Should taste-aversion learning experiments control duration or volume of drinking on the training day?

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It has been reported that increases in volume drunk of a solution, prior to poisoning, lead to greater learned aversions. However, this effect may be due totally or partially to differences in time spent drinking rather than to amount drunk. When duration of drinking is held constant, rats differ spontaneously in how much of a solution they drink. In 29 experimental groups, varying in procedural details, the correlation between amount drunk on the training day and percent preference for the solution on the test day (the opposite of aversion) was positive in 16 cases, negative in 13, and usually low. Regardless of whether volume drunk affects taste-aversion learning under some conditions, evidently it is sufficient to control duration of drinking rather than volume, since the spontaneously occurring variations in volume have only slight, if any, effects on the individual differences in learned aversion.

When an animal is poisoned after drinking a solution, it acquires an aversion to that solution (see review by Rozin & Kalat, 1971). Recently Bond and DeGiusto (1975), Bond and Harland (1975) and Barker (in press) have reported that rats drinking larger volumes prior to equal doses of poison learn greater aversions than rats drinking smaller volumes. This result is surprising, considering the apparent difficulty rats have in monitoring and calibrating their nutrient intake in other situations (LeMagnen, 1971; LeMagnen & Tallon, 1966; Snowden, 1969; Young, Gibbs, Antin, Holt, & Smith, 1974).

The finding of a correlation between volume drunk and learned aversion has potentially important implications for methodology in future experiments on taste-aversion learning. Typically, experimenters have presented solutions for a fixed period of time, regardless of volume drunk, on the training day. Since rats spontaneously vary in the volumes they drink in a fixed period, one may be introducing substantial variation by controlling duration rather than volume.

However, it is not clear whether the demonstrations that volume drunk affects taste-aversion learning actually depended on volume drunk or duration of drinking. In all three experiments, the experimenters manipulated how much each rat drank simply by presenting different amounts of solution, leaving the solution until the rat had drunk it all. Thus, rats which drank larger volumes of the solution also spent longer times drinking it. It is possible that increased duration of exposure increases the associability of the taste independently of the volume drunk, as in fact the data of Domjan (1972) strongly suggest. (Barker, in press, did not commit himself on whether his results were due primarily to differences in volume or duration of presentation.) If so, it remains to be determined whether or not differences in volume per se have any effect on taste-aversion learning. Smith and Morris (1963) manip-

ulated volume drunk independently of drinking duration by varying thirst levels; under these conditions they found no differences in learned aversion between rats drinking 4.6 or 9.2 g of a saccharin solution. However, one hesitates to draw a conclusion from a single negative result.

Since rats spontaneously differ in how much of a solution they consume in a limited period of time, it is possible to look for a correlation between amount of CS drunk and the individual's later preference for the test solution. The results of Bond and DiGiusto, Bond and Harland, and Barker suggest that this correlation should be negative.

In order to measure the correlation in question, I have reexamined old data which I have collected with regard to taste-aversion learning. In a variety of experiments not designed with the present issues in mind, I have presented a solution for a brief, limited period of time, with a set delay between the solution and poison. Upon removing the solution I recorded the amount each rat drank (± 0.5 ml). In reexamining the data, I have correlated the spontaneous variations among rats in volume drunk on the training day with their preference for the solution on the test day.

METHOD

Subjects were several hundred rats, some albino but mostly pigmented, bred in the author's laboratory and kept in individual wire mesh cages. All had ad lib access to Purina Lab Chow at all times. The rats were used in a variety of studies, the details of which are of no concern for present purposes. The elements of procedure common to all were as follows: Rats in each group were offered a solution (not necessarily novel) for a limited period of time, under conditions in which nearly all rats spent the entire presentation period at the drinking tube. At the end of the presentation period, the drinking tubes were removed and the volume drunk was recorded. After a set delay period (varying among the groups) each rat was removed from its cage and intubated with a poison in proportion to its body weight, typically 1 ml 0.15M LiCl per 30 g. Control groups were treated similarly except that the delay between drinking and poisoning was 24 h. After one or more days of recovery, during which the rats received only water, for either 1 or 2 h per day, each rat was offered the test solution and water. In most experiments

