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BRIEF COMMUNICATION

A Simple Method for Studying Intravenous Drug Reinforcement in a Runway

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GEIST, T. D. AND A. ETTENBERG. *A simple method for studying intravenous drug reinforcement in a runway*. PHARMACOL BIOCHEM BEHAV **36**(3) 703–706, 1990.—A simple low-cost swivel-carriage device is described which permits animals to freely traverse a straight alley for intravenous drug reinforcement with virtually no "pulling" force exerted on its cannula implant.

Intravenous drugs   Operant behavior   Runway apparatus   Drug reinforcement

ALLEY running has been long and widely used as an operant behavior in studies of traditional consummatory reinforcers such as food or water. However, while "runway behavior" has on occasion been employed in studies involving intraperitoneal or subcutaneous drug reward (5,6), the use of this operant for investigating intravenous drug reward has been limited by methodological considerations related to the need to deliver drug to the animal over large distances without interfering with the animal's behavior. There are, of course, several possible solutions to this problem. For example, while one could employ chronically implanted remote control catheter pumps as a drug-delivery system, such systems become prohibitively expensive for applications involving large numbers of subjects. Some investigators [e.g., (4)] have employed pulley systems in which a counterweight attached to the PE tubing/lead (which connects to the animal's IV catheter) serves to suspend the tubing away from the animal as it traverses the runway. In our experience, this and similar procedures have proved unsatisfactory due to the shifting directional force exerted by the counterweight on the animal's catheter implant as the rat moves up and down the alley. The rats' repeated accelerations, decelerations and turns produce, over repeated trials, enormous strain at the point where the cannula and animal are connected, a situation that eventually results in a high frequency of drug-flow problems, particularly during long-term experiments. Ideally, one would want a system in which movements on the part of the animal produced little or no "pull" on the animal's implant. Additionally, given that some force is required to suspend the PE tubing away from the animal, the ideal direction of this force would be perpendicularly up from the animal (i.e., the tubing should preferably always be suspended directly above the animal independent of its position in the alley). Such a situation minimizes the strain at the junction between animal and cannula. Suspension of the PE tubing from high above the runway in a pendulous manner could approach this directional ideal, however, there are obvious limitations with this tactic related to the slack or pull on the tubing depending on the location of the animal in the alley relative to the vertex of the pendular angle. We describe here a simple cost-effective device in which the cannula tubing hovers directly above the animal regardless of where the animal is positioned in the runway. In addition, the device permits the subjects to freely traverse the alley in any direction with only minimal force exerted on its lead catheter connection. We have found this device to dramatically reduce the loss of subjects due to the pulling force exerted by the cannula lead as the animal traverses the alleyway. It has, consequently, permitted a more efficient long-term examination of runway operant behavior for IV drug reinforcement [e.g., (2)].

GENERAL DESCRIPTION

A track consisting of two magnetic rails aligned in parallel and a few centimeters apart is positioned directly above the center of the runway (see Fig. 1). Resting freely between the two rails of the track is a swivel assembly one end of which is connected by PE tubing to the rat and the other end to a syringe pump located a few feet away. The length of the lead (from the swivel to the animal) will vary depending upon the height of the track relative to the runway below. The bottom edge of our track is located 53 cm

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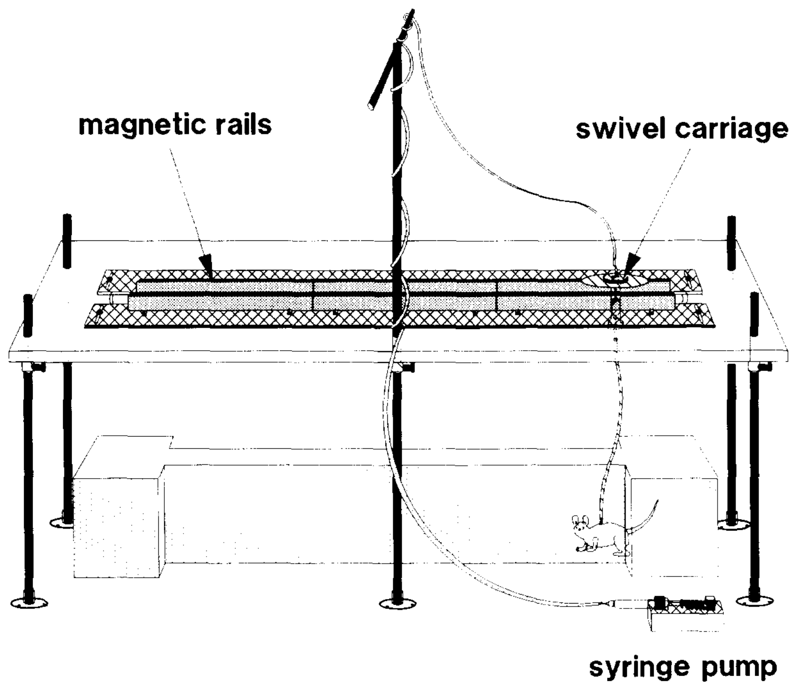

