UNPUBLISHED PRELIMINARY DATA

The rat's anticipation of diurnal and a-diurnal feeding[1]

Robert C. Bolles and Louis W. Stojkiewicz[2]

Hollins College

Abstract

Ss were trained to press a bar for food and then confined for 21 days to boxes where they could press at any time but where food was obtained only at regularly scheduled feeding times. Different groups were scheduled to eat on diurnal, i.e., 24-hr., cycles or on a-diurnal, 19 or 29 hr., cycles. The a-diurnal Ss were also born, reared and tested under 19 or 29 hr. environmental conditions to provide further stimulus support for the anticipation of feeding. Noneless, they failed to show any genuine temporal discrimination or anticipation of feeding. The fact that the diurnal Ss showed a large, clear anticipation effect indicates that when such an effect occurs it is governed by some sort of 24-hr. biological clock rather than being based upon d eprivation-produced stimuli. *Author*

cv 6022Y

N66 32117

(ACCESSION NUMBER)   (THRU)

11

(PAGES)   (CODE)

CA-60224

(NASA CR OR TMX OR AD NUMBER)

04

(CATEGORY)

FACILITY FORM 608

GPO PRICE $ _____

CFSTI PRICE(S) $ _____

Hard copy (HC) *1.00*

Microfiche (MF) *.50*

ff 653 July 65

The rat's anticipation of diurnal and a-diurnal feeding[1]

Robert C. Bolles and Louis W. Stojkiewicz[2]

Hollins College

If rats are fed regularly once a day they soon come
to show behavior indicating the anticipation of feeding.
For example, in activity wheels there is a marked in-
crease in running in the hours immediately preceding the
regular feeding (Richter, 1922; Shirley, 1928). Similarly,
consummatory behavior has been found to have greater
strength at a regularly scheduled feeding than at other
times (Baker, 1955; Bousfield & Elliott, 1934; Lawrence
& Mason, 1955). Birch, Burnstein and Clark (1958) have
reported that there is a sharp increase in the frequency
of contacts with a food trough as the hour approached at
which it was regularly filled with food. In more clear-
ly instrumental situations, too, performance has been
found to be maximal when it is tested at the accustomed
time of day of testing (Birch et al., 1958; Bolles, 1961).

Thus, for a number of different sorts of behavior
we have a consistent pattern of maximum motivation at the
regular feeding time, and a gradient of increasing moti-
vation, i.e., anticipation of feeding, in the hours just
before feeding. The criterion behavior, whether it be
consummatory or instrumental or just general activity,
may be assumed to be at least in part conditioned to
stimuli that recur regularly at the time of feeding. We
are not concerned here so much with the mechanisms in-
volved, e.g., whether r_g should be invoked, as with the

---

identity of the stimuli to which the anticipation of
feeding becomes conditioned. Sheffield and Campbell
(1954) have shown that the rat comes to be highly re-
sponsive to external stimulus changes that signal feeding,
so that any external stimulus changes that are correlated
with the time of day may be assumed to gain some control
over the anticipation of feeding. However some of the
studies cited above have been conducted in relatively con-
stant environments, so some other source of stimulation
would seem to be required.

Brown and Belloni (1963), among a number of other
writers, have emphasized the potential role of internal
stimuli correlated with S's drive state, so-called drive
stimuli. Presumably the stimuli arising from a particular
physiological state, such as 24 hrs. of food deprivation,
are discriminately different from those arising from other
states. The anticipation of feeding then becomes a con-
sequence of imperfect discrimination between the parti-
cular drive stimuli regularly present at the time of feed-
ing and the similar stimuli that arise at slightly shorter
deprivation times. The difficulty with this interpreta-
tion is that it is based on research with diurnal, i.e.,
24-hr., feeding cycles which confound whatever drive
stimulus changes there may be with all of the other diurnal
stimulus changes. We cannot tell if S anticipates feeding
because it is almost as hungry as it usually is at meal
time or because the time of day for feeding is almost at
hand.

