Determinants of polydipsia in rats: A reply to Stein. I. Emptying the water bottle[1]

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Abstract

Rats were reinforced with dry food for licking a water nozzle. Emptying the bottle disrupted licking. This does not demonstrate that the drinking was controlled by thirst. It does demonstrate that an operant is controlled by its characteristic feedback.

Problem

Stein (1964) has challenged earlier explanations of excessive drinking by rats on dry-food reinforcement schedules. We welcome his criticisms, and will reply to his arguments.

Falk (1961a,b, 1964b) called the drinking "psychogenic polydipsia," which we take to mean that he thinks it is not explicable solely on a thirst basis. Clark (1962) suggested that the drinking was adventitiously reinforced by arrival of the next food pellet. Segal & Holloway (1963) suggested that drinking may somehow provide a unique discriminative cue for spaced responses on a DRL schedule. Segal & Deadwyler (1964a,b) attempted to distinguish between thirst-motivated drinking, and operant drinking that is reinforced by food. They suggested that drinks following immediately after food are probably thirst-motivated. Segal (1965) revived the possibility that even food-prompted drinking is adventitiously reinforced, arguing from the findings that on a free-reinforcement schedule, (1) fullscale polydipsia takes several days to develop (See also Stein, 1964), and (2) one rat performed a regular sequence of eating-then-drinking-then-bar-pressing between pellets. If the bar pressing was superstitious, why should not the drinking be, too?

Stein's (1964) criticisms of the adventitious reinforcement explanation rest on several observations. (1) Polydipsic rats stopped licking the water-bottle nozzle when water was removed. Stein concluded that the rats drank because they were thirsty. (2) Rats stopped drinking when the reinforcer for bar pressing was changed from dry food to milk. Stein concluded that dry food made rats thirsty, but milk did not. (3) On an FI schedule, rats drank immediately following pellets, not immediately before the next pellet. Stein concluded that the drinking could not have been reinforced adventitiously by the FI schedule, for then the drinking should have resembled the usual scalloped pattern of FI behavior. Stein explained polydipsia as: "rats have a strong tendency to drink after they have finished a meal ... doling out the food ... over a period of hours ... is tantamount to increasing the number of meals and therefore the number of drinking periods ..." (Stein, 1964).

We agree that pellets have a strong tendency to initiate drinking. We do not think that other factors are thereby ruled out, nor do we think Stein's evidence proves his case. On point (2) above, Falk (1964a) found that polydipsia persisted when the reinforcer was a small (but not a large!) amount of a viscous SKF diet. If the diet made the rats thirsty, should not the larger quantity have made them thirstier? On point (3), Segal's (1965) observation of a drinking-bar pressing sequence suggests that drinking might be only the initial, food-prompted member of a linked adventitious chain. Disruption of the chain by eliminating the S^D for the first link would hardly prove that the chain was not adventitiously reinforced.

We will say more on points (2) and (3) later. Now we are concerned with whether abolishing drinking by emptying the water bottle proves that the drinking was controlled solely by thirst. The argument assumes that an operantly-reinforced licking response would not be adversely affected by this procedure. Our experiment tested that assumption.

Method

Three adult, male, albino rats, maintained at 80% of ad lib weight, with free water, were run in a sound-resistant conditioning chamber with a bar, water nozzle, and food cup, all three electrically connected to counters. The rats were being run for another purpose, but inasmuch as one of the operants reinforced was licking, they served as suitable Ss here.

The experimental schedule was a multiple chain. Each chain had three links, and the two chains alternated.

Licking chain: Chain FR 100 (licks) VI 5 sec. (food cup contacts) DRO 30 sec. (licks). In link 1, 100 licks at the water nozzle produced the stimuli for link 2; in link 2, food cup responses produced a 45 mg Noyes peanut pellet on a VI 5 sec. schedule; reinforcement changed the stimuli to those for link 3. Link 3 was a DRO lasting a minimum of 30 sec.; licks during link 3 prolonged it, so that link 3 ended 30 sec. following the last lick. When it ended, the bar-pressing chain began.

Bar-pressing chain: Chain FR 20 (bar presses) VI 5 sec. (food cup contacts) DRL 30 sec. (licks). In link 1, 20 bar presses produced the stimuli for link 2; in link 2, food cup responses produced a food pellet on VI 5 sec.; arrival of food changed the stimuli to those for link 3—the DRO. The end of link 3 initiated the licking chain.

