

temporally related to REM periods, which are more frequent and of longer duration during the last half of the night. The total time and the percentage of the time that the subjects spent dreaming, and their general sleep-dream cycles, except for the somnambulistic incidents themselves, were similar to those recorded for control subjects of the same ages (6). Additionally, in a given subject, the time spent dreaming did not differ when nights in which several somnambulistic incidents occurred were compared with nights without such incidents (Table 1).

During the incidents, the sleepwalkers appeared to be aware of their environment but indifferent to it. Their eyes were open, expressions blank, and movements somewhat rigid. Activity ranged from sitting-up or walking, to pulling at the electrodes and cables, and rarely more violent activity such as running, jumping, and appearing to be searching for something. Somniloquy was common; if spoken to, the subjects answered monosyllabically as if annoyed. If they did not return to bed spontaneously, they usually could be led there easily. There was complete amnesia for the incidents when they awakened in the morning and, on occasion, when they awakened spontaneously during an incident. Dream recall in the morning was infrequent. When recall did occur, the manifest content did not resemble the activity during the somnambulistic incidents of the previous night.

Gastaut and Broughton (7) reported an incident of sleepwalking that occurred during a shift from stage 2 of sleep to an REM period, but no dream recall was elicited. More recently these authors also found that somnambulistic incidents begin during slow-wave sleep (8). Our results indicate that somnambulism does not occur during REM periods, and that the long-assumed relation between dreaming and sleepwalking is highly questionable.

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Eatometer: A Device for Continuous Recording of Free-Feeding Behavior

Abstract. *Minor modifications of a commercially available food cup permit automatic recording of a rat's contacts with common dry food. It is thus possible to measure the frequency and duration of the "meals" that rats take over extended periods of time, and, in conjunction with existing devices for measuring drinking, to record contingencies between eating and drinking.*

The apparatus described in this report was developed in order to measure conveniently the duration and frequency of the "meals" that rats take when provided continuously with dry food. Meals may be defined as sustained periods of contact with food, separated by arbitrary intervals of no contacts. Of the three most commonly used measures of eating, namely, the amount ingested over a standard unit of time (1), the frequency of observed instances of eating in a standardized time-sampling technique (2), and the frequency of instrumental responses which produce food (3), only the third measure yields data sufficiently detailed to enable the frequency and duration of meals to be determined. However, when these data are interpreted, the variables introduced by training the rat perform the instrumental response have also to be considered.

When the regular diet consists of liquid food, free-feeding behavior is easily measured by means of a drinkometer (4). The drinkometer records each tongue lap when a circuit, which passes a small subthreshold current, is closed through the rat and the liquid. It is thus possible to record drinking automatically and continuously over long periods of time.

The eatometer (Fig. 1) permits automatic and continuous recording of eating over long periods of time. Operating on a principle similar to the drinkometer, the eatometer records each contact of the rat with a food shield, the normal function of which is to prevent scatter and waste of dry food. When a rat is eating through the 1.4-cm holes in the food shield, the sides of its snout must make contact with the shield. The cover of the food cup prevents the rat from playing with the shield when it is not eating. The aluminum food cup,

stainless steel cup cover, and stainless steel food shield are available commercially (5), and only minor modifications are required. A banana jack connector is installed into a hole drilled on the side of the food cup near the bottom, a conducting wire is soldered

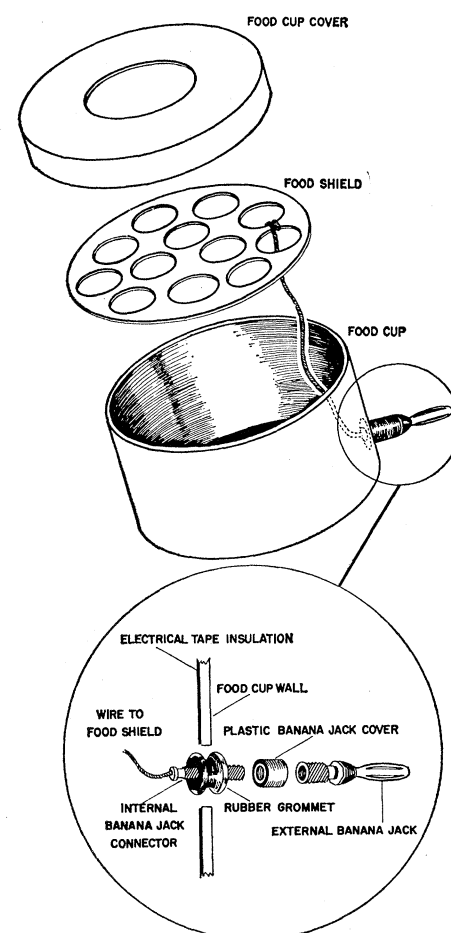


Fig. 1. Drawing of a food cup modified to function as an eatometer. The food shield lies on the food, and access to the food and shield is through the opening on the food cup cover. The inset shows how an insulated lead to the food shield is connected to a banana jack used for recording.

to the banana jack and the food shield, and a lining of electrical tape is applied to the inside of the cup for insulation (Fig. 1). Either the vacuum-tube circuit developed by Stellar and Hill (4) or a solid-state amplifying circuit (6) may be used in order to activate a relay for recording. The active lead of the contact circuit is secured to the banana jack on the eatometer, and the ground lead is secured to the rat's cage.

