A NEW DEVICE FOR PROGRAMMING CONTINGENCIES BETWEEN DRINKING, RUNNING, AND LEVER-PRESSING¹

ROBERT W. SCHAEFFER

FLORIDA STATE UNIVERSITY

A rat activity test chamber, which permits arrangement of contingencies between running, drinking, and lever pressing, incorporates (1) a pneumatic system to present and retract drinking tubes and levers, (2) a magnetic particle clutch used to vary to the force requirements of the activity wheel and which serves as the wheel braking system, and (3) a tachometer-generator and photoelectric system to record rate of running.

The test chamber, shown in Fig. 1, is mounted in a standard 72-in. open relay rack. The clear plastic faceplate and sides permit direct observation of the animal's activity. A plastic sliding door in the faceplate provides subject access to the wheel, which is a standard Acme drum assembly (cost, \$43.50), 14 in. in diameter. Insertion and retraction of the bars and the drinking tubes through the apertures in the plastic faceplate are accomplished by a pneumatic system controlled by standard 24 v dc programming equipment described below. All electrical connections required for the recording of drinking, lever pressing, and running behaviors, and for the programming of contingencies between drinking, lever pressing, and running terminate in Nu-Way studs and "six-way" binding posts on the control panel, located just below the test chamber. The control panel, constructed of plastic and 14 gauge aluminum sheet metal, is hinged on one side to provide easy access both to the electrical system and to the adjusting screws which regulate length of travel of the drinking tubes and levers. Graduated 100 ml Kaufman H-28527 plastic cylinders (cost, \$4.20), which provide a measure of fluid volume ingested by

the subject, are mounted on each side of the relay rack. The cylinders are connected to the glass drinking spouts by flexible plastic tubing. A conventional Lehigh Valley Electronics Model 1520 drinkometer circuit senses tongue contacts on the drinking spouts. A speaker, 115 v ac house light, and a Dayton No. 4C004 blower (cost, \$7.40) are mounted on the chamber ceiling. An excreta pan is located on the aluminum floor of the chamber.

Fig. 1. Photographic front view of the test chamber mounted in a standard relay rack.

¹This work was supported by Grant MH-08775 from the United States Public Health Service. The author is indebted to Darrell G. Patterson for technical assistance in the design of this apparatus. Reprints may be obtained from the author, Dept. of Psychology, The Florida State University, Tallahassee, Florida 32306.

Fig. 2. Photographic side view of the test chamber, with slides extended.

Figure 2 shows a side view of the test chamber. The activity wheel assembly is mounted on a pair of Bud SC-4230 chassis slides (cost, \$31.80 per pair). This facilitates cleaning of the interior of the test chamber and the wheel. The small cylindrical objects located directly below the slide are air flow adjusting valves to regulate air volume for the air cylinders which control insertion and retraction speed of the bars and tubes. All electrical connections from the braking and recording section of the wheel assembly (located just behind the wheel, on its centerline) terminate in a male 32-pin Amphenol Blue Ribbon connector. When the slides are closed, the male connector mates with a female connector under the control panel. All weight and stress-bearing structural parts of the test chamber, including the braking and recording section housing, are constructed of 0.5-in. aluminum plate.

A scale drawing of the wheel braking and

recording system as viewed from the top of the chamber is shown in Fig. 3. The activity wheel is attached to a 0.5-in. drill rod by a flange mounting. The drill rod is supported at two points by sealed ball bearings which are press-fitted into the aluminum housing and press-fitted onto the drill rod. The gear which drives the Lear-Sigler Series 900 24 v dc magnetic particle clutch (cost, \$60.00) was brazed onto the drill rod. The torque of this magnetic particle clutch is a linear function of applied voltage and is continuously variable from 0.1 oz/in. to 8.0 lb/in. The upper torque available from the clutch at 24 v dc is sufficient to prevent all wheel movement by even a 400 g rat. As shown in the drawing, the inner shaft of the clutch is held stationary by a locking pin; the clutch body rotates freely on a ball bearing support point. Thus, the braking force of the clutch is transmitted to the aluminum housing when voltage is applied to the clutch.

Fig. 3. Scale drawing of the activity wheel braking and recording systems.

