DEVELOPMENT AND CONTROL OF LICKING BEHAVIOR
IN THE GUINEA PIG (CAVIA PORCELLUS)

by

Jack R. Alvord

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Jack R. Alvord
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ABSTRACT
Development and Control of Licking Behavior
in the Guinea Pig (*Cavia Porcellus*)

by

Jack R. Alvord, Master of Science

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Major Professor: Dr. Marvin F. Daley
Department: Psychology

Four non-licking guinea pigs were reinforced with water for successive approximations to licking an operandum feeder. Once all subjects had obtained their total liquid intake for a three-week period by licking, an optimum deprivation schedule was determined.

Fixed ratio and variable interval schedules were found to affect licking behavior of the guinea pig in a similar way as with the rat, mean lick rate of guinea pigs being slightly lower than that of the rat. Precise control over the onset and offset of licking was demonstrated through discrimination training.

(53 pages)
INTRODUCTION

The licking response has been widely used by psychologists concerned with consummatory behavior (Williams and Teitelbaum, 1956), taste preferences (Fisher, 1965; Burright and Dappaul, 1963), motivation (Davenport and Goulet, 1964), time mediation (Hodos, Ross, and Brady, 1962), theoretical hypothesis testing (Premack, 1962, 1963), and numerous biological and physiological processes. Most of these studies used the rat.

However, the investigation of licking behavior has been extended to cats, rabbits, hamsters (Schaeffer and Huff, 1965), infant albino rats (Schaeffer and Premack, 1963), and monkeys (Schaeffer and Collier, 1965).

In their efforts to accurately and reliably measure drinking behavior, Hill and Steller (1951) developed an electronic drinkometer. Each tongue lick making contact with a drinking tube resulted in the closure of a relay contact. Since licking is a consummatory response in rats and some other subhuman species, whatever liquid is picked up on the tongue is ingested. A count of relay closures indicates the number of licks emitted; and by multiplying the size of the drop on the tube by the number of drops delivered, one can calculate the amount drunk. A precision liquid feeding system (Hulse, 1960), which increases the accuracy of measurement of the water licked, has allowed investigators to extend the analysis of licking behavior. Hulse's system includes a motorized, graduated syringe which automatically forces out a precisely sized drop with each response.
Due to increased use of and interest in guinea pigs (GP) for behavior research, it is desirable to draw empirical parallels to the behavior of other more often used research animals such as the rat (Rattus norvegus). Such factual data is required in order to access the degree of allowable inter-species generality.

A number of reasons exist for using the GP in research concerned with the consumption of liquids: (a) biologically, the GP, like the rabbit, drinks excessively and, on the third day of a fast will drink as much as 650 per cent more than normal. A GP will also die of polydipsia (Cizak, 1954). With such a high water intake, one would have a nearly insatiable response to work with; (b) a second reason for investigating liquid consumption would be that of inter-species generality, etc.; (c) once the means for establishing licking as a controllable response have been developed, we would be adding to the GP's total behavioral repertoire. Thus, behavioral research could be conducted utilizing multiple responses and allowing for precise measurement of consummatory behavior in the GP.

A probable reason that GPs have not been used in any investigation of licking is that GPs simply do not lick. They manage to obtain their liquid needs by eating the succulent leaves found in their natural tropical settings. In the laboratory, the GP is fed dry food and is supplied with a tube, which rats lick—but the GP merely puts it into his mouth and lets the water run through.

The purpose of this research was to acquire experimental control over licking behavior in the GP and to relate it to that of the rat. Once the behavior was established, the effects of various reinforcement
schedules were observed and compared. In order to establish water as a suitable reinforcer, deprivation variables were also investigated.
Licking

Although the behavior of licking appears to be a relatively simple instance in an organism's total behavior repertoire, the variables concerning the onset, rate, duration, and patterns of licking are now known to be quite complex. Total fluid intake is thus a function of conditions endogenous and exogenous to the organism (Wagner, 1964).

Schaeffer and Huff (1966) reviewed some of the literature and concluded that lick rate does not vary with age, sex, weight, fluid, or amount of deprivation. They put forth the hypothesis that the mean lick rate is genetically determined and that each species may exhibit its own characteristic lick rate. Hulse (1966, p. 33) stated that "the number of tongue licks elicited in rats by a single drop of water . . . is a function of the volume of the drop." He saw consummatory licking in rats as reflexive, with the volume of fluid touching the tongue representing an intensity parameter of the eliciting stimulus. His data indicated that licking is respondent in part and may be initiated with each successive drop.