Bolles and de Lorge (1962) maintained Ss in activity
wheels either on diurnal (24 hr.) or a-diurnal (19 hr. or
29 hr.) feeding cycles and found that only the diurnal Ss
showed a clear anticipation effect. The activity of
a-diurnal Ss tended to follow the available 24-hr. cues
rather than their feeding cycle; they would run when it
became dark regardless of how soon they were scheduled to
eat. This finding suggests that drive stimuli are less
important than diurnal stimulus changes in the anticipa-
tion effect. However, the presence of 24-hr. environmental
cues in the Bolles and de Lorge study may have made this
too stringent a test. In the present study a-diurnal Ss
lived in a compatible a-diurnal environment so that en-
vironmental conditions would support rather than conflict
with deprivation time cues. The question then is whether
rats can anticipate a-diurnal feeding if they are maintain-
ed and fed while isolated from the normal 24 hr. world.

Method

Subjects

Results are presented on 24 male albino rats, Sprague-Dawley strain, approximately 100 days old.

Apparatus

The Ss were tested four at a time in four student demonstration type Skinner boxes. The boxes were in picnic chests which were mounted on rubber in a heavy wooden frame in a specially constructed isolation room. This room had double walls of plywood and acoustic tile, was heavily carpeted, and was located in a small free-standing building. With the exhaust fan running, human observers in the isolation room can hear nothing outside except the low frequency component of loud noises. The rat probably cannot hear sounds of the low frequency which enter, and is, in addition, provided with another 20 db. of isolation by the picnic chest. The lights both in the isolation room and in the Skinner boxes were automatically timed to be on 9.5, 12, or 14.5 hrs. and off a like period. Temperature in the boxes varied between about 75° and 85° each day, warming when the lights were on and cooling when they were off. Temperature in the isolation room varied between 75° and 80°.

Procedure

The a-diurnal Ss were born and reared in the a-diurnal environment in which they were to be tested, and lived in the isolation room until they were old enough to be tested. The 29-hr. Ss occupied the isolation room for about 3 months, then two groups of them were run. Then two groups of 24-hr. Ss were run, and, finally, two groups of 19-hr. Ss were run after they had been in the room for 3 months. The diurnal Ss were obtained from a local supplier and lived in a normal diurnal laboratory situation for two weeks prior to testing.

All Ss were deprived for an irregular period of time between 48 and 72 hrs., put in a Skinner box and trained to press the bar for food. (This was the only time at which the a-diurnal Ss left the isolation room and were not in their accustomed a-diurnal environment.) At this time,

which was generally close to the time at which it was to
be regularly fed, S̲ was allowed to press until satiated
in the experimental situation in which it was to be test-
ed. S̲ was then confined to its box for the duration of
the experiment. The experiment lasted 21 feeding cycles
during which time the bar was always present and all
responses were recorded, but only responses made during
the scheduled feeding time resulted in food (45-mg.
Noyes pellets). For half of the S̲s in each group of four
food was scheduled for the middle of the night, and for
the other half it was scheduled for the middle of the day.
The feeding period lasted 1.9 hrs. for the 19-hr. S̲s, and,
correspondingly, 2.4 hrs. and 2.9 hrs. for the other two
groups, and started 3.8, 4.8, and 5.8 hrs. respectively,
after the lights changed. S̲s were checked and their
supplies replenished generally during a feeding period,
after S̲s had started pressing.

It should be emphasized that in the present situation
S̲ had no cue to indicate the start of a feeding period;
without some anticipatory or generalized responding S̲
would miss its feeding. It is noteworthy that this never
happened, and that the rate of responding was generally
high enough that there was never much danger of a meal
being missed except in the case of the first test meal.
Upon this occasion S̲ was given about 1 hr. to start re-
sponding and if it did not E̲ would then deliver several
"free" pellets. Only one S̲ failed to start responding
then and it was replaced. All S̲s had returned to within
5% of their pre-test ad lib. weight by the end of testing.

Results and Discussion

The data were analyzed in terms of a rather unusual
response measure, viz., the number of 4-min. intervals
each hour in which at least some responding occurred. The
relationship between this measure of the probability of
responding and the more familiar raw number of responses
during each hour is shown in Fig. 1. Fig. 1, which pre-
sents the results for a single typical S̲ during the non-
feeding hours in a 5-day experimental period, indicates
that there is a high but non-linear correlation between
the two measures. The 4-min. interval measure is more
sensitive to differences between low rates of responding

and increasing less sensitive to differences between high-
er rates of responding.