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Table 1
Correlations Between Volumes Drunk on Training Day and Percentage Consumption
of Test Solution on Test Day: Experimental Groups

Group	Solution	N	Training Day		Test Day		Correlation
			Volume (ml)	SD	Percentage Consumption	SD	
1	Suc 2½'	7	3.0	1.0	1.6	2.5	-.466
2	CH 2½'	11	4.0	1.8	3.7	4.1	+.127
3	CH 2½'	11	2.7	1.2	4.5	10.9	+.182
4	CH 2½'	7	1.6	.6	5.4	4.0	+.373
5	Suc 2½'	6	3.6	1.2	5.6	9.5	+.462
6	NaCl 2½'	10	4.8	1.5	7.2	10.2	-.401
7	NaCl 2½'	11	7.2	.9	8.2	7.3	-.403
8	Sacch 5'	10	6.3	2.8	9.5	18.0	+.522
9	CH 2½'	10	4.1	1.7	13.1	17.2	-.597
10	NaCl 2½'	10	6.0	2.2	13.1	8.6	-.211
11	Suc 2½'	7	4.2	.7	14.8	15.9	+.474
12	Sacch 5'	10	7.0	2.2	15.1	21.3	-.290
13	QS 2½'	11	2.0	.5	15.2	11.5	-.014
14	QS 10'	7	1.6	.9	17.1	10.5	+.795*
15	NaCl 2½'	10	5.4	1.3	22.9	12.3	+.033
16	QS 2½'	9	2.4	1.2	23.8	9.7	-.113
17	Suc 2½'	8	3.8	.9	24.4	12.5	+.171
18	QS 2½'	10	1.5	.5	27.6	21.8	+.470
19	QS 2½'	10	2.2	.9	32.4	19.9	+.486
20	Sacch 5'	11	6.0	2.1	37.0	11.2	+.403
21	CH 5'	9	3.2	2.5	37.5	23.0	-.020
22	Sacch 5'	10	6.0	1.4	37.7	27.0	+.119
23	QS 2½'	11	1.8	.7	39.3	13.5	-.535
24	CH 5'	9	1.9	.9	40.5	20.5	-.255
25	CH 2½'	11	4.0	.8	41.1	19.9	-.268
26	Sacch 5'	11	6.3	2.2	41.2	26.7	-.077
27	CH 5'	9	2.3	1.4	44.9	19.4	+.542
28	QS 2½'	11	1.4	.5	51.3	15.4	+.679*
29	Sacch 5'	10	6.4	1.7	53.2	14.9	+.665*

Note. Suc = 10% sucrose, CH = 5% casein hydrolysate, NaCl = .15M NaCl, Sacch = .2% Na saccharin, and QS = .0033% quinine sulfate.

* $p < .05$

the test solution and water were available simultaneously for 30 or 60 min; in a few experiments the test solution was presented alone for 1 h, then water alone for 1 h. The percent consumption of the test solution was determined for each subject.

For each group, a product-moment correlation was calculated between volume drunk on the training day and percent consumption of that solution on the test day. Excluded from consideration were all groups which received more than one solution, or more than one presentation of a single solution on the training day; also all groups in which the poison dosage was not determined on the basis of percent of body weight; also all groups subjected to physiological or pharmacological manipulations. All the remaining groups showed a mean percent consumption of the test solution that was lower than that of the control group, though not always significantly lower. Individual rats were excluded if they drank 0 ml on the training day or if they drank 0 ml of both the test solution and water on the test day.

RESULTS AND DISCUSSION

Tables 1 and 2 present the data for 29 experimental and 10 control groups. The groups are arranged in order according to their mean percent consumption of the test solution on the test day.