In addition, Hulse (1960, p. 363) showed that the taste of a drop is also important. His rats licked at a higher mean rate for more volume and more concentration of sucrose solution "... as if the effectiveness of the reinforcement was increased." The higher mean rates, however, hold only to the point where a sufficiently large mean volume or a sufficiently high concentration results in a reduced rate of lever pressing or tongue licking. The average rate of licking is
not affected either by total volume or by total licks per second, and running behavior does not vary with variations in volume of the reinforcer (or reinforcing stimulus) or in number of licks required (Snyder and Hulse, 1961).

Hulse (1966, p. 34) added to the concept of licking as an elicited reflex. He further recognized the limits of this "reflex" in the total sequence of events which constitutes the rat's drinking behavior; for instance, "the approach to the drinking tube and the initial touch of the tube with the tongue clearly fall into the realm of emitted behavior."

In 1966, Patten classically conditioned and extinguished licking in rats by using a 500 cps tone (conditioned stimulus) and a light from a partially darkened 15 watt bulb. He found a rapid extinction curve and absence of spontaneous recovery.

Operant conditioning techniques have been used successfully to control licking behavior. Williams and Teitelbaum (1956), using operant conditioning techniques, were able to make rats drink large amounts of fluid to avoid a noxious shock contingent upon non-drinking.

When licking is treated as a free operant, rates of responding decrease dramatically as ratios of reinforcement increase (Hulse and Bacon, 1962; Hulse, Snyder, and Bacon, 1960). The mean amount of reinforcement becomes smaller as ratios of reinforcement increase; therefore, for most free operants, rate of response increases as mean amount of reinforcement decreases. For licking, the converse is true (Hulse and Firestone, 1964). The literature suggests that the tongue lick has many of the properties of a fairly low-order reflex (Steller and Hill, 1952). Thus, perhaps, the function of the reinforcing stimulus
in free operant licking is to elicit tongue licks as much as it is to reinforce tongue licks after they are emitted.

Hellwig (1966, p. 5558) found support for the hypothesis that there is a "... non-monotonic relation between amount of reward per lick and its reinforcing capacity." To vary the amount of reward, he used three tubes of different sizes--2, 4, and 6 mm each--which delivered different size drops of a .5 per cent saccharin solution. There appeared to be homeostatic regulation of drinking with small non-significant differences among groups for volume and significant differences for licking. When the 4 and 6 mm tubes were paired, more licks were elicited by the 4 mm tubes, providing some evidence to support the hypothesis.

J. D. Davis and J. D. Keehn (1959) reported a rat's licking rate to be higher at the beginning of a session than at the end of the same session. Davis also stated, contrary to Hellwig, that he found licking rates to be unrelated to changes in the size of the drop licked. Their animals licked between five and six licks per second.

Keehn and Arnold (1960) reported lick rates slightly higher than those of the Davis study. They attributed this increase to the use of a 4 mm, rather than a 3 mm tube aperture. Contrary to findings reported by Hellwig (1966) and Davis and Keehn (1959), Keehn and Arnold later found that the volume of fluid obtained per lick might affect rate of licking. They concluded (p. 740) that "licking rates of rats are not absolutely constant, although variations are small." The fastest and slowest drinkers differed by less than one lick per second.

In another study of licking rates in rats (Schaeffer and Premack, 1963), two groups of neonatal rats were raised from birth without the
opportunity to drink and then were tested at different age levels. They exhibited the same general characteristics of licking rate as those of adult rats. However, it is difficult to identify genetic or maturational variables; thus, these results may be misleading in that licking rate may have been produced by the learning effects of nursing and grooming. Moreover, individual differences existing between some neonate rats were reported.

In a study of taste preferences, Bloomquist and Kandland (1965) found rate of tongue licking and rate of bar pressing not significantly related to age in the rat. In addition, there is reasonably close agreement between bar pressing and licking except for quinine intake.

Licking has been used as the more probable response to reinforce intra-cranial stimulation (ICSS) which has served as an instrumental response with licking as the reinforcing response (Holstein and Hundt, 1965). When licking was made contingent on ICSS, ICSS was greatly increased relative to its baseline and frequency of occurrence.