The drill rod shaft also drives a Servo-Tek Model SA-740-B-1 tachometer-generator (cost, \$37.00) which has a linear output of 20.8 v dc per 1000 rpm. In the present application, a gear ratio of 4:1 was selected so that the generator would put out 5 v dc when the activity wheel is moved at a rate of 1 rps, the most typical running rate of the albino rat (Premack and Schaeffer, 1962, 1963). The tachometer-generator provides a direct reading of both momentary rate of running and direction of wheel rotation when the generator output voltage is recorded, without amplification, on the analog head of an Esterline Angus Model A609C Analog-Event recorder (cost, \$627.50). Wheel movement is also recorded by the light control disc and photocell arrangement shown in Fig. 3. The light control disc is attached to the drill rod by set screws and has

four 0.125-in. holes, spaced 90 degrees apart, on the periphery of the disc. With each 90 degrees of wheel rotation, light emanating from the 28 v dc light source is sensed by the Clairex CL-603 photocell (cost, \$3.00) shown recessed in the photocell assembly, then recorded, via a Lehigh Valley Electronic Model 1520 drinkometer circuit, on a digital pen of the Esterline Angus recorder.

The levers and drinking tubes are presented and retracted by the pneumatic system shown in the scale drawing in Fig. 4. The guide channel block and the bracket which support the Parker Hannifin Midget Series "S" air cylinder (cost, \$10.90) are both securely bolted to the aluminum base plate which serves as the chamber floor. The guide channel block was machined from cast iron stock to accommodate the 0.5 by 1.0 by 5.0 in. ground flat stock which

Fig. 4. Scale drawing of the air system used to insert and retract the drinking tube. The same system is used to insert and retract the levers, merely by replacing the drinking tube assembly with a lever assembly.

couples the drinking tube mechanism to the air cylinder piston rod. Initial adjustments of the length of travel of the drinking tube away from its aperture in the plastic faceplate are accomplished by the travel adjustment screw shown in the drawing. Initial adjustment of the length of travel of the drinking tube toward its aperture is accomplished by appropriate positioning of the support bracket upon which the air cylinder is mounted. Additional necessary adjustments of the drinking tube are made by repositioning it in the tube holder. Insertion and retraction of the drinking tube is controlled by the 24 v dc Parker Hannifin Model GG-200-25 Air Control Solenoid Valve (cost, \$22.50) shown in Fig. 4. Each drinking tube and each lever requires a separate system identical to that shown in Fig. 4. Speed of insertion and retraction of the drinking tubes and levers is precisely regulated by Autopoint Pneu-Trol Flow Control Valves (cost, \$3.65). It should be noted that the air cylinders used in this application are 0.75-in. bore, double action cylinders with a 1.0-in. stroke which require air pressure for movement in either direction.

Total cost of the test chamber, including all parts, but exclusive of the electrical and machine work and the Esterline Angus recorder was \$490. Total time required to machine and wire the test chamber was 50 hr. All parts used in the test chamber, with the exception of the Lear-Sigler clutch which may be ordered from Lear-Sigler, Inc., Power Division, Cleveland,

Ohio, are available at commercial electronic, laboratory, and industrial supply houses.

At the time of this writing, the test chamber had been in continuous use for nine months, for more than 8 hr daily. During this period, there has not been a single failure of the clutch, tachometer-generator, or photoelectric systems. One of the air solenoid valves proved to be defective after three months and was replaced. With this one exception, there have been no failures of the pneumatic system. Efficient, reliable operation of the pneumatic system is largely dependent upon a clean, moisture free, lubricated source of compressed air maintained between 60 and 80 psi. Assuming an adequate air supply, a Wabco Model P7201 combination regulator-filter-lubricator (cost, \$31.50) filled with Phillips Unique SAE 20 motor oil will provide adequate cleaning, drying, and lubricating of the air supply. To prevent shorting of the drinkometer circuit, it is essential that the drinking tube aperture in the plastic faceplate be 0.125 in. larger in diameter than the diameter of the drinking tube.

REFERENCES

- Premack, D. and Schaeffer, R. W. Distributional properties of operant-level locomotion in the rat. *J. exp. Anal. Behav.*, 1962, 5, 89-95.
- Premack, D. and Schaeffer, R. W. Some parameters affecting the distributional properties of operant-level running in rats. *J. exp. Anal. Behav.*, 1963, 6, 473-475.