leading to motoneurons of flexor muscles are located primarily dorsally in the internuncial zone. Their counterparts, leading to motoneurons of extensor muscles, might therefore be located more ventrally.

A comparison of this organization of the internuncial zone with the differential termination of the two descending brainstem systems suggests that these pathways have preferential access to different interneuronal areas. Thus the medial group of fibers would have access principally to interneurons leading to motoneurons of proximal and extensor muscles, while the lateral group would have access primarily to interneurons leading to motoneurons of distal and flexor muscles. The two brainstem systems would therefore appear to be concerned preferentially with steering distal and flexor and proximal and extensor mechanisms. Such an organization seems to be implicit in previous reports (*10*), and has been largely corroborated by experiments with cats (*11*).

An attempt was made to test this hypothesis. After a recovery period of at least 6 weeks following interruption of both pyramidal tracts, lesions were placed medially or laterally in the brainstem at pontomedullary levels. The resulting changes in motility were studied over a period of several weeks. The brains of four animals in which such lesions were made have been studied histologically. Lesions of the medial brainstem pathways (Fig. 2) resulted in a severe impairment of proximal motility (long-lasting deficit in righting and unsteadiness in progression) associated with a flexor bias of the extremities, while distal movements (picking up food) were relatively unaffected.

In contrast, lesions interrupting the lateral brainstem pathways (Fig. 3) had relatively little effect on proximal motility, while distal movements were impaired. The same held true if the lateral lesion preceded the pyramidal interruption. These findings seem to support the hypothesis regarding the functional differences between the two long descending brainstem systems in directing motility.

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Somnambulism: All-Night Electroencephalographic Studies

Abstract. *Using special techniques allowing for subject mobility, we obtained continuous electroencephalographic recordings of known sleepwalkers. Somnambulistic incidents occurred during periods of slow-wave sleep. The incidents were not related temporally to dream periods, nor did they affect the total time or the percentage of time spent dreaming during the nights on which the subjects were studied.*

Somnambulism has been the subject of numerous anecdotal and clinical reports based on indirect evidence rather than direct observation. Not infrequently, it has been stated that sleepwalking incidents occur during dreaming and are in fact the acting-out of a dream (*1*). We have studied the relation of sleepwalking to the sleep-dream cycle directly, utilizing Dement and

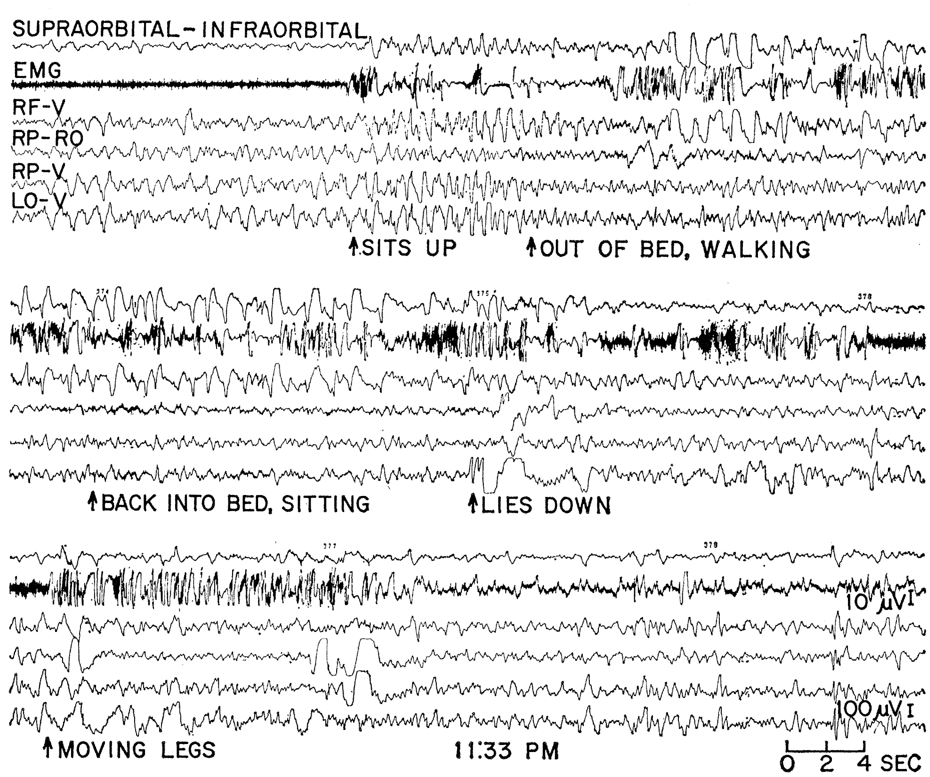

Fig. 1. Sleepwalking incident. The high-voltage slow-wave pattern begins as the subject sits up, and the slow-wave record is maintained throughout most of the incident. Eye movements are recorded by the orbital and frontal electrodes when the subject begins sleepwalking. (*R*, right; *L*, left; *F*, frontal; *P*, parietal; *O*, occipital; *V*, vertex.)