Holstein and Hundt's study tested Premack's (1962) generalization that for any pair of responses, the more probable response will reinforce the less probable one. They questioned whether Premack's generalization extended to ICSS. Their results showed that lick contingency greatly increased the duration of ICSS for all animals. When brain stimulation followed licking-reinforced bar-pressing, the total duration of responding was consistently higher than when licking alone reinforced bar-pressing. Thus, the effect of brain stimulation itself was decidedly relevant.

Studies of spaced-response schedules show that licking is often a mediating (collateral) behavior. In schedules where a dry food
reinforcer is contingent on a response; after some time, excessive drinking occurred (Clark, 1962; Falk, 1961). In Clark's and Falk's experiments, the intervals between reinforcement were spent licking. A reinforcer which occurred following a response also reinforced the licking that had occurred during the previous interval.

Mediation of timing in a monkey has been observed with a monkey licking the plastic holder of its water bottle (Hodos, Ross, Brady, 1962). The reinforcement of responses with food and the ease of recording drinking made this arrangement with drinking useful in the study of "timing" (Segal and Holloway, 1963).

Guinea Pig

The guinea pig has been used in the biological sciences for many years because of his docility, inexpensiveness, high reproductive rate, and bearing of mature young.

This genus of about 20 species occurs in South America from Columbia and Venezuela southward to Brazil and northern Argentina. *C. porcellus* is the wild form of domestic GPs. The type species of the genus is *C. porcellus (linnaeus)*. GPs occupy a wide variety of habitats ranging from rocky regions and savannahs to forest edges and swamps (Walker, 1964).

The length of the GP's body is 225 to 355 mm and the weight of adults is 450 to 700 gm. These figures are greater for laboratory animals, whose weights often exceed 1000 gm. An external tail is lacking. In the wild forms, the pelage is fairly coarse and long; but in domesticated GPs it may be smooth and short, smooth and long, or coarse and short. In some forms, the hair radiates in rosettes. Although
domesticated GPs exhibit an extremely wide range of colors, the wild forms are generally greyish or brownish. Members of the genus Cavia have stocky bodies, fairly short hind legs, and short ears. The hind feet are long, with three digits—all of which are armed with sharp claws.

GPs live in burrows which they excavate singly or in small groups (usually 5 to 10 individuals) and are always prepared to flee at the slightest indication of danger. At nightfall they leave their burrows and follow paths to feeding places, where they eat many kinds of vegetation.

These animals mate throughout the year. One to four young constitute a normal litter in wild forms, but in domestic animals the litters are somewhat larger. The gestation period of about 60 to 70 days in domestic forms is rather long for an animal so small. The young are able to run within a few hours, nurse for about three weeks, and become sexually mature at between 55 and 70 days of age. Their life span may extend eight years.

In spite of their unpleasant odor, GPs make ideal pets as they are gentle, do not bite, and thrive in captivity if kept warm and given a reasonable amount of care. They are used extensively in laboratory studies on disease, nutrition, heredity, and serum development. The Incas raised them for food because their flesh is of excellent quality.

Biologically, much is known about the GP (C. porcellus). Pertinent to any investigation involving liquid reinforcement are the following points:

1. Heat seems to inhibit drinking in the GP (Adolph, 1947) and intra-peritoneal injections of water do not increase heat tolerance.
2. The water content of the GP is 74.5 per cent (Moulton, 1923).

3. GPs make up a small percentage of a small deficit in one drink (Adolph, 1947), whereas dogs replenish the entire water deficit in one uninterrupted period of drinking. Man similarly replaces only 50 to 80 per cent of his fluid deficit in the first half hour after a prolonged fluid deprivation.

4. At four days after birth, the GP's urine flow is 50 per cent of the adult rate (Boyan, 1958).

These data indicate that the GP should be ideally suited for the use of a liquid reinforcer.

**Deprivation**

GP's have been reinforced with carrot juice (Gundy, 1959) for stable variable interval (VI) responding. Without any deprivation of food or water, Gundy's animals took between 30-60 reinforcements per session—each reinforcement being 0.25 cc of carrot juice available for 4 seconds.

Maintaining GPs at an adequate deprivation level has presented special problems for several years (Valenstein, 1957). Food rewards proved to be impractical due to technical difficulties inherent in using a mash and the long consummatory time involved with pellets. Also, as mentioned above, the GP's life span may be up to eight years. In many laboratories, deprivation levels are established as a certain percentage of body weight. The GP, in contrast to the rat which seldom lives beyond two years (Farris, 1949), grows at a rapid rate at the age most likely to be used. Using percentage of body weight as a guide,
experimenters have encountered problems in keeping the GP both healthy and motivated for longer than several months.