FIG. 1. A schematic conception of the runway apparatus. The magnetic tracks are supported approximately 53 cm above the runway floor with the swivel-carriage device sitting between the two rails of the track. A magnet on the swivel carriage is aligned to repel the "like" poles of the track magnets and hence cause the entire carriage to "float" a few centimeters above the surface of the track.

above the runway floor and our "lead" extends 45 cm from the lower tip of the swivel to the animal. In general, one should construct the system so that the "lead" cannula hangs to within 2–3 cm of the apparatus floor. Note that we presume here the use of a detachable intravenous cannula, i.e., animals are removed from their home cage and connected to the cannula lead for testing [e.g., see (3)]. Our system consists of spring-covered cannula (Plastic Products Co., Roanoke, VA: item No. C313C5) one end of which fits securely over the lower tip of the swivel and the other end of which comes attached to an internal cannula (item No. C313I). For behavioral testing, the internal cannula is screwed into a complimentary guide cannula (item No. C313G) which is affixed to the animal's back. Therefore, the guide cannula is in effect the external portion of an implanted jugular vein catheter.

As the animal traverses the alley, it pulls the swivel assembly along between the two rails of the track. The originality of this design is reflected in the fact that the carriage assembly to which the top of the swivel is attached remains suspended a few centimeters above the tracks. This is accomplished by affixing a disc-shaped pot magnet to the bottom of the carriage (see Figs. 2 and 3) with its magnetic poles appropriately aligned to repel the magnetic charge of the tracks. Thus the entire swivel-carriage assembly appears to float slightly above the tracks. The extremely low friction afforded by the magnetic repulsion between the swivel carriage magnet and the opponent tracks permits the animal to wander through the runway essentially unfettered.

MATERIALS AND ASSEMBLY

The Swivel

While any suitably sized nonmagnetizable flow-through swivel would likely be appropriate, the one which we have used is a slightly modified version of that described by Brown *et al.* (1). The advantage of their model is that it is an extremely lightweight (i.e., plastic) low-cost item that is easily assembled by hand from materials commonly found in the laboratory. The reader is referred to the original source for simple instructions on the assembly of this flow-through swivel, however, one should note that we have made two minor structural changes to Brown *et al.*'s (1) design: 1) the "torque arm" which they describe is unnecessary in our apparatus and has been omitted, and 2) we use a 23-gauge (rather than 22-gauge) needle which we have found to fit more easily into the Plastic Products spring-covered cannula lead. All other aspects of the swivel design are as described by Brown *et al.* (1).

The Magnetic Track

The magnetic track is supported on a stand (see Fig. 1) approximately 53 cm above the center of the alley. While we have employed sufficient lengths to service a 190 cm runway (including start and goal boxes), the actual length can of course be modified to suit individual research needs. The track is made from six magnetic tool holders (available from most common hardware distributors; specific lengths can be made to order from All Magnetics, Placentia, CA; item No. AMC-24). The tool holder magnets are arranged in two long rails each consisting of three magnets in tandem. The two rails are then placed in parallel with a 2.5 cm space between them. It is essential to properly orient the bar magnets relative to each other so that the inside surfaces of the rails (the sides facing each other) have "like" (i.e., repelling) poles (see Fig. 2). Note (Figs. 2 and 3) that the inside of each rail is lined with 3.2-mm thick (⅛ inch) strips of plastic. Each strip is