While the drinkometer measures discrete licking responses, the eatometer measures only contacts with the food shield, and consequently, the record from the eatometer is less refined than a drinkometer record. However, the identification of meals on an eatometer record is relatively simple. Since contacts with the eatometer occur in clusters which are rarely less than 1 minute in duration, it is convenient to define one meal as a cluster of contacts having a duration of more than 1 minute, and two separate meals are recorded when there is an interval of more than 3 minutes between contacts. This definition effectively eliminates the possibility of recording as a meal such an artifact as a rat's poking its paw into the cup, and very few data are lost.

Several eatometers have been used for a few weeks (7), and have provided continuous and reliable records of frequency and duration of meals (8). Data collected from six rats under free-feeding conditions during one continuous 22-hour period of 11 hours of darkness and 11 hours of light are shown in Table 1. While there was some variation in the pattern of eating (for example, rat 2 ate seven long meals while the others ate numerous shorter meals) the total time spent eating was remarkably consistent from one animal to another (mean, 2.0 hours; range, 1.5 to 2.5 hours). On the average, 75 percent of the total eating time was concentrated in the 11 dark hours of the 22-hour period. The mean frequency

of isolated eatometer contacts of less than 1 minute in duration was 2.3, and in each case these brief contacts were clearly distinguishable from the average meal.

In conjunction with a drinkometer, the eatometer may also be used to obtain contingencies between eating and drinking (7). Of course, the device may be easily modified for use with species other than rats.

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9. Supported by NIMH grant MH 04920 to F. W. Finger and L. S. Reid.

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Paradoxical Sleep: Deprivation in the Cat

Abstract. *In cats, the paradoxical phase of sleep occupies about 33 percent of the total sleeping time. Cats which were deprived of paradoxical sleep, by being awakened at its onset, required an increased number of awakenings on successive days of deprivation in order to prevent paradoxical sleep. On the first day of recovery after deprivation, when sleep was not experimentally interrupted, the paradoxical phase occupied 53 percent of the total sleeping time.*

Dement and Kleitman (1) demonstrated that in humans the phase of sleep characterized by low-voltage, high-frequency waves in the electroencephalogram (EEG) and rapid eye movements (REM) is reliably related to dreaming. In humans this phase of sleep has been called stage 1-REM. A similar phase occurs in chimpanzees, monkeys, dogs, cats, rabbits, rats, and mice (2, 3); but it is not known whether the functional significance is the same for animals as for humans. In animals this phase of sleep has been called paradoxical, activated, deep, and rhombencephalic.

The functional significance of stage 1-REM sleep was explored by Dement (4) who deprived humans of this phase for 3 to 7 nights and found that an increased number of awakenings was necessary on successive nights of deprivation in order to prevent occurrences of REM sleep. He also found an increase in the percentage of the time spent in stage 1-REM on recovery nights. This finding was recently replicated by Agnew *et al.* (5). It is as if a "need" exists for a certain amount of paradoxical sleep, which, if not permitted, will be made up during a recovery period. Also, Dement's subjects demonstrated various degrees of behavioral deterioration as a result of deprivation of paradoxical sleep.

We have attempted to determine whether cats also have a need for paradoxical sleep and whether this species shows signs of behavioral deterioration

if deprived of this phase. Electrodes were implanted permanently on the cortex and in deep brain structures of four adult cats, and were also implanted in the dorsal neck muscles for electromyograms (EMG) and in subcutaneous tissue of the forelegs for electrocardiograms (EKG).

Each cat was adapted to a sleep-waking cycle and to the experimental chamber for 2 weeks. According to this cycle the animal was permitted to sleep 10 to 12 hours per day in the experimental box. Between these sessions of sleep the cat was returned to the colony room and placed on a brick in the middle of a pan of water which was the floor of a cage. The animal could not lie down and did not sleep under these conditions. In the morning the cat was fed, permitted to exercise, placed in the experimental box, and connected to the stimulating and recording equipment. Approximately midway through a day's session, the animal was removed from the box and given food and exercise for about 30 minutes.

After the adaptation period, control data were obtained for 5 days by continuously recording the EKG, EMG, and EEG from the cortex and the hippocampus. These electrographic data were used to put the animal's behavioral state into three categories: awake, high-voltage sleep, or paradoxical sleep. A summary of the control data comprises one-half of Table 1 and shows the normal amount of paradoxical

Table 1. Frequency and mean duration of meals for six rats during one continuous 22-hour period. A meal was defined as at least 1 minute of sustained contacts with the eatometer. Separate meals were recorded when there was an interval of more than 3 minutes between eatometer contacts.

Rat	Frequency of meals	Mean duration of meals (min)
1	16	9.10
2	7	18.54
3	11	11.25
4	18	7.37
5	16	6.19
6	16	5.42