Schedules

Several investigators have reported unusual frequencies and quantities of water drinking by rats maintained on interval reinforcement schedules for food.

Falk (1961) has reported that rats on VI schedules of food reinforcement for bar pressing show a high rate of drinking when a water bottle is placed in the test chamber. He termed this phenomenon "psychogenic polydipsia" since the excessive intake of water is dependent on psychological factors; that is, the schedule of food reinforcement for the bar press response when reinforcement is not contingent on water intake.

Variable intervals (Clark, 1962; Falk, 1961, 1964), differential reinforcement of low rates (DRL) (Segal and Holloway, 1963; Deadwyler, 1964), and continuous reinforcement (CRF) (Segal and Deadwyler, 1964a) schedules produce polydipsia. Liquid as well as dry food reinforcers are effective in producing polydipsia (Falk, 1964); alcohol solutions (Lester, 1961) as well as water are drunk. Mallot and Cummings (1965) attempted to replicate the phenomenon of polydipsia, not only with positive reinforcement, but also with a schedule of negative reinforcement.

Two subjects (Ss) were reinforced on VI 64 seconds, two Ss were reinforced on a DRL 8 seconds, and two Ss were reinforced on a normal avoidance schedule in which both the time between uninterrupted shocks
and the time between an avoidance response and the next shock was 16 seconds. The shock was a .5 milliamperes and lasted for .2 seconds.

The results obtained by Mallot and Cummings were essentially the same as those previously reported by Falk and Segal (1963). However, neither of the animals on the avoidance schedule emitted any drinking responses during these sessions. No timing behavior on the avoidance schedule developed. Since the VI and DRL schedules do result in timed behavior, perhaps the lack of timing behavior in an avoidance schedule is responsible for the absence of psychogenic polydipsia. The other obvious difference between the interval and low rate schedules on the one hand and the avoidance schedule on the other hand is the use of negative instead of positive reinforcement in the latter case. This factor might also account for the absence of psychogenic polydipsia.

Segal (1965) experimented: (1) to follow the time course of the development of polydipsia over days, and (2) to observe the interaction of water drinking and bar pressing, where neither was related to the delivery of reinforcements. Her results showed a gradual increase in drinking behavior over days; this increase indicated a learning process, probably adventitious reinforcement from a burst of licking running into a fixed interval, noncontingent food reinforcer.

Clark (1962) has also suggested that water drinking on a VI bar-pressing schedule is maintained adventitiously by the arrival of reinforcement soon after the subject shifts from drinking to bar pressing.

Hulse and Firestone (1964) investigated the mean amount of reinforcement and instrumental response strength. They found no difference in mean lick rate for CRF, FR2, and FR8 schedules of reinforcement with
rats. It would appear to this author, however, that the different schedules used by Hulse and Firestone are not different enough in their overall rates for an observer to detect a difference in mean lick rate. Perhaps a DRL or VI schedule compared to CRF would make more probable the detection of any difference in lick rate.
EXPERIMENT I

Shaping of the Licking Response

Operant conditioning techniques (Skinner, 1938) have been used to train animals to obtain food or water or to avoid electric shock by performing certain arbitrary responses such as pressing a lever. In the present experiment, we asked whether licking could be treated as operant behavior and conditioned with procedures similar to those used in developing responses such as the bar press. Responses have been developed as we reinforced successive approximations to the final response (Holland and Skinner, 1961).

The question we asked was: "Once the first group of animals had learned to lick, would they then serve as discriminative stimuli for naive animals to begin licking?" Skinner (1967) points out that a response must have a history of having been reinforced in the situation before a subject will "imitate" the trained subject's behavior. Since GPs had previously emitted no licking, it was not expected that the naive subject would lick without the specific training received by the others. The experiment tested this assumption.

Method

Subjects

Four female albino guinea pigs were taken from the colony maintained by the Psychology Department of Utah State University. They were between 60 and 90 days old and housed together from the beginning of the experiment.
Apparatus

A wooden box 14 inches high, 18 inches long, and 14 inches deep was used to house the animals. An adjustable 3/8-inch tube protruded into the box about 3 inches above the floor of the box.