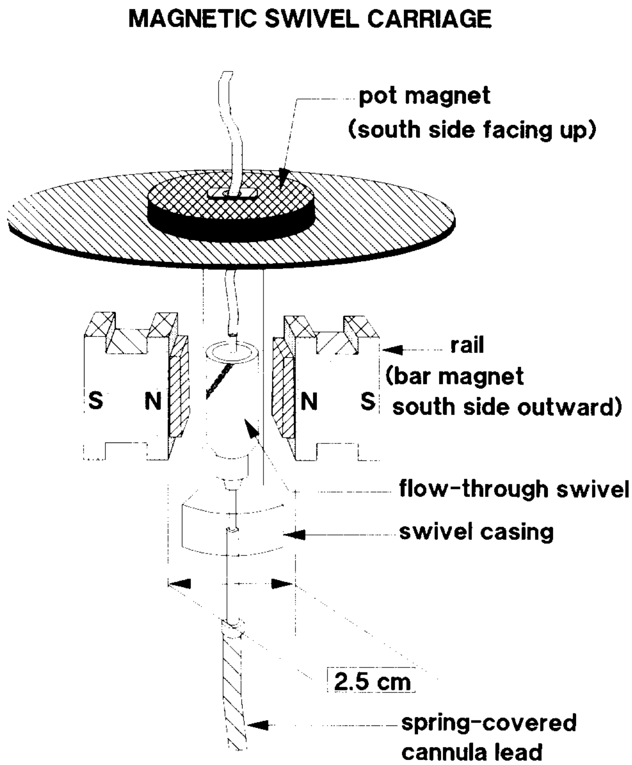

FIG. 2. A cross-section of the track illustrating the position of the swivel-carriage device. The letters "N" and "S" have been used to indicate the opposing poles of the magnets. Note that the inside face of the two rails and the down-face (hidden) side of the pot magnet (on the swivel carriage) must all be of the same polarity.

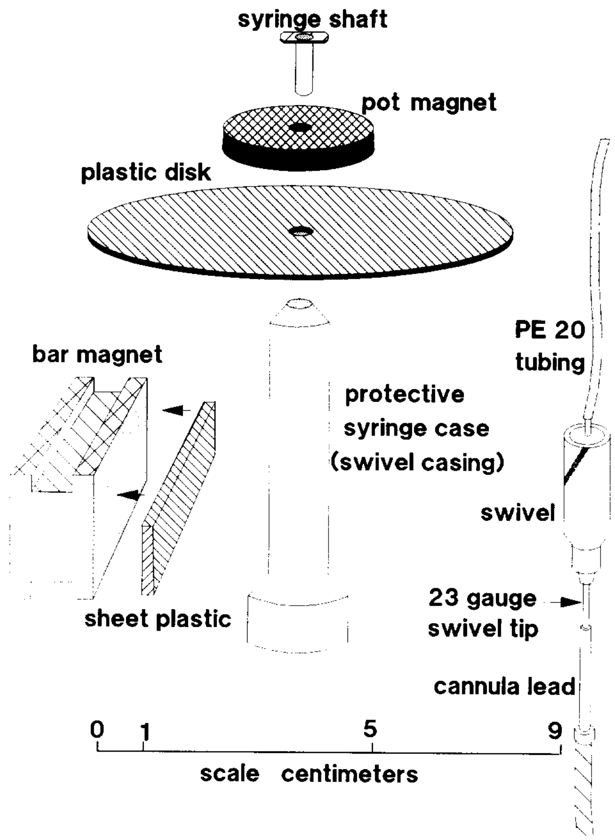

FIG. 3. Exploded view depicting the size and assembly of parts for the swivel-carriage device. The flow-through swivel is constructed of plastic syringe parts and is a modified version of that described by Brown *et al.* (1). Note that when assembled, the swivel resides inside the protective syringe case with the "cannula lead" descending down to the animal and the PE 20 tubing passed through the center of the plastic disk, pot magnet and syringe shaft toward a drug-filled syringe positioned in a Razel pump (see Fig. 1).

2.5 cm wide and is glued in place along the entire length of the track. This serves to limit the lateral tilt of the swivel carriage so as to prevent the pot magnet on the carriage (see Fig. 2) from coming into close proximity, and hence magnetic attraction, to the outer edges of the rails. Finally, a small plastic block fills the space between the two parallel rails at each end of the track thereby preventing the progress of the swivel carriage beyond these points.