Of the 29 experimental groups, the correlation between volume drunk on the training day and percent

consumption on the test day was positive in 16 cases and negative in 13. The median correlation was +.119; the mean was +.098. Three correlations, all positive, were significant ($p < .05$); one would expect about one or two "significant" correlations by accident for 29 groups (or 39, if one includes controls).

Although there is little overall trend in the data, it is entirely possible that certain conditions would be more favorable than others for demonstrating a significant correlation. For instance, the correlations might be weak when all aversions were strong, since there would be a "floor" effect. However, the correlations are about equally divided between positive and negative for groups with low percent consumption on the test day, as well as for groups with high percent consumptions. One might expect more meaningful correlations in groups which drank large volumes on the training day, relative to the error of measurement (0.5 ml). However, groups which drank 5.0 ml or more had a mean correlation of +.085; those which drank lower mean volumes had a mean correlation of +.105. Similarly, one might expect more meaningful correlations when the standard deviation was large relative to the error of measurement. However, the 10 groups with relatively large standard

Table 2
Correlations Between Volumes Drunk on Training Day and Percentage Consumption
of Test Solution on Test Day: Control Groups

Group	Solution	N	Training Day		Test Day		Correlation
			Volume (ml)	SD	Percentage Consumption	SD	
1	NaCl 2½'	11	5.6	.9	35.8	20.8	-.111
2	NaCl 2½'	11	6.0	.7	42.7	12.2	-.093
3	CH 2½'	11	1.6	1.0	53.7	21.3	+.052
4	Suc 1½'	6	4.5	2.2	57.6	19.3	-.311
5	CH 5'	9	1.8	.5	70.2	6.7	-.202
6	QS 2½'	11	1.5	.7	71.8	10.3	+.285
7	CH 2½'	10	3.6	1.5	73.1	14.4	+.166
8	Sacch 5'	11	6.0	2.1	88.5	9.7	-.445
9	Sacch 5'	11	6.2	2.4	89.5	15.2	+.380
10	Sacch 5'	11	7.4	2.0	95.9	8.8	+.150

Note. Suc = 10% sucrose, CH = 5% casein hydrolysate, NaCl = .15M NaCl, Sacch = .2% Na saccharin, and QS = .0033% quinine sulfate.

deviations (≥ 1.5 ml) on the training day had a mean correlation of only +.012, as compared to a mean correlation of +.144 for the remaining groups.

The mean correlation also remains low if we restrict our attention to groups with $n = 10$ or more (+.047) or to groups with $n \geq 10$ and a mean volume drunk on the training day greater than 5 ml (+.085) or less than 5 ml (+.013). The mean correlations for particular solutions were: sucrose, +.160; casein hydrolysate, +.011; NaCl, -.246; saccharin, +.224; and quinine sulfate, +.253.

Even if there were a large effect of volume drunk upon learned aversions, there are many reasons why this effect might not be clear within a particular individual group, particularly with small n . However, if there were such an effect, large enough to take seriously, there should be some pattern in the within-group correlations. That is, suppose there were a strong correlation observed in a group of 300 or so rats. If one randomly divided that group into a number of smaller groups, about 10 rats each, and computed the correlation within each group, not all of the groups would have significant correlations, and some might even have correlations in the opposite direction. However, one would not expect the pattern seen in Table 1: a nearly random distribution of correlations around a mean near zero. (In fact, the mean is slightly positive, opposite to the direction reported by Barker, Bond and DiGiusto, and Bond and Harland.)

There are some difficulties inherent in testing whether or not volume drunk is an important variable in food-aversion learning; primarily, that volume drunk does not vary over a wide range when duration is held constant. However, even if we presume that volume drunk does affect food-aversion learning under some conditions (direction of effect uncertain), one method-

ologically important conclusion remains: under conditions of brief exposure to a solution (2-5 min), rats do not spontaneously vary in volume drunk to a sufficient extent that these variations become a major factor in determining the magnitude of the learned aversions.

In short, it is methodologically satisfactory (possibly preferable) to control duration of drinking rather than volume in experiments on food-aversion learning.

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