Table 1. Percentage of time spent in periods of rapid eye movement and distribution of somnambulistic incidents in nine sleepwalkers. For each subject, nights with and without incidents are compared for the percentage of total sleep-time spent in periods of rapid eye movement (average REM time). The total number and type of incidents for each subject is also shown.

Subject	Age (yr)	Nights with incidents		Nights without incidents		Total No. of incidents	
		No.	Av. REM time (%)	No.	Av. REM time (%)	Sitting up	Sleep-walking
JB ♂	13	3	21.1	0		8	0
RB ♂	9	14	16.9	0		24	4
GC ♂	16	3	16.2	0		7	1
AH ♂	11	8	21.6	1	15.0	12	3
MH ♀	15	1	15.4	2	17.1	1	0
DJ ♀	19	0		2	20.2	0	0
DK ♂	14	3	16.9	1	16.6	4	0
DL ♂	23	3	24.4	1	21.1	3	1
BW ♂	11	4	19.3	1	21.7	6	0

Kleitman's method of dream detection (*2*) and obtaining electroencephalographic (EEG) recordings throughout the night by means of special modifications in the equipment which allowed for subject mobility (*3*).

Through various sources we located 40 purported sleepwalkers. Along with their families or roommates, or both, they were interviewed to determine the legitimacy and frequency of their sleepwalking claims. Nine subjects (seven males and two females, aged 9 to 23 years) were selected on the basis of greatest frequency of sleepwalking. After routine EEG and physical examinations, they were studied for a total of 47 nights in our laboratory.

The subjects slept in separate air-conditioned rooms with doors open to give access to the main laboratory. Electroencephalograms, submental electromyograms (EMG) (*4*), and eye movements were continuously monitored throughout the night on a 16-channel Grass model IV-C electroencephalograph. Most of the records were obtained by means of special cables (*3*) which permitted the subject freedom to move about within a 6-m radius. Alternatively, we employed four-channel biotelemetry (*3*) which provided the subject with unrestricted mobility throughout the laboratory. For our purposes, we arbitrarily defined a sleepwalking incident as anything from sitting upright in bed to more complex behavior, including sleepwalking.

Probably because of the unfamiliar environment, the frequency of somnambulistic incidents was less than the subjects' reported activity at home. Seventy-four incidents were directly observed and recorded, including nine incidents of sleepwalking and 65 of sitting up.

All incidents began during periods of slow-wave sleep rather than during periods of rapid eye movement (REM). Typically, the incidents (Fig. 1) began during stages 3 or 4 of sleep (*5*) with increased EMG discharge and high-voltage activity of 1 to 3 cy/sec in the EEG. This EEG pattern, which was similar to that seen in partial arousals in normal children, persisted from 10 to 30 seconds; it was followed by waves of lower amplitude primarily in the delta range and resembling slow-wave sleep. This type of EEG activity persisted if the incidents did not last longer than 20 to 40 seconds. After lying down, spindles and slow waves typical of a lighter sleep (stage 2) appeared in the EEG. The longer somnambulistic incidents (up to 7 minutes) showed low-voltage tracings consisting of theta, alpha, and beta frequencies. About one-fourth of all incidents were followed by an EEG pattern characteristic of waking. Occasionally, the subjects showed a rhythm of alpha frequency similar to that of wakefulness, but not blocked by eye opening. Figure 2 illustrates the EEG of a somnambulist during different periods of the same night.