The Swivel Carriage

The orientation of the swivel carriage with respect to the magnetic rails is depicted in Fig. 2 and its component parts are drawn to scale in Fig. 3. The swivel carriage consists of five parts: 1) a single plastic Monoject (Division of Sherwood Medical, St. Louis, MO) outer syringe case (this is the protective casing in which Monoject 1 ml syringes are packaged); 2) a 1 ml plastic (Monoject) syringe; 3) a thin 9.5 cm diameter disk constructed from a plastic petri dish the rim of which is removed; 4) a shallow disc-shaped pot magnet of 3 cm diameter (General Hardware Mfg., New York, NY, item No. 376A) with its metal casing removed (a feat easily accomplished after the magnet has been left to sit in an acetone bath for 1 hr); and 5) a flow-through swivel as described above.

The exploded view depicted in Fig. 3 provides a simple guide for the assembly of the swivel components. First, holes equal to the outer diameter of the 1 ml Monoject syringe are drilled into the center of the plastic disc (petri dish), the pot magnet (if a center hole is not already predrilled), and the rigid plastic casing in which the 1 ml Monoject syringe was packaged. Next the plunger in the 1 ml syringe is removed and the syringe shaft is cut and discarded leaving only the top (plunger end) 2.5 cm of the shaft intact. This piece is used to align the holes of the pot magnet, petri dish and syringe casing (see Fig. 3) while gluing them together with Super Glue (or an equivalent fast-drying strong bonding glue). It is important to ensure that the large syringe casing is glued perpendicular to the planes of the petri dish and pot magnet. In addition, the side of the pot magnet which is glued face-down to the plastic disc (petri dish) *must* be the same as that of the inside edges of the two magnetic rails (see Fig. 2). The pot magnet will, therefore, be repelled by the inner "like" poles of the rail and hence cause the entire swivel carriage to float above the track.

It should be noted that the optimal space between the two rails of the track is proportional to the diameter of the disk-shaped pot magnet one chooses for the swivel carriage. As already indicated, we have found a space of 2.5 cm to be optimal given the construction of a swivel carriage with a pot magnet 3 cm in diameter. As the magnet's diameter is increased the space between the two parallel rails must also be increased to reduce the chances that the pot magnet will be attracted to the outer edges (opposite pole) of the railing and thereby impede the movement of the swivel carriage.

The final step in the assembly of the device is to secure the swivel within the protective syringe case (see Fig. 3) with the "cannula lead" descending down to the animal and the PE 20 tubing passed through the center of the plastic disk, pot magnet and syringe shaft toward a drug-filled syringe positioned in a Razel pump (see Fig. 1). The diameter of the swivel is such that with minimal force it can be securely fitted inside the casing without the need for any glue or fixative. Once this step is completed the swivel carriage can be gently placed between the two rail magnets where it will float above the track thereby providing a low-resistance drug delivery system for studying the effects of drug reward on operant runway behavior.

SUMMARY

We have described a swivel carriage device that permits animals to easily traverse a runway for drug reinforcement. The system provides for free movement within the alleyway while producing minimal "pulling" stress on the animal's catheter implant. By constructing a magnetic track and a moving magnetic carriage device whose "pole" is aligned to repel the polarity of the track, the swivel assembly floats above the entire length of the runway and can be pulled down the alley with extremely low friction. While it might appear obvious, it should be noted that the "floating" magnetic carriage concept could easily be adapted for research purposes other than drug self-administration.

ACKNOWLEDGEMENT

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REFERENCES

1. Brown, Z. A.; Amit, A.; Weeks, J. R. Simple flow-thru swivel for infusions into unrestrained animals. Pharmacol. Biochem. Behav. 5:363–365; 1976.
2. Geist, T. D.; Ettenberg, A. Diazepam pretreatment reduces conflict behavior in rats traversing a straight-alley for intravenous cocaine reward. Soc. Neurosci. Abstr. 15(1):254; 1989.
3. James, D. T. D.; Macmanus, D. The effects of post-acquisition-trial sodium amylbarbitone on subsequent extinction behavior. Q. J. Exp. Psychol. 38(B):327–340; 1986.
4. Koob, G. F.; Le, H. T.; Creese, I. D-1 receptor antagonist SCH-23390 increases cocaine self-administration in the rat. Neurosci. Lett. 79: 315–321; 1987.
5. LaCerra, M. M.; Ettenberg, A. A comparison of the rewarding properties of "free" versus "earned" amphetamine. Soc. Neurosci. Abstr. 10:1207; 1984.
6. White, N.; Sklar, L.; Amit, Z. The reinforcing action of morphine and its paradoxical side effect. Psychopharmacologia 52:63–66; 1977.