Water drinking and air drinking: Some physiological determinants¹

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Hypertonic saline injections induced more water and air drinking in 10 nondeprived rats than did isotonic saline. In a second experiment, scopolamine hydrochloride suppressed both water and air drinking in nine thirsty rats, in contrast with isotonic saline. In a third experiment, olfactory bulb ablation had no measurable effect upon air drinking in rats.

Air drinking, the licking by rats at a stream of air, is similar to water drinking in several respects. Both responses increase with water deprivation but not with food deprivation, both responses inhibit subsequent water drinking, and both can serve as rewards for instrumental acts (Miller, 1961; Hendry & Rasche, 1961; Williams, Treichler, & Thomas, 1964). However, the responses differ in at least one respect. Treichler & Hamilton (1967) showed that water drinking is reduced while air drinking is maintained if rats are deprived of both food and water.

In an effort to explore further the relationship between air and water drinking, two experiments were performed to determine the effect upon air drinking of manipulations known to influence water drinking. These experiments involved injections of hypertonic saline in nondeprived rats and scopolamine hydrochloride in thirsty rats. A third experiment assayed the role of the olfactory bulbs in air drinking.

EXPERIMENT 1

The injection of hypertonic saline induces more water drinking in nondeprived rats than does isotonic saline (Adolph, Barker, & Hoy, 1954). Experiment 1 was performed to determine whether air drinking is similarly affected, since there is evidence suggesting that thirst induced by normal dehydration and that resulting from hypertonic saline injections may be mediated by different mechanisms (Vance, 1967).

Method

The effect of tonicity of saline injections upon both air and water drinking was observed in 10 male rats of the Long-Evans strain, which were six months old. They were housed individually in an air conditioned room, and they had constant access to Purina Lab Chow. Drinking water was provided as indicated below.

Water drinking. The S's intake of water from a graduated cylinder attached to the home cage was observed during four tests, lasting 70 min each. Immediately prior to each test, S received an intraperitoneal injection of 8 ml NaCl solution. Two of the injections contained 5.85% saline (hypertonic), and two contained 0.8% saline (isotonic). The order of presentation of treatments was counterbalanced, and tests were separated by 72 h. During this phase of the experiment, Ss had constant access to water.

Air drinking. The same 10 Ss were observed to bar press for air in an operant chamber following injections of either hypertonic or isotonic saline. The chamber, measuring 8 x 10 x 12 in., contained the end of a telegraph key and the tip of a drinking tube. The key was situated 0.5 in. above the floor, and the tube was positioned 1 in. above and to the right of the key. By pressing the key, S activated a solenoid-driven air valve and gained access to a 3-sec puff of air through the tube. The air came from a compressor, passed through a CaCl₂ dessicator and a glass tube containing activated charcoal and silica gel, and then entered the drinking tube at about 2 psi.

Rats apparently learn to air drink only if they are thirsty. Therefore, following a one-week accommodation period in which Ss received water in their home cages for 1 h per day, Ss were given 10 daily training sessions in the operant chamber during which they bar pressed for air (CRF) while they were 22-h water deprived. Each session lasted 1 h and was followed by access to water in the home cage for another hour.

For the remainder of the experiment, Ss had constant access to water in their home cages. Beginning three days after training was completed, each S was observed to bar press for air during four daily 1-h tests. Ten minutes before each test, Ss were injected with either hypertonic or isotonic saline, according to the procedure described above.

Results and Discussion

As shown in Table 1, water intake following hypertonic saline injections was significantly greater than that following isotonic saline (Wilcoxon Test, $T = 5$, $N = 10$, $p = .02$). Further, the number of bar presses for air following hypertonic saline injections was significantly greater than that following isotonic saline ($T = 3$, $N = 10$, $p = .01$). These findings suggest a common mechanism underlying both air and water drinking.

EXPERIMENT 2

The intake of water by thirsty rats is suppressed by injection of scopolamine hydrochloride, as compared with isotonic saline (Stein, 1963). Experiment 2 was performed to determine whether air drinking is also affected by this anticholinergic compound.

Method

The effect of injection of scopolamine HCl upon both water and air drinking was observed in nine male rats of the Long-Evans strain, which were 12 months old. Prior to testing, Ss were reduced to 80% of their ad lib weights by restricting their daily water rations. Except as noted below, the experimental conditions were identical to those of Experiment 1.

Each S received four 1-h tests, two involving water drinking and two involving air drinking. Thirty minutes prior to each test, S was injected with either scopolamine HCl (0.4 mg/kg) or isotonic saline in approximately 0.5 ml volume adjusted to body weight. Tests were conducted while Ss were approximately 22 h water deprived.

Results and Discussion

As shown in Table 1, scopolamine HCl injections suppressed significantly both the intake of water ($T = 0$, $N = 9$, $p < .01$) and the number of bar presses for air ($T = 1$, $N = 9$, $p < .01$), as compared with isotonic saline. These findings suggest that both air and water drinking are mediated cholinergically.

EXPERIMENT 3

Thirsty rats may air drink because of the cooling effect resulting from evaporation of saliva (Hendry & Rasche, 1961). Alternatively, the response may be mediated by events in the

Table 1
Water and Air Drinking in Response to Treatments

Treatment	Mean No. Bar Presses for Air	Mean Water Intake (in ml)
Experiment 1 (N = 10)		
Hypertonic Saline	198.2	10.8
Isotonic Saline	32.6	4.6
Experiment 2 (N = 9)		
Scopolamine HCl	607.8	13.1
Isotonic Saline	1292.9	29.2

nasal cavity, perhaps through mechanical stimulation of the chemoreceptors (Adrian, 1951). Experiment 3 was performed to determine the effect of olfactory bulb ablation upon air drinking in thirsty rats.

Method

The Ss were seven male rats of the Long-Evans strain which were six months old. The bar was removed from the operant chamber and the drinking tube provided a constant flow of air. While under 23.5 h water deprivation, S was placed in the chamber for 20 min per day for 12 days and the time spent air drinking was recorded. An S was said to be air drinking if it was making licking movements within 0.5 in. of the tube. Performance over the last five days served as the preoperative baseline.

Following training, four Ss were selected randomly for olfactory bulb ablation and three were sham-operated. For the first three postoperative days, Ss were provided food and water ad lib. Thereafter, they were maintained on a 23.5 h water deprivation schedule, and from the seventh to the eleventh day the time spent air drinking was recorded during daily 20-min tests.

Results and Discussion

For the bulb ablated Ss, the mean time spent air drinking during the five test sessions was 480 sec preoperatively and 680 sec postoperatively. For the sham-operated Ss, the means were 569 sec and 651 sec, respectively. Neither group differed significantly in their pre- vs postoperative performance, nor

did the groups differ significantly from each other. Thus, olfactory bulb ablation had no measurable effect upon air drinking in thirsty rats.

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NOTES

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