Fig. 2 gives the main findings, the probability of
anticipatory or generalized responding as a function of
time before feeding for Ss fed diurnally every 24 hrs.,
or fed a-diurnally every 19 or 29 hrs. Each data point
represents the mean over the 8 Ss in each g roup of the
mean performance over the last five cycles. Since feed-
ing time changes 5 hrs. a day for the a-diurnal S, feed-
ing time over a block of five cycles is almost evenly dis-
tributed over a 24 hr. period and a block of five cycles
also distributes whatever diurnal effects there may be over
the feeding cycle. The 24-hr. Ss show a very high proba-
bility of responding in the hr. just before feeding and
a fast-rising gradient of responding indicating good
temporal discrimination. By contrast, both groups of a-
diurnal Ss showed a gradually rising probability of re-
sponding and a relatively low probability of responding
just before feeding. The difference in probability of
responding at the time the feeding period starts is not
adequately represented in Fig. 2. However, it was possible
to determine directly from the records how long after food
was made available that the first response occurred. The
mean interval, averaged over the last 5 days, was .38 min.
for the 24-hr. Ss and 4.1 min. for the a-diurnal Ss.

Within each group, Ss fed at night behaved somewhat
differently from Ss fed in the middle of the day. Fig. 3
shows the results of night-fed and day fed Ss separately.
Other things being equal, all Ss respond more in the dark
than in the light. The a-diurnal night-fed Ss evidently
wait for the lights to go off and then proceed to respond
at a fairly high rate; they show little temporal discrimina-
tion after the lights go off and before food becomes avail-
able. The 24 hr. Ss, on the other hand refrain from re-
sponding to the change in illumination for at least one
hour, and then respond at an increasing rate as the time
for feeding approaches. The a-diurnal day-fed Ss show
essentially no discrimination during the day, but the 29-hr.
Ss show a gradual increase in responding during the last
hours of the night. It is interesting to note that the
lights change for the 29 hr. Ss about 24 hrs. after their
last feeding, and they behave as though they were anticipat-

ing this event at 24 hrs. rather than the feeding which
follows 5 hrs. later. Thus it does not seem that any of
the groups of a-diurnal Ss were making a true temporal
discrimination. Rather, they seemed to be responding to
illumination changes, to 24-hr. cues of some sort, or to
still more generalized cues in the environment. By contrast,
the 24 hr. day-fed Ss refrain from responding for almost
three hrs. after the lights go on before beginning to anti-
cipate feeding.

The temporal discrimination improved gradually and
continuously over the course of the testing. The proba-
bility of responding of night-fed Ss during the day and of
day-fed Ss during the night dropped by a factor of about
two for the 24 hr. Ss and increased by a factor of about
two in the 19 hr. and 29 hr. groups over the 21 days of
testing. However, at no time, not even on the first test
day, did the discrimination performance of the diurnal Ss
look as poor as the best performance of the a-diurnal Ss.

We cannot say on the basis of these results that rats
are unable to anticipate a-diurnal feeding, but we can say
that such a phenomenon would have to involve a temporal
discrimination which is very difficult for rats to make.
Moreover, it now seems certain that the stimuli which
control the anticipation of diurnal feeding, which the
rat learns quite readily, are not those arising speci-
fically from its physiological condition, or drive state
- - they are not "drive stimuli" in any real sense. The
stimuli that make it easy for the rat to anticipate feed-
ing every 24 hrs. seem to be inexorably bound up with
the 24-hr. cyclicity, as though they were being generated
by a biological clock. The rat fed every 24 hrs. seems to
anticipate feeding not because it is almost as hungry as
it usually is at meal time, and not because the time of day
for feeding is almost at hand, but primarily because it
has not eaten for 24 hrs.

References

Baker, R. A. The effects of repeated deprivation depriva-
        tive experience on feeding behavior. J. comp. physiol.
        Psychol., 1955, 48, 37-42.

Birch, D., Burnstein, E., & Clark, R. A. Response
    strength as a function of hours of food deprivation
    under a controlled maintenance schedule. J. comp.
    physiol. Psychol., 1958, 51, 350-354.

Bolles, R. C   Generalization of deprivation-produced
    stimuli. Psychol. Rep., 1961, 9, 623-626.

Bolles, R. C., & de Lorge, J. The rat's adjustment to
    a-diurnal feeding cycles. J. comp. physiol. Psychol.,
    1962, 55, 760-762.

Bousfield, W. A., & Elliott, M. H. The effect of fast-
    ing on the eating behavior of rats. J. genet.
    Psychol., 1934, 45, 227-237.