Procedure

All animals were weighed daily in order to judge whether they were getting enough water to maintain their weights. First, a naive subject (S1) was put into the box with the water tube withdrawn so that only licks could obtain the water. When the animal did not find and lick the tube, two other animals (S2 and S3) were also deprived and put into the box. The water tube was then retracted 1/8 inch at a time until the tube was behind a plexiglass shield that had a slotted aperture (0.3125 by 0.25 inch) which forced the animal to use his tongue to obtain water and prevented the lips or nose from touching the water tube. Once the tube was completely withdrawn with all subjects licking, a third procedure was initiated in which a fourth naive subject (S4) was put into the box and left to obtain water in the same way as those already trained and licking--this step tested to see if the new animal would imitate the trained animals and thereby learn to lick.

Results and Discussion

In spite of severe deprivation, no licking was observed in the untrained subject (S1), and its weight dropped steadily over four days. The three naive subjects (S1, S2, and S3) were differentially reinforced for each approximation to a lick, and within several weeks the subjects were maintaining their total liquid intake by licking. At that point,
S4 was introduced to the housing where the three licking animals were kept. Given no training as to the location of the liquid dispenser, S4 lost weight over a two-week period and on the fifteenth day he died. Although he nosed around the location of the tube, he was not observed to lick. This behavior supported what was expected from Skinner's (1953) statement on imitation. It was not enough to be motivated, since this behavior was not in the subject's history.
EXPERIMENT II

Schedule Effects

Once the guinea pigs could be taught to lick, it should then have been possible to bring their behavior under schedule control. Once licking was controlled, we were in a better position to test the reliability of the procedures and equipment by a comparison of cumulative records with the records of animals on similar schedules as reported in the literature (Ferster and Skinner, 1967).

Method

Subjects

The subjects were the same as those reported upon in Experiment I. One adult female Sprague-Dawley hooded rat was used to relate procedure and apparatus to the literature.

Apparatus

A Lehigh-Valley electronic lickometer was used to convert each lick into a brief 40 ms pulse which operated the recording equipment, counters, and discriminative stimuli within the chamber. The apparatus is the same as that reported by Justeson, Levenson, and Daley (1967).

A .5 inch diameter plexiglas tube with a 2 millimeter fluid hole in its center served as the lickerandum. A piece of 9.0625 inch brass rod, which served as a contact for the electronic relay, was press-fitted through a second hole in the tube so that one end was flush with the beveled surface of the tube's tip and located 0.025 inch below the
fluid hole. A plexiglas shield with a 9.3125 by 0.25 inch slot was attached to one wall of the chamber. This shield prevented the animal’s nose from making the electrical contact with the brass rod. Since this system makes fluid delivery directly contingent upon the occurrence of licking behavior, the system provided a means for using the tongue lick as an operant response.

Procedure

Two guinea pigs were reinforced initially on low fixed-ratio reinforcement schedules which were increased to observe whether high ratios could be obtained and maintained.

A third subject (S3) was placed on a VI30.

All interval schedules are reported in seconds; for example, VI30 is the same as saying a variable interval of 30 seconds.

After 8 sessions on VI30, S3’s schedule was lengthened to a VI60 and 35 sessions later was returned to the VI30 schedule. This was done to produce two different rates of licking (Ferster and Skinner, 1957) and as a check for reliability (Sidman, 1957).

For the purpose of comparing our apparatus and procedures with those reported in the literature (Justesen, Levinson, and Daley, 1967), a rat (RL1) was put on a number of fixed ratio schedules.

To determine if the rate of licking could be changed from its characteristic rate of approximately 8-9 licks per second, continuous reinforcement, RL1 was first put on an FR50 and then switched to variable interval schedules VI20, VI60, and VI70, respectively. Finally, to prevent high rates from receiving reinforcement, a DRL component was added and the mean interval was shortened to VI30.
Results and Discussion

Figure 1 presents cumulative response records of a rat (RL1), a guinea pig (S1) and a rat reported in the literature (Justesen, Levinson, and Daley, 1967). All responding was under the control of an FR50 schedule for each drop of water. In actuality, the schedule was a CRF-FR40 since the first 10 responses in consumption of the reinforcer counted on the next ratio. Examination of the records indicate approximately the same rate for both rats, averaging 3.9 responses per second. Guinea pig S1's rate is slightly lower, averaging 3.1 responses per second. On this schedule, the guinea pig responds at a rate closer to his maximum rate than does the rat. This rate for the rat is considerably lower than the mean 8-9 licks per second for continuous reinforcement reported by Schaeffer and Huff (1966). Hulse and Firestone (1964) found no difference in mean lick rate for CRF, FR2, and FR8 schedules of reinforcement with rats. Such stable licking on low-ratio intermittent schedules is not surprising, since a single water reinforcement may elicit a burst of eight or more licks. The overall rate of rat RL1 dropped 4-5 licks per second with reinforcement delivery contingent upon the FR50 schedule.

