An olfactory discrimination apparatus: Modification of the basic "wind-tunnel" design[1]

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A modified "wind-tunnel" olfactory discrimination apparatus for rats is described and evaluated. The apparatus, constructed of Teflon, features a precise stimulus delivery system that is easy to build, and a high contiguity of stimulus, manipulandum and reward. Discrimination between odorants to a high performance criterion is obtained within 3 - 6 h of shaping and training.

Situations and apparatus for the behavioral evaluation of olfaction in rats have ranged from choice situations that allow only crude control of relevant stimulation (e.g., Liggett, 1928; Stone, 1941) to the elegant "wind-tunnel" method described by Pfaffman, Goff, & Bare (1958) and by Goff (1961), which, though somewhat cumbersome to construct, allows relatively precise control over stimulation. A modified version of the wind-tunnel apparatus has been designed and evaluated in our laboratory. The present apparatus is constructed almost entirely of Teflon which is very inert chemically, is not detectably odorous, and is easy to machine. This device is designed to provide close contiguity of stimulus, manipulandum, and reward, and utilizes a nose-press response which assures that the rat will be appropriately oriented to an odorant stream while responding.

Testing Chamber

Diagrammed cross-sectionally in Fig. 1, the testing chamber consists basically of a Teflon cylinder the inside of which has been machined in the shape of a funnel. At the large end of the funnel a perforated Teflon disk (the manipulandum) is suspended vertically from the arm of a microswitch (M) which protrudes through a small hole atop the cylinder. A hollow Teflon insert (1 cm diameter), machined to fit snugly into the small end of the funnel, is attached to a source of purified air. Two holes in the barrel of the insert (3 mm diameter) allow injection of odorant vapor into the main air stream through Teflon odorant tubes. Small holes at the proximal end of the insert disperse the odorized air into the funnel and thence to the rat. Reward consists of .1 cc of .05% saccharin solution delivered into a Teflon cup (C) located at the base of the cylinder. This apparatus is mounted in a Plexiglas frame with stainless steel bars for a floor; the back of the cage is perforated and a fan attached thereto exhausts into activated charcoal. A relay (R) located beneath the cylinder is activated when reinforcement is delivered; the sole purpose of this relay is to cue the occurrence of reinforcement. The entire apparatus pictured in Fig. 1 is housed in a refrigerator casement with a speaker for white noise.

Stimulus Delivery

The odorant delivery system is a revised version of the one described by Pfaffman, Goff, & Bare (1958). As diagrammed in Fig. 2, a source of compressed air branches into two separate systems; rate of airflow through each is controlled and balanced by separate needle valves. Air in the upper system passes through a flow meter and purification tube, and connects to the insert shown in Fig. 1. The lower airstream passes through two stopcocks that bridge two flow meters; these stopcocks determine which flow meter will be used to monitor flow rate (note the overlapping ranges). A third stopcock is used to select the purification tube and corresponding odorant bottle (Pyrex gas-washing bottles, coarse dispersion tubes) through which this airstream will be diverted. The final stopcocks (Teflon) control entry of odorant into the test chamber, the odorant is exhausted through the side arms of these stopcocks while flow rate is adjusted. In addition, the side arms are used to allow a saturation equilibrium to be reached before odorized air is diverted into the testing chamber. These latter stopcocks are positioned close to the test chamber in order to minimize delay of odorant delivery when a valve to the chamber is opened. The components of this system are joined by Teflon tubing; joints are sealed with nonadhesive Teflon tape. The cylinders containing the purification chemicals (Pyrex, heavy wall, 1 m

