

pattern of orderly changes of dominance rank within a fairly stable overall dominance structure. For example, rank order correlations between the dominance hierarchies determined at 6-month intervals were quite high in value. The Spearman rank correlation between Dominance Tests I and II was  $r_s = .92$ . ( $p < .01$ ), between Dominance Tests II and III was  $r_s = .95$ , ( $p < .01$ ), and between I and III was  $r_s = .85$ . ( $p < .01$ ). Consequently, longitudinal dominance relationships between squirrel monkeys may be characterized as relatively stable over long periods of time in the absence of interpolated social contact.

The status changes that were observed in the present study appeared to be both slight and orderly. As can be seen in Table 1, 7 of the 10 monkeys in the group experienced a change of one or less ranks in dominance across the three measurement occasions (Ss 154, 165, 158, 170, 156, 171, and 163). The remaining 3 animals changed status positions in an orderly appearing fashion. Both the initially most dominant male (S 168) and the initially most dominant female (S 162) consistently lost rank from Test I to Test II and from Test II to Test III, with male S 168 occupying the fourth position and female S 162 occupying the seventh position by the completion of the study. Finally, while the initially dominant male (S 168) lost status, the initially fourth dominant male (S 137) consistently gained rank over the repeated tests to occupy the first position by the end of the year. Whatever the explanation for these status changes, it obviously cannot involve the experiences of winning or losing in competitive social situations. The monkeys in the present study were continuously segregated from one another between the dominance tests.

#### DISCUSSION

The present experiment was conducted to determine the degree of long-term stability in dominance relationships between squirrel monkeys who had received no interpolated social experiences with other group members. The changes in status positions that were observed during the 12-month period of time, interrupted by only a single brief dominance measurement, were found to be slight. Thus, in general terms, the dominance hierarchy was found to be highly stable. This result is consistent with previous studies, in which similar stable dominance

relations were observed over long spans in pairwise-tested rhesus monkeys (Warren & Maroney, 1958), and in pigtail macaques, crab-eating macaques, gelada baboons, Celebes black apes, and sooty mangabeys (all Old World primates) living in established groups (Bernstein, 1970). However, the present experiment is the first to demonstrate long-term stable dominance in a New World primate species, the squirrel monkey.

The status position changes involving male monkeys, which were observed in the present study, were very similar to those reported by Baldwin (1968) for a group of free-living squirrel monkeys. As previously mentioned, Baldwin measured several different status hierarchies among the four adult males of his group during a 4-month span of time. Most of these different orders resulted from the rank changes of two of the males, who frequently exchanged occupancy of the first and fourth ranks in the dominance structure of the male group. The primary status changes in the present instance also involved two males, who initially ranked first and fourth but, by the end of the year, had exchanged status positions. An important difference between these two results is that the reversal in ranks observed by Baldwin occurred during a much shorter span of time than was employed in the present study, several weeks as opposed to 12 months. On the other hand, the Baldwin monkeys received continuous social contact throughout his study, while the animals in the present experiment were socially restricted. The obvious conclusion is that dominance status may change "spontaneously" in a very gradual manner, but the addition of social experiences may serve to facilitate or accelerate these changes.

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## Licking response distributions associated with the acquisition of schedule-induced polydipsia\*

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The relation between drinking and pellet delivery was examined in a rat that acquired polydipsia when it was exposed to a free fixed-interval (FFI) 50-sec food (Noyes 45-mg pellets) schedule. A distributional analysis

of responding in the interpellet interval indicated that drinking, which was originally distributed equally throughout the interpellet interval, became concentrated predominantly as a postpellet event within the first FFI session. The redistribution of drinking as a postpellet event was followed by an increase in water consumption, with asymptotic water intake occurring by the fourth FFI session. These results indicated that schedule-induced polydipsia cannot be attributed to adventitious food reinforcement.

The validity of Falk's (1961) original observation that intermittent food reinforcement schedules produce polydipsia in the rat is well established (Falk, 1971; Segal, 1972). Although the factors responsible for producing this excessive collateral water drinking are not currently understood, the possibility that schedule-induced polydipsia may be associated with an adventitious reinforcement paradigm in which drinking, initially emitted as a prandial behavior, coincides with, and thus is reinforced by, pellet delivery, continues to fascinate some psychologists.