Brown, J. S., & Belloni, M. Performance as a function
    of deprivation time following periodic feeding in
    an isolated environment. J. comp. physiol. Psychol.,
    1963, 56, 105-110.

Lawrence, D. H., & Mason, W. A. Food intake in the rat
    as a function of deprivation intervals and feed-
    ing rhythms. J. comp. physiol. Psychol., 1955,
    48, 267-271.

Richter, C. P. A behavioristic study of the activity of
    the rat. Comp. Psychol. Monogr., 1922, 1, (Serial
    No. 2).

Sheffield, F. D., & Campbell, B. A. The role of exper-
    ience in the "spontaneous" activity of hungry rats.
    J. comp. physiol. Psychol., 1954, 47, 97-100.

Shirley, M. Studies in activity, II. Activity rhythms;
    age and activity; activity after rest. J. comp.
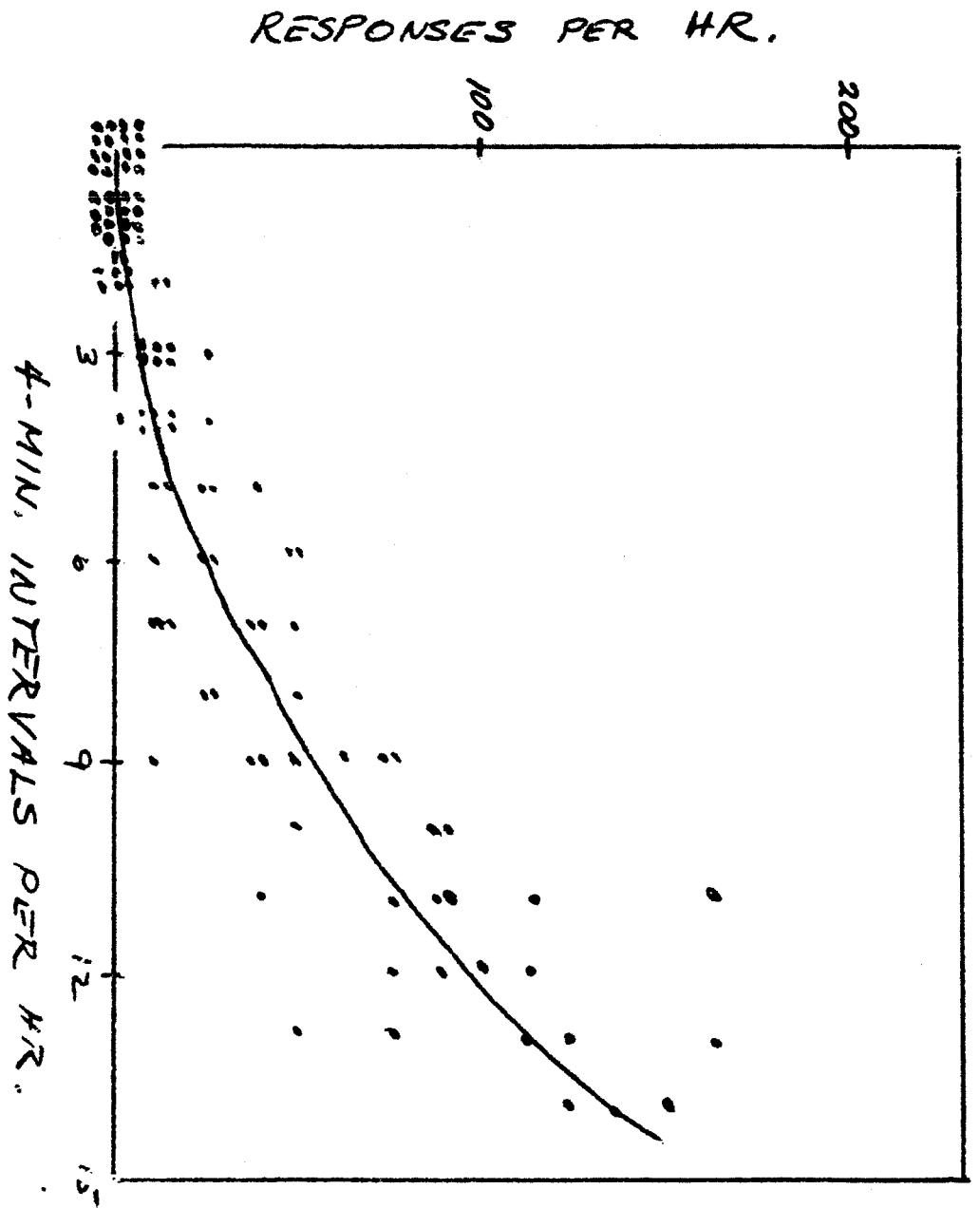   Psychol., 1928, 8, 159-186.