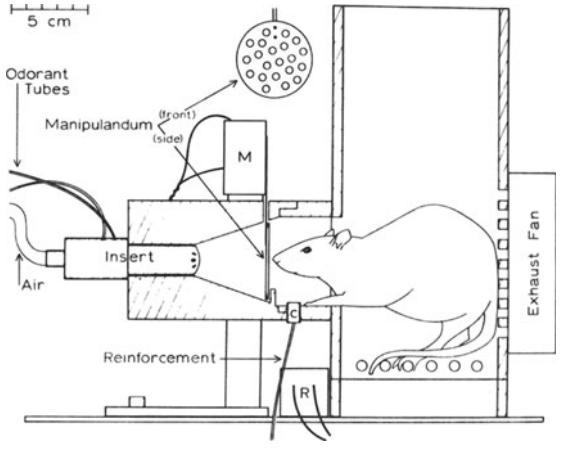

Fig. 1. Testing chamber.

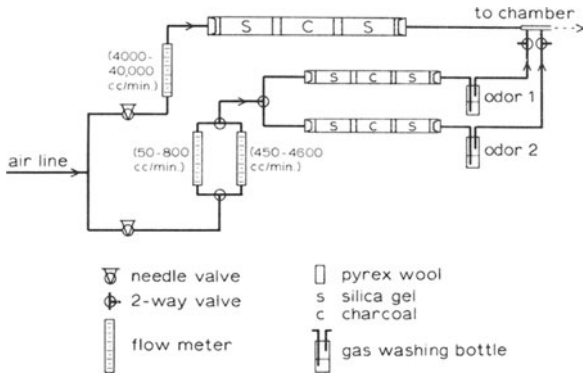

Fig. 2. Stimulus delivery system.

long) are sealed with Teflon plugs that have been machined for that purpose; the plugs are held in place by external aluminum pressure plates (not pictured) bolted to a plywood sheet upon which this delivery system is mounted. The liberal use of Teflon minimizes extraneous odorants, as does placement of control and measuring components *in front of* the purification tubes. In addition, the use of separate purification systems for separate odorants minimizes the possibility of cross contamination. Odorant concentration can be varied substantially through the use of the needle valves and flow meters, and further variation can be achieved by manipulating the dilution ratio of a solvent (water or mineral oil) and an odorant.

Discrimination Training

Training events are programmed and recorded with standard programming equipment with the exception of stimulus delivery, which is controlled by hand.[2] A Davis liquid pump is used for reinforcement delivery, and responses are recorded on an event recorder.

In the confinement of the small testing cage, rats quite readily explore the cylinder and push the response key when first introduced into the apparatus; initial shaping is further facilitated by the relay beneath the water cup which serves as a secondary reinforcer. Following initial shaping, a variable interval reinforcement schedule of 30 sec is utilized for discrimination training.[3] Rats are rewarded on this schedule in the presence of a "positive" odorant (S^D), but not during a "negative" odorant (S^Δ) period. Stimuli are presented for 1-min trials according to a Gellerman series, with an intertrial interval of 20 sec. Since equivalent pressure changes accompany all stimulus changes, pressure variation is not a differential cue. Pairing of suprathreshold concentrations of various alcohols and water soluble odorants as stimuli, we reliably train rats to a highly stable performance level (S^D response frequency: $S^D + S^\Delta$ response frequency > 90%) within 3-6 h of shaping and training. Daily training sessions do not exceed 1 h duration, and within sessions, trained rats average from 50 to 120 responses/min in the presence of S^D; this performance level is maintained even within intentionally nonrewarded S^D intervals (test trials). Rate of stimulus delivery is usually 200 cc/min against a constant background of 14000 cc/min of air.

In addition to its adaptability for measuring olfactory thresholds and for assessing qualitative olfactory discrimination in rodents, this apparatus can be quite readily modified for use in a variety of situations that call for olfactory stimulants. For instance, the reinforcing properties of odorants can be tested (Carr et al, 1966) by making solenoid-controlled puffs of odorant contingent upon manipulation of the response key.

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Notes

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2. Recently, through the use of solenoids, we have completely automated this apparatus for the initial shaping and training phase of our experiments.

3. More detailed information concerning training procedures is available from the authors.