Instrumental and contingent saccharin-licking in rats: Response deprivation and reinforcement*

JAMES ALLISON and WILLIAM TIMBERLAKE
Indiana University, Bloomington, Ind. 47401

It has been suggested that an instrumental response will increase above its baseline if and only if the contingency schedule deprives the S of the contingent response. Several experiments are reported in support of this contention. The principal finding was that instrumental licking of a .4% saccharin solution was increased above its baseline by the contingent

opportunity to lick a less preferred saccharin solution if
the contingency schedule satisfied the response
depprivation condition, but not otherwise.

Most reinforcement theories would agree that among
thirsty rats, water-licking should reinforce instrumental
wheel-running. It is a readily elicited consummatory
response (Sheffield, 1966) in the approach category
(Glickman & Schiff, 1967) which ought to reduce drive
(Hull, 1943) and strong thirst stimuli (Miller, 1951), and
prevent counterconditioning (Guthrie, 1935). It has a
higher operant probability than running (Premack, 1959,
1962). The rat seems sufficiently prepared (Seligman,
1970) to learn an association between running and
water-licking, because contingent water-licking has often
been found to increase instrumental running (Premack,
1962). Nevertheless, Premack (1965) reported that
running does not increase if the contingency schedule
does not deprive the S of the contingent water-licking
response.

In this particular context, response deprivation is
defined in terms of the total amount of running (O₁) and
the total amount of licking (O₂) performed during an
operant baseline session in which the rat has free access
to the running wheel and the drinking tube. In the
contingency session, which is otherwise identical to the
baseline session, the rat must run for access to the tube,
and the parameters of the contingency schedule determine
how much licking can be obtained for a particular amount of running. The contingency schedule
is said to deprive the rat of licking when the following is
ture: if the rat performs only the baseline amount, O₁, of
the instrumental running response, it will necessarily
perform less than the baseline amount, O₂, of the
contingent licking response.

For example, consider a fixed-ratio schedule which
requires I units (commensurable with O₁) of running for
access to C units (commensurable with O₂) of licking.
Suppose that I is less than O₁ and C is less than O₂. The
contingency schedule deprives the rat of the contingent
response if (I/C) > (O₁/O₂). Each time the rat performs I
and then C, it performs a greater proportion of O₁ than
of O₂. It follows that if the rat performs only O₁ of the
instrumental running response, it will necessarily
perform less than O₂ of the contingent licking response.
To approach O₂ more closely, the rat must perform
more than the baseline amount of running. The
contingency schedule does not deprive the rat of the
contingent licking response if (I/C) ≤ (O₁/O₂), because
the rat can then approach O₂ without performing more
than the baseline amount of running.

When Premack (1965) first called attention to the
response deprivation condition, he suggested that
response deprivation was necessary for an increase in
instrumental responding. Eisenberger, Karpman, &
Trattner (1967) attributed even more importance to the
response deprivation condition by suggesting that it was
not merely necessary, but sufficient. One of the most
striking implications of their position is that a
contingency schedule which satisfies the response
depprivation condition will increase instrumental
responding even if the contingent response has a lower
operant probability than the instrumental response.
Eisenberger et al (1967) reported a confirmation of this
implication in a series of experiments on manipulatory
behavior in humans. Because of its theoretical
importance, we attempted to determine whether their
finding could be generalized to consummatory behavior
in rats.

All of the experiments reported here employed adult
male albino rats, experimentally naive, given continuous
access to food and water in the home cage. The test
chamber was a standard operant conditioning box. Metal
licking tubes were accessible through two holes drilled in
a side wall, and access to each tube was controlled
automatically by means of a motor-driven shutter,
attached to the outside wall of the box. Licking was
monitored by solid-state drinkometer circuits grounded
to the grid floor. All baseline and contingency sessions
were 10 min long. In some experiments, we recorded the
number of licks, and in others, the time spent licking at
each tube. Time was cumulated by 1-sec clocks, which
started with the beginning of each burst of licks and
stopped at the end of each burst. The end of a burst was
defined as an interlick interval greater than 250 msec