The first two links of the chains were marked by four different combinations of steady or flickering lights and steady or pulsating white noise; all DRO's were in silence and darkness. The Ss had been on the schedule for several months, and were under good stimulus control. Sessions lasted for 50 pellets.

The experiment consisted of a control day, identical with the normal schedule; eight experimental days during which the water bottle was empty; and another control day, with water replaced.

Results

Figure 1 shows the performance of one of the Ss. (Results for the other two were similar.) The recorder recorded only the FR behavior (licks or bar presses) in the first link of the chains.

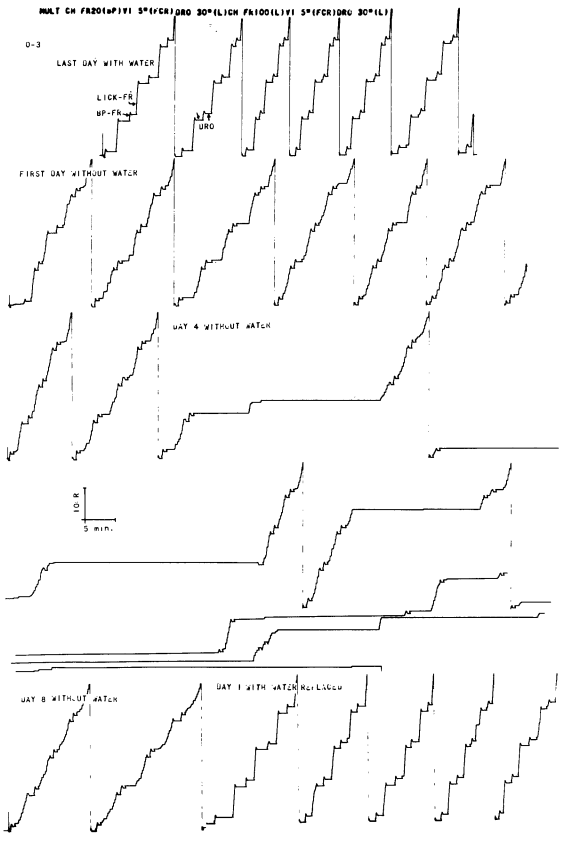

Fig. 1. Cumulative records of FR responding in the lick and bar pressing chains, rat 0-3. The recorder motor stopped during links 2 and 3.

The first control session shows typical performances on the multiple chain. Both FRs were run off with little initial pausing. The first effect of emptying the water bottle was a small lengthening of the pauses that preceded licking FRs, a coarsening of the grain of licking FRs, and a lengthening of the session. All in all, the effect was small. By the fourth day without water, the effect had increased. Long pauses preceded coarse-grained licking FRs and even some of the bar-press FRs. By the eighth no-water day (only the initial portion of which is shown) performance was about where it was on the first no-water day. The second control session showed almost complete recovery of normal performance.

Discussion

The data indicate that licking that is controlled by food reinforcement, and presumably little affected by thirst, is disrupted by altering the stimulus consequences of the behavior. Licking at a dry water-bottle nozzle is not the same operant as licking at a wet water-bottle nozzle. The assumption underlying Stein's (1964) point (1) is untenable.

In Stein's (1964) experiment, emptying the water bottle totally abolished licking. In ours, it did not. The difference is predictable, inasmuch as our rats had to lick to get food and to get on to the bar-press chain. Our data suggest that nozzle-licking first underwent extinction, brought about by depriving the response of its normal (wet) stimulus feedback, and then a period of differentiation, during which a new nozzle-licking operant, with different (dry) feedback, gradually developed.

We believe that the determinants of psychogenic polydipsia are multiple, and probably include, at the least, (1) thirst, (2) adventitious reinforcement, (3) timing cues, (4) whiling away the time between spaced bar presses or reinforcements, and (5) emotional "pacification," perhaps akin to compulsive eating and drinking in humans—engaging in some consummatory behavior, albeit irrelevant to the rat's current deprivation, may make it easier for the rat to wait for the next food delivery. It is unnecessary to argue, and unlikely, that thirst plays no role in polydipsia, or that all the factors we have mentioned contribute equally to psychogenic polydipsia in all circumstances. The problem is to discover which factors determine polydipsia in which circumstances.

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Note

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