A decision as to whether schedule-induced polydipsia is, or is not, an adventitiously reinforced behavior depends largely upon a developmental analysis of the temporal and sequential relations between drinking and pellet delivery. If the polydipsia generated by intermittent food reinforcement schedules is under the control of adventitious reinforcement contingencies, then, for a rat in the process of developing polydipsia, a distributional response analysis of drinking in the interpellet interval should show (a) that initially drinking is distributed essentially equally throughout the entire interpellet interval, and (b) that the acquisition of polydipsic behavior is paralleled by (1) a decrease in drinking immediately following pellet delivery, and (2) by an increase in drinking occurring immediately prior to, or coincidental with, pellet delivery.

Although most studies have indicated that schedule-induced polydipsia, when well instated, occurs primarily as a postpellet event (King & Schaeffer, 1973), there have been few studies which have systematically examined the interpellet interval drinking response distribution in animals that are developing the behavior. Consequently, the present study was undertaken to provide data on the temporal course of the development of polydipsic behavior in an experimentally naive animal exposed to an intermittent food reinforcement schedule known to produce excessive fluid intakes.

## METHOD

S was an experimentally naive albino rat, approximately 3 months old at the beginning of the experiment. S was individually housed in an animal colony room in which lighting, temperature, and humidity were maintained at a constant level. S had free access to water in its home cage at all times; pelleted Purina Dry Laboratory Rat Chow was used for the daily food ration that was presented in the home cage.

The apparatus consisted of a Lehigh Valley Electronics Model 1316 pellet-dispensing rat test chamber, modified by the installation of a drinking tube aperture in place of the right level. A glass water bottle to which a metal drinking spout was attached was affixed to the exterior wall of the inner test cubicle. Plastic positioning devices insured that the metal drinking spout was located in the same position in each test session. All programming and recording were accomplished automatically by standard electromechanical relay circuitry. The distributional analysis of licking was accomplished by programming apparatus which divided each interpellet interval into equal time segments of 10 sec.

After receipt in the laboratory, S was maintained on ad lib food in its home cage for a period of 2 weeks and was weighed daily. A restricted feeding schedule was then instituted in which S was reduced to 80% of its ad lib body weight over a period of 10 days; thereafter, S was maintained at 80% of its ad lib weight by supplementing its daily test session intake with limited feeding of Purina pellets given in the home cage approximately 15 min after the completion of each daily test session.

Baseline sessions, in which S was placed in the test chamber for a 125-min period, were then begun. In these baseline sessions, 150 Noyes 45-mg food pellets were placed in the food trough prior to introduction of S into the test chamber. In these sessions, as in all subsequent experimental sessions, water was freely available in the test chamber. After a total of 14 baseline sessions, water intake for S had stabilized. S was then switched to a free fixed-interval (FFI) 50-sec schedule, in which one Noyes 45-mg food pellet was delivered into the food trough, independently of S's behavior, every 50 sec. As in the preceding baseline sessions, S received a total of 150 food pellets in the 125-min daily sessions. S was continued on the FFI schedule for a total of nine sessions, at which time all three response measures (water intake within each session, the number of licks per reinforcement, and the temporal distribution of licking in the interpellet interval) had reached asymptotic stability.