Occasionally, a pause followed the delivery of reinforcement. This FR characteristic appeared approximately 10 responses after reinforcement was delivered. One would assume that Justesen, Levinson, and Daley delivered a larger drop of water per reinforcement than was delivered in this study, since their rat's post-reinforcement pause appeared considerably later than did either RL1's or S1's, as seen in Figure 1. It is hypothesized that the amount of responding between
Figure 1. Comparison of cumulative response records for a rat (RL1), guinea pig (S1) and a rat from the literature (Justesen, Levinsen, and Daley, 1967). Reinforcement delivery was on an FR50 licks for liquid reinforcement.
RAT

JUKTESEN ET AL.
(1997)

G. PIG

RAT

Justesen et al. (1997)

G. PIG
reinforcement delivery and a pause in the FR record is a function of the size of the drop. These delayed FR pauses could be eliminated from the record by delivering reinforcement via an alternate tube, thereby resulting in ratio records more familiar in appearance. However, use of an alternate tube for water delivery eliminates the desirable feature of immediate delivery of the reinforcer, although this could be circumvented by special programming of a conditioned reinforcer (Holland and Skinner, 1961).

The highest ratio used was FR120, which was in effect for only one day. Irregularly occurring long pauses characterized the record, as was common for the first day on any new schedule. An FR110 schedule was in effect for 10 days. In Figure 2, we see the extent to which this high ratio was maintained. Records A, B, and C are considered good records. Record D occurred on a day in which the subject's weight had increased from the last session. Although the weight dropped again, the behavior was not recovered.

Figure 3 relates FR50 records. S1 was maintained on FR50 for 80 one-hour daily sessions. Record A was selected from the early sessions in which a slower recorder was used; therefore, its slopes are not to be directly compared to Record B. Although excellent records are available on all subjects, many sessions were similar to the broken records shown in Figure 2. FR50 was maintained by the GP and it is probable, due to the few good FR110 sessions, that ratios as high or even higher could also be maintained.

S3 was given a history of being reinforced on variable interval schedules up to a VI30. After eight sessions, the schedule was changed to a VI60, which was followed by a decrease in the overall rate in the
Figure 2. Deterioration from baseline responding on an FR110 over five sessions for a guinea pig (S2).
Figure 3. Cumulative response records by a guinea pig (S1) on an FR50 maintained over 80 sessions: (A) early session, (B) final session. Recorder speeds differ for the two records.
following sessions. Although it was expected that returning to VI30 would reinstate the previous rate, a still lower rate occurred after the change. (See Figure 4.) This should not be taken as an example of irreversibility (Sidman, 1953), but rather, it seems more likely that the VI30 was not established at its baseline rate for that schedule when the mean interval was increased to 60 seconds.

Figure 5 demonstrates that by proper schedule manipulation, the overall rate of licking in a rat can be modified. RL1 was given a VI history up to VI70 and even at this length of mean interval, high rates of licking were spanning the interval and adventitiously being reinforced. With the DRL component added, reinforcement of high rates was not possible and negatively accelerated scallops were generated. The schedule was returned to a VI30 with the DRL component still in effect.

These records consist of bimodal responding. Immediately following reinforcement, high rates are noticeable. This would be the elicited licking discussed by Hulse (1966). Responding gradually levels off--this behavior is probably operant behavior.

Based on the data presented here, it seems safe to conclude that the tongue lick may be controlled by operant conditioning procedures.
Figure 4. Cumulative response records by a guinea pig (S3) on a variable interval schedule of licking with 30 and 60 second mean intervals.
Figure 5. Cumulative response records by a rat (RL1) indicating development of bimodal responding resulting from adding a DRL5 component to the VI contingency.
EXPERIMENT III

**Differential Effects of Three Deprivation Procedures**

Once licking had become an integral part of the guinea pig's behavior in the experimental situation, three deprivation procedures were investigated. Operations most conducive to reliable behavior in the test environment were determined. A systematic manipulation of hours of deprivation resulted in an optimal schedule for maintaining licking throughout an experimental session.

