44-1-2-2023-006.pdf

Abramson, C. I., Onstott, T., Edwards, S., & Bowe, K. (1996). Classical-conditioning demonstrations for elementary and advanced courses. *Teaching of Psychology, 23*(1), 26–30. https://doi.org/10.1207/s15328023top2301_4

Chicas-Mosier, A. M., & Abramson, C. I. (2015). A new instrumental/operant conditioning technique suitable for inquiry based activities in courses on experimental psychology, learning, and comparative psychology using planaria (*Dugesia dorotocephala* and *Dugesia tigrina*). *Comprehensive Psychology*. https://doi.org/10.2466/09.IT.4.6

Corning, W. C., & Kelly, S. (1973). Platyhelminthes: The turbellarians. In *Invertebrate Learning: Volume 1 Protozoans Through Annelids* (pp. 171–224). Springer US.

Corning, W. C., & Ratner, S. C. (2013). *Chemistry of learning: Invertebrate research*. Springer. (Original work published in 1967).

d'Isa, R., & Abramson, C. I. (2023). The origin of the phrase comparative psychology: An historical overview. *Frontiers in Psychology*, l. *14*, 1174115. doi: 10.3389/fpsyg.2023.1174115

Hitesh, V., & Abramson, C. (2020). The use of 3D printing in comparative research and teaching. *International Journal of Comparative Psychology*, *33*. http://dx.doi.org/10.46867/ijcp.2020.33.05.12

Nicolas, C., Abramson, C.I., & Levin, M. (2008). Analysis of behavior in the planarian model. In R.B. Raffa & S.M. Rawls (Eds.) *Planaria: A model for drug action and abuse* (pp. 83-94). R.G. Landes Co.

Paskin, T. R., Jellies, J., Bacher, J., & Beane, W. S. (2014). Planarian phototactic assay reveals differential behavioral responses based on wavelength. *PLOS ONE*, *9*(12), e114708. https://doi.org/10.1371/journal.pone.0114708

Rilling, M. (1996). The mystery of the vanished citations: James McConnell's forgotten 1960s quest for planarian learning, a biochemical engram, and celebrity. *American Psychologist, 51*(6), 589–598. https://doi.org/10.1037/0003-066X.51.6.589

Thompson, R., & McConnell, J. (1955). Classical conditioning in the planarian, *Dugesia dorotocephala*. *Journal of Comparative and Physiological Psychology, 48*(1), 65–68. https://doi.org/10.1037/h0041147

Tscheulin, T., & Abramson, C. I. (2023). An inexpensive low-cost video monitoring system for automated recording of behavior and ecological interactions. *International Journal of Comparative Psychology*, *36*. http://dx.doi.org/10.46867/ijcp.2023.36.5648

Varnon, C. A., & Abramson, C. I. (2013). The propeller experimental controller: Low cost automation for classroom experiments in learning and behavior. *Comprehensive Psychology*, https://doi.org/10.2466/07.08.IT.2.2

Varnon, C. A. & Abramson, C. I. (2018). The propeller experimental controller: Automation for the comparative analysis of behavior in research and teaching. *The Journal of Mind & Behavior*, *39(*1,2). https://jmb-online.com/vol/volume-39-numbers-1-and-2-winter-and-spring-2018-special-issue.php

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