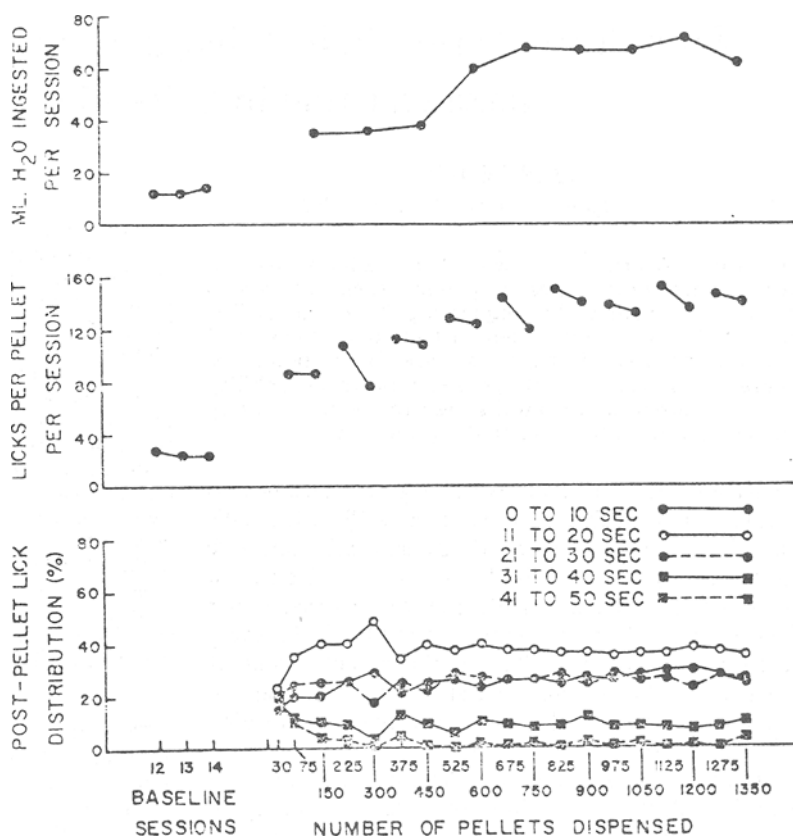
## RESULTS AND DISCUSSION

The data obtained are summarized in the three panels in Fig. 1. As is evident from the upper panel in Fig. 1, S's water intake per session (i.e., per 150 pellets) increased abruptly, from a stable base rate of 10-12 ml to 38 ml in the first FFI session. In subsequent sessions, S's water intake increased monotonically up to, and including, the fifth FFI session. Thereafter, sessional water consumption stabilized between 64 and 72 ml. From the fourth FFI session on, S's water intake was greater, by a factor of five, than its water intake in the baseline sessions.

The middle panel in Fig. 1 shows number of licks as a function of number of cumulative pellets dispensed. For the baseline sessions, the data points represent mean licks per 150 pellets ingested. For the FFI sessions, each data point represents mean licks obtained for the first 75 and the last 75 pellets dispensed in each daily session. In addition to showing the consistent within-session decrement in licking obtained, the middle panel shows that the mean number of licks per pellet, over successive FFI sessions, described an increasing, negatively accelerated, function, which paralleled the water ingestion curve shown in the upper panel of Fig. 1.

The distribution of licking responses within the 50-sec interpellet interval is shown in the lower panel of Fig. 1. For the first 30 pellets, licking was approximately

Fig. 1. Behavioral measures of rat S as a function of baseline sessions and cumulative number of pellets dispensed. The upper panel shows total milliliters of water ingested per session. The middle panel shows mean licks per 150 pellets ingested in the baseline sessions, and mean licks for the first and last 75 pellets dispensed in each FFI session. The lower panel shows the postpellet licking distribution.



equally distributed throughout the five 10-sec segments of the interpellet interval. A trend toward redistribution of this initial licking pattern in this first FFI session was discernible when 75 pellets had been dispensed, and a stable redistribution of licking in the interpellet interval was clearly evident by the time S had received its sessional allotment of 150 pellets. Thus, within the first FFI session, licking that was initially distributed throughout the interpellet interval became concentrated primarily as a postpellet event. The redistribution of licking that occurred in the first FFI session persisted throughout all eight subsequent FFI sessions, with approximately 27%, 38%, 26%, 8% and 1% of the licking occurring in each successive 10-sec segment of the interpellet interval. The fact that more licking occurred in the second 10-sec interval following pellet delivery than in the first 10-sec interval immediately following pellet delivery is explicable entirely upon the basis of the amount of time required for pellet ingestion. Direct observation of S indicated that it required between 4 and 6 sec to consume the pellet and to go from the food cup to the drinking tube, permitting only a maximum of 6 sec of drinking time in the first 10-sec segment of the interpellet interval.

A comparison of the data summarized in the three panels in Fig. 1 shows that maximum water intake and licks per pellet were not obtained until the fifth FFI session, whereas the redistribution of licking was

maximal by the end of the second FFI session, thereby indicating that a redistribution of licking precedes, rather than follows, the maximal polydipsia generated by the FFI schedule.

As has previously been discussed by King & Schaeffer (1973), this particular relationship between drinking and pellet delivery in antithetical to a reinforcement analysis of schedule-induced polydipsia. It is of interest, however, that schedule-induced polydipsia is a behavior which does describe an acquisition curve that is independent of the reinforcement contingency. This, of course, is precisely the relationship that would be expected if schedule-induced polydipsia is, as some authors maintain (cf. Falk, 1971; King & Schaeffer, 1973; Segal, 1972), a behavioral indicant of a developing motivational state rather than a product of a specific or an adventitious reinforcement contingency.

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