**Method**

**Subjects**

The subjects were the same as those used in Experiments I and II.

**Apparatus**

The same apparatus used in Experiments I and II was used for this experiment.

**Procedure**

Four different water deprivation procedures were compared in terms of duration and reliability of licking behavior: (1) two sessions per day, free access to food, and no free access to water, (2) 1-hour session, 23 hours free access to food and water followed by 24-hour liquid deprivation, (3) 12-hour sessions alternating with 12-hour water deprivation, and (4) 22½-hours deprivation, 1-hour session, and one-half hour free access to water.
Results and Discussion

In the first procedure S1 was run on an FR50, twice a day with no water in its home cage for three days. Its weight dropped steadily from 664 gms to 620 gms. The sharp drop forced the termination of this procedure because the animal's ad lib weight was 714 gms and at 620 gms its life was endangered. High rates were obtained as the weight decreased. A second subject's weight dropped from 664 gms to 628 gms before he was also terminated. (See Table 1.)

Table 1. Weight loss and responses per hour increase over six one-hour sessions, two sessions each day, 11 hours apart.

<table>
<thead>
<tr>
<th>Date</th>
<th>WT/gms</th>
<th>Responses/hr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-8-67</td>
<td>664</td>
<td>400</td>
</tr>
<tr>
<td>2-8-67</td>
<td>656</td>
<td>2800</td>
</tr>
<tr>
<td>2-9-67</td>
<td>632</td>
<td>6548</td>
</tr>
<tr>
<td>2-9-67</td>
<td>628</td>
<td>3400</td>
</tr>
<tr>
<td>2-10-67</td>
<td>628</td>
<td>4660</td>
</tr>
<tr>
<td>2-10-67</td>
<td>620</td>
<td>6125</td>
</tr>
</tbody>
</table>

Most of the remaining sessions were run once a day for approximately one hour. Following the session, the subject was given one-half a bottle (200 milli-liters) of water or one hour free access to water, whichever happened first. This schedule was slightly less than maintenance so that there was a slight weight loss for most days. On weekends,
one day of free access to tomato juice restored the animal's weight. They were deprived 22.5 hours again before the succeeding session. Once schedule control was exerted, using this deprivation schedule, weights varied in either direction from the preceding day while not affecting the performance adversely.

A Pearson Product moment correlation over all sessions and procedures for S1 and S2 showed a low (r = 0.338) correlation between weight change from the preceding day's session and number of responses emitted in the first one-half hour of the session.

Although this figure was statistically significant, it does not allow us to make a statement concerning weight change as being a causal factor in amount of responding. However, nearly all good records, early in the training, were from days in which there was a weight loss from the preceding day. Since the 22.5 hour daily deprivation produced a slight weight loss each day, the subjects appeared more highly motivated in terms of their behavior. Thus, this procedure allowed for a constant deprivation on the organism, similar to the procedure developed and reported by Skinner (1940).

These results are well founded in the literature, with behavior maintained on interval schedules being affected by deprivation level (Ferster and Skinner, 1957; Skinner, 1938, 1950), interval size, and reinforcement frequency (Ferster and Skinner, 1957; Wilson, 1954).

Both deprivation and frequency of reinforcement on VI responding have been shown to significantly affect response rate (Clark, 1958). The deprivation operation found to be best in this study, controlled for deprivation; however, the deprivation effect was diminished under
prolonged VI schedules. Resistance to rate change occurring on pro-
longed VI schedules was first noted by Ferster and Skinner (1957).
EXPERIMENT IV

Discriminative Control of Licking

In utilizing the lick as a response which may be used as a tool in the development of new behaviors, it is necessary to demonstrate that it can be brought under environmental control. This experiment established stimulus control over licking, such that the subject licked in the presence of a white light and did not lick in the presence of a red light.

Method

Subjects

One guinea pig (S2) with a history of licking as in Experiments I, II, and III was studied.

Apparatus

A 10 x 12 inch chamber with three lights evenly spaced 4 inches from the chamber floor was used. The licking contact was placed directly beneath the middle light (white). The lights to the right and left of the licking contact were red and were operated simultaneously.