Fig. 1. Correlation between total number of responses per hr., and the number of 4-min. intervals per hr. in which responses occur for a typical S.
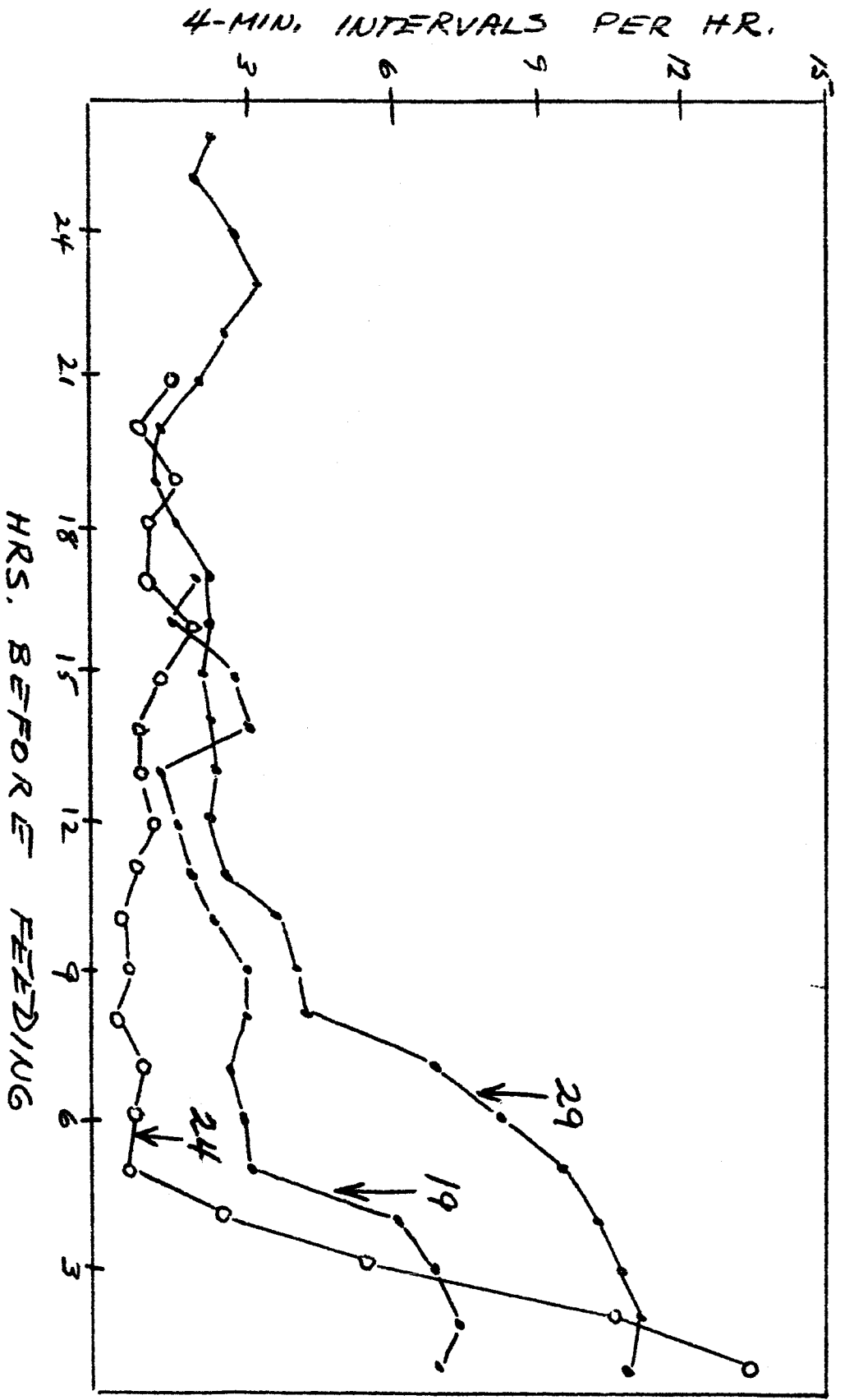
Fig. 2. The number of 4-min. intervals per hr. in which