The somnambulistic incidents occurred predominantly during the first few hours of the night and were not

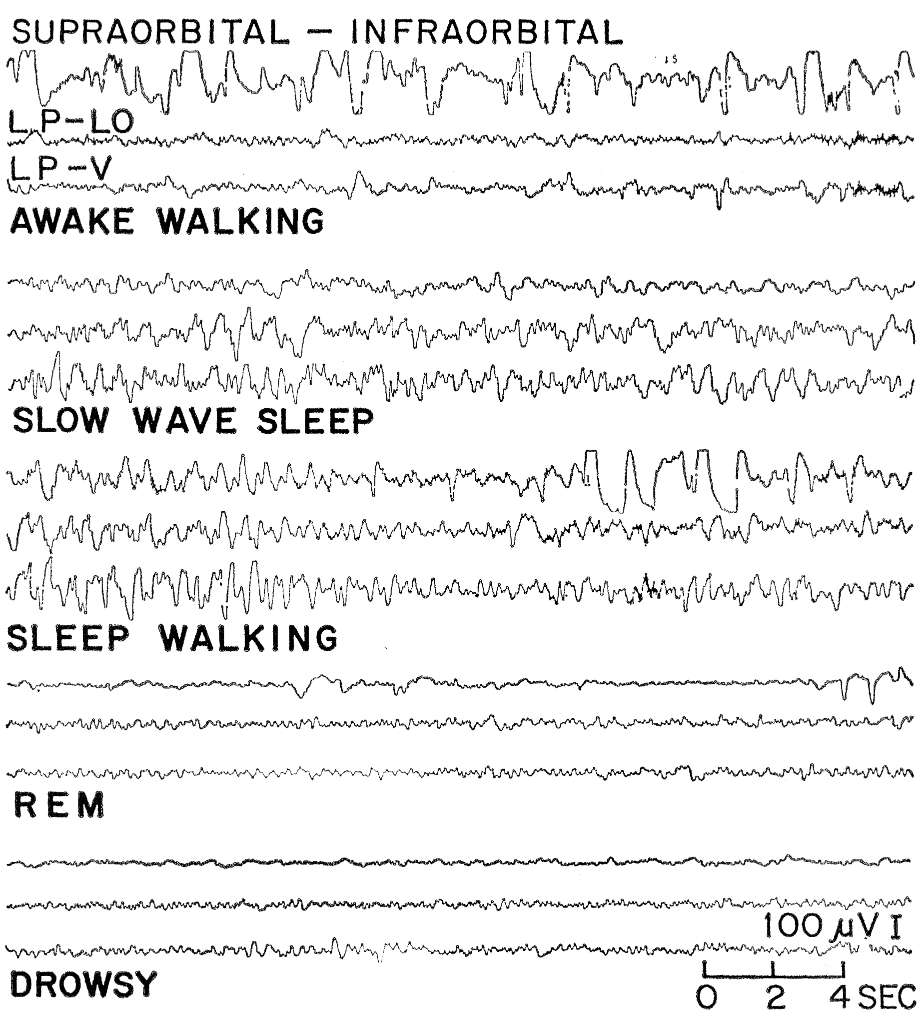

Fig. 2. A comparison of the EEG of a sleepwalker at different times during the same recording session. The top section portrays a recording taken before the subject went to bed, while the third tracing was taken during a sleepwalking incident. The eye movements occurring during the period of rapid eye movement (*REM*) are different from those recorded during the waking walk and sleepwalking.

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

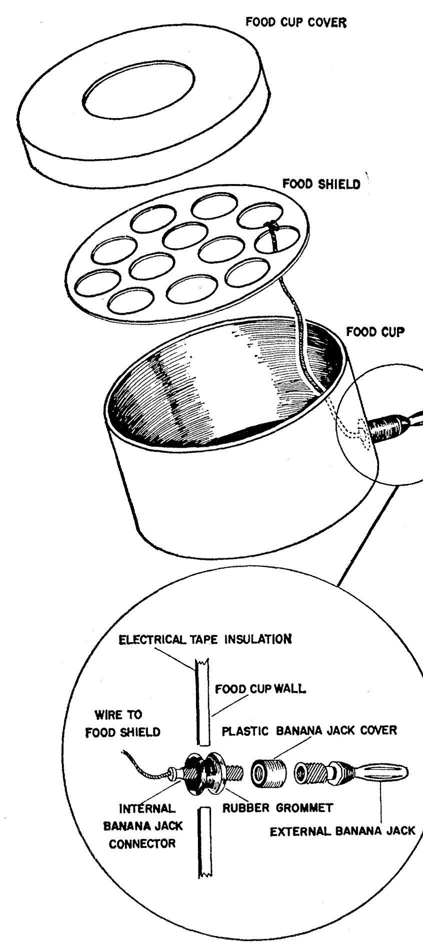

Fig. 1. Drawing of a food cup modified to function as an eatometer. The food shield lies on the food, and access to the food and shield is through the opening on the food cup cover. The inset shows how an insulated lead to the food shield is connected to a banana jack used for recording.