Procedure

Every 30 seconds, the white light was presented as a discriminative stimulus ($S^D$) for 10 seconds. During this time, the subject licked and was reinforced on a fixed ratio of five licks for one drop. When the 10 seconds were up, the white light went out and the two red lights came
on \( (S^\Delta) \). No licks were reinforced while the red lights were present. Licks occurring during \( S^\Delta \) were punished by resetting the \( S^\Delta \) timer. This extinction procedure required a minimum of 15 seconds without a response to produce \( S^D \). The chamber house light was dimmed to enhance the brightness of the stimulus light.

**Results and Discussion**

Figure 6 shows the control which the red and white light presentations exerted over the licking behavior. The records are characterized by no pausing during \( S^D \) periods. "Magazine training" was rapid, and by the third session, licking occurred at high FR5 rates with little or no responding into \( S^\Delta \). Delivery of the reinforcer on an FR5 is actually continuous reinforcement, because at least five licks are required to consume the liquid and these licks are all counted in the next ratio.

Figure 6, at B, indicates the extinction period lasting 15 seconds from the last response. The \( S^D \) for responding, shown on Figure 6, at A, "set the occasion" for the occurrence of a conditioned operant (Skinner, 1938; Keller and Schoenfeld, 1950). Terrace (1966) has demonstrated that with traditional discrimination training, typically accomplished by a rigorous reinforcement procedure, emotional behavior often followed the onset of the \( S^\Delta \). No emotional behavior was evident in the guinea pig, and it would have been difficult to decide just what constituted emotional behavior in this animal. In any case, stimulus control was quickly acquired and maintained over 70 sessions.
Figure 6. Cumulative record of responding by a guinea pig (S2) on a multiple FR5 extinction schedule. The FR5 component was in effect for 10 seconds, followed by 15 seconds extinction. All responding in extinction reset the extinction timer.
S 2 DISCRIMINATION TRAINING

CONTINUED

12-27
CONCLUSION

Although guinea pigs do not lick in a laboratory setting, they can be taught this behavior. The lick response can be accurately counted and delivery of reinforcement is immediate. The optimum deprivation procedure appears to be 22.5 hours liquid deprivation preceding a one-hour session with 200 milliliters or .5 hours access, whichever occurs first.

The licking behavior of guinea pigs, although occurring at a lower rate, demonstrates schedule characteristics comparable to the rat.

It is in this use with a secondary or conditioned reinforcer that the lick response may prove its greatest utility to the researcher. Such control at the hands of the researcher allows him to, figuratively speaking, "turn the animal on."

On the basis of these experiments, the C. porcellus should prove to be a useful experimental subject for investigations dealing with consummatory behavior, motivational variables, multiple stimuli, and/or multiple operant analysis within a functional analysis of behavior.
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VITA

Jack R. Alvord

Candidate for the Degree of

Master of Science

Thesis: Development and Control of Licking Behavior in the Guinea Pig (Cavia porcellus)

Major Field: Psychology

Biographical Information:

Personal Data: Born at Salamanca, New York, January 11, 1943, son of Justin P. and Betty L. Alvord; single.

Education: Attended elementary school in Buffalo, New York; attended Seneca Vocational High School, 1957-60; schooled in electronics and psychiatric administration in the Air Force 1960-64; received the Bachelor of Arts degree from University of Missouri at Kansas City, with a major in psychology and a minor in sociology, in 1966; completed requirements for the Master of Science degree, specializing in motivation and learning, at Utah State University, in 1968.

Professional Experience: 1968 to present, manager of Operant Conditioning Laboratory, Utah State University; 1967-68 research-teaching assistantship, Department of Psychology, Utah State University; 1966-67 laboratory research assistant, Psychology Laboratory at Utah State University; 1966, summer work as detached worker in the Recreation Department in Kansas City, Missouri; 1964-66, play therapist with Brandon Psychiatric Clinic in Kansas City, Missouri; 1965-66, field researcher with the Neurological Hospital, Kansas City, Missouri; 1964-65, laboratory technician at the Department of Psychology, University of Missouri at Kansas City; 1964-65, worked with Operation Head Start Experimental Program, Kansas City, Missouri.

Affiliations: Student member American Psychological Association, 1964 to present; member Psi Chi (national honorary psychology fraternity) 1964 to present; vice president of Graduate Association at Utah State University, 1966; member American Association for the Advancement of Science, 1967 to present.