responses occur as a function of time before feeding
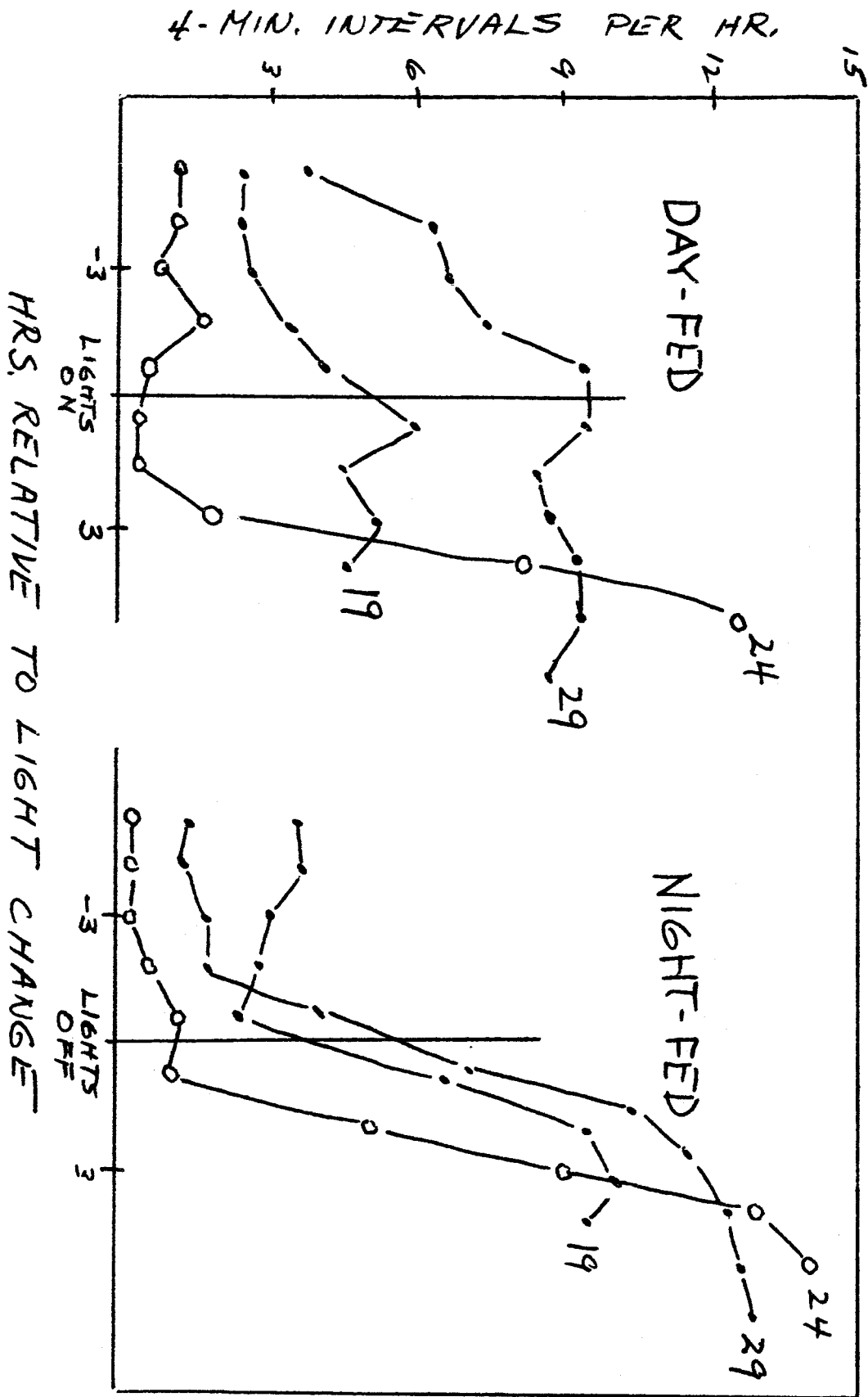for Ss fed every 19, 24, or 29 hrs.

Fig. 3. The number of 4-min. intervals per fr. in which responses occur as a function of time relative to the change in illumination preceding feeding.