In the first experiment, one tube contained .4% saccharin solution, and the other, .3% saccharin solution.
The rats first received 18 baseline sessions, one per day,
with both tubes freely available. The baselines, defined
in terms of the mean of the last two sessions, showed
that each of the 11 rats spent more time licking the .4%
tube than the .3% tube. The group means were 269.9
and 39.5 sec, respectively. This baseline phase was
followed by seven contingency sessions with .4% licking
as the instrumental response and .3% licking as the
contingent response. Each time the rat licked the .4%
tube for a total of 80 sec, the .4% hole was closed and
the .3% hole opened simultaneously for 10 sec
(I = 80 sec, C = 10 sec). At the end of each 10-sec access
period, the .3% hole was closed and the .4% hole
reopened. This contingency schedule deprived the S of
.3% licking, as (80/10) > (269.9/39.5). If the average S
were to approach 39.5 sec of .3% licking, it would have
to lick the .4% tube for considerably more than
269.9 sec.

Instrumental .4% licking showed a significant increase
across the seven contingency sessions (F = 2.43,
df = 6/60, p < .05). The value obtained in the final
session, 322.4 sec, was significantly higher than the
baseline value of 269.9 sec (t = 2.94, df = 10, p < .02; all
t tests reported here are two-tailed). Time spent licking
the .3% tube also increased across sessions (F = 3.74,
df = 6/60, p < .01). After the contingency phase,
baselines were remeasured in another session with both
tubes freely available. There was no significant difference between pre- and postcontingency baselines (t < 1). The data are summarized in Table 1.

A second experiment with eight rats obtained similar results, using 4% saccharin licking as the instrumental response and 1% saccharin licking as the contingent response. This experiment used reciprocal contingency schedules (Allison, 1971), in which the S must perform I units of the instrumental response for access to the contingent response, and must then perform C units of the contingent response to regain access to the instrumental response. The baselines were 851 licks at the 4% tube and 613 licks at the 1% tube (t = 2.54, df = 7, p < .05). Each rat was tested with four contingency schedules in a Latin square design, four sessions per schedule. One schedule required that the rat make 100 licks at the 4% tube for access to the 1% tube and 10 licks at the 1% tube for regained access to the 4% tube (I/C = 100/10). The other three schedules employed the same I/C ratio as the schedule just mentioned, but differing values of I and C: 200/20, 300/30, and 400/40. Each schedule deprived each S of .1% licking. These identical I/C ratios produced statistically identical amounts of .4% licking (F < 1) and .1% licking (F < 1). The mean number of .4% licks, calculated across the four schedules, was 1,069—significantly more than the baseline value of 851 (t = 2.48, df = 7, p < .05). The results are summarized in Table 2.

A third experiment discounted the possibility that .4% licking increased not because of its role as an instrumental response, but because it had direct substitute value for the less preferred response. When both tubes were freely available, eight rats spent 273.2 sec licking the .4% tube and 2.3 sec licking the .1% tube. If .4% licking has substitute value for .1% licking, then .4% licking should increase if the .1% tube is withdrawn. In fact, the rats spent only 273.3 sec licking the .4% tube in baseline sessions which offered free access to .4% saccharin but no access to .1% saccharin (t < 1).

The same eight rats were used in a follow-up experiment to determine whether .4% licking would increase if the schedule did not deprive the rats of .1% licking. The reciprocal contingency schedule involved 50 sec of .4% licking and 4 sec of .1% licking. It did not deprive the Ss of .1% licking, as (50/4) < (273.2/2.3), and it did not increase .4% licking. The time spent licking the .4% tube, averaged across eight homogeneous training sessions, was only 211.4 sec—significantly less than the baseline value of 273.2 sec (t = 2.98, df = 7, p < .05).

These experiments support the conclusion that an instrumental response will increase above its baseline if and only if the contingency schedule deprives the S of the contingent response. The increase occurs even if the contingent response has a lower commensurable baseline than the instrumental response.

REFERENCES


(Received for publication June 18, 1973.)