A TECHNIQUE FOR SELF-INJECTION OF DRUGS IN THE STUDY OF REINFORCEMENT¹

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Behavioral observations on experimental animals may be influenced to an undesirable degree by the presence of the investigator, handling or immobilization of the subject, and stimuli associated with pharmacologic treatments. An automatic, self-administration technique which eliminates these influences is desirable for the study of the reinforcing effects of drugs. We have developed an apparatus enabling repeated injections from a distance on a continuing basis in the unrestrained, freely active rat. The apparatus will inject rapidly a predetermined volume of liquid upon the performance of an instrumental response by the experimental subject.

The apparatus is illustrated in Fig. 1, while the lettered components and their functions may be described as follows:

- A. A syringe-pipette (Aupette²) delivers a certain volume of liquid and then refills by spring action for another delivery.
- B. A dual one-way valve (the Hirsch-Adams Automatic Bi-valve²) is attached to A and connected by short lengths of rubber tubing to C and D.
- C. A calibrated glass reservoir holds the injection liquid from which the syringe-pipette refills.
- D. An inexpensive and readily-constructed ground glass swivel allows easy and complete rotation by the rat. This swivel consists of a 2 cc. glass injection syringe with a hollow plunger. Both ends of the plunger are ground off so that there is a continuous passage through the plunger to the delivery orifice of the syringe barrel. The syringe projects through a hole in the top of the

box being supported by the lips at the rear of the barrel. The barrel is free to rotate completely and to yaw slightly on its axis. The plunger does not rotate but is

Fig. 1. Self-injector apparatus. Components are explained in the text.

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²Obtained from Clay-Adams, Inc., New York 10, New York.

held in constant alignment by the rubber tube which connects it to B and by a wire loop attachment which prevents the plunger from being pushed upward out of the barrel. Another attachment limits the barrel to a slight vertical movement.

E. A length of polyethylene tubing (1.14 mm. inside diameter) which leads to the rat through a 6 mm. protective rubber tube is connected to the lower end of the swivel by a hypodermic needle with point removed. From the point of subcutaneous insertion behind the shoulder blades the tubing passes to the flank and through the abdominal wall into the peritoneal cavity. Intraperitoneal injection has proved satisfactory in our experiments. However, intravenous or intra-arterial intubation methods would be adaptable to this situa-

tion, although perhaps more difficult to maintain for long periods of time.

F. A harness consisting of two loops, one of wire which fits snugly around the lower neck just in front of the legs, and the other a metal band which circles the chest behind the legs. Both are enclosed by lengths of soft rubber tubing and attached at their ends to an aluminum plate that rides over the ridge of the back. The metal plate also serves as point of attachment for H.

G. A 15 in. length of spiral metal spring attaches to F and to the base of the needle described under E and fits tightly around the 6 mm. tubing which encloses E. The spring transmits rotary movement of the animal to the swivel. An elastic rubber strip attaches to the swivel and the spring to support the weight of the spring and

Fig. 2. Diagram of control circuit for paired self-injection mechanisms.

"A"—Circuit for slave actuator is not shown, but is a duplicate of executive actuator circuit shown at "B."

C—80 mfd capacitor

K₁ and K₂—115 VAC counters

L.A.—Lear linear actuator

PEN—Polygraph pen actuator

R₁—115 VAC DPDT relay

R₂—115 VAC three pole-DT relay

R₃—10,000 ohm DPDT relay

S₁—5 gm leaf-actuated microswitch (slave manipulator)

S₂—5 gm leaf-actuated microswitch (executive manipulator)

S₃—Microswitch for reversing slave actuator

S₄—Microswitch for reversing executive actuator

S₅ and S₆—internal limit switches in actuator

tubes, thus preventing them from interfering with movements of the subject.

- H. A Lear linear actuator³ (connected to a metal lever) rides on the upper end of the plunger of the syringe-pipette and provides 50 lbs thrust to operate the plunger during injection (1 cc per 1.5 sec).
- I. The housing box serves also as operant conditioning box by addition of J and K, and as stand for the injection equipment. A sheet of glass fitted into tracks serves as both door and observation window.
- J. A sensitive lever mounted on one wall of the box actuates the injection control mechanism.
- K. A discrimination light above the manipulandum is wired to operate briefly during injections.

Control circuitry and recording equipment are described in Fig. 2. A press on the slave manipulandum S_1 merely causes the counter K_1 to record the event. A press on the executive manipulandum S_2 initiates a 3 sec (for 1.0 cc) cycle of injection ($1\frac{1}{2}$ sec) and refilling ($1\frac{1}{2}$ sec). To ensure a complete refilling of the syringe between injections, R_3 makes the executive manipulandum ineffective for about 5 sec as C discharges. K_2 counts injections. Thus, delivery of drug solution is practically *ad libitum* for the executive rat. Extension of

the actuators opens the normally-closed microswitches S_3 and S_4 . Since this reverses the actuators by de-energizing R_1 and R_2 , the physical position of these switches determines the volume of fluid injected. The reversed actuators are stopped by the internal limit switch S_6 and the devices are then re-set for the next cycle.

An effective control procedure for drug reinforcement studies is that of testing a pair of rats as an experimental unit. One serves as the "executive" or "active" member in that its lever responses result in drug injections for both subjects. The other may be termed the "slave" or "passive" member of the pair, as its lever presses are not rewarded with an injection but are merely tallied. Thus, both rats receive the same number of drug injections, but only the former does so as a result of its operant behavior. Usefulness of this procedure is evident in preliminary observations on lever-pressing of pairs of either non-dependent or morphine-dependent rats (receiving 1.0 or 5.0 mg. of morphine per injection, respectively). These suggest that executive subjects develop higher levels of lever-pressing behavior than paired slave rats when such behavior results in morphine administration. Applicability of this apparatus and technique to prolonged studies has been demonstrated by maintenance of rats in a continuing self-injection situation for as long as 50 days.

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