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PATTERNS OF BASAL SKIN RESISTANCE DURING SLEEP

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ABSTRACT

There are qualitative differences between *S*s in the pattern of basal skin resistance (BSR) through a night's sleep. The most common is a rapid rise to maximum value of BSR in the first hour, with a steady fall the rest of the night. A steady rise through the night is also common. No relationship between BSR and the occurrence of stage 1 dreaming was found.

DESCRIPTORS: Dreams, GSR, Individual differences, Skin resistance, Sleep. (C. T. Tart)

In 1962, Hawkins, Puryear, Wallace, Deal, and Thomas (1962) presented data on the temporal course of BSR during sleep and dreaming (stage 1 EEG sleep with rapid eye movements, REMs). They reported a gradual increase in BSR through the night, a sharp drop on awakening, and a frequent rise in BSR with the onset of stage 1 dreaming. This is the only recent published report[1] on BSR during nocturnal sleep and is widely quoted. My findings suggest that this data on BSR during sleep is incomplete: there are qualitatively different patterns of BSR between *S*s, and no consistent relationship between BSR and the onset of stage 1 dreaming.

METHOD

The present data are from 1 female and 16 male *S*s, all normal, young college students. They were observed from 1 to 16 nights each in four separate experiments[2, 3, 4, 5] for a total of 59 nights of technically satisfactory data. In general,

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[1] The earlier work may be discounted as it is replete with polarization artifacts from poor electrodes, averaging of data, etc. It is summarized in Kleitman (1963).

[2] Tart, 1964. Nine *S*s were observed for one night each, with pure zinc electrodes and zinc sulphate electrode paste, one electrode on the sole of each foot. Electrode area was 3 cm^2 with a constant current of 70 microamperes from a Fels Dermohmmeter.

[3] Tart, 1966. Measurement as in (2), one *S* for 14 nights, another *S* for 16 nights. The latter *S* was in study (2) for one night.

[4] Tart, study submitted for publication. Silver-silver chloride electrodes, described by O'Connell and Tursky (1960), were used with Sanborn Redux paste, one on the thenar eminence of the palm of the right hand, the other over a neutral area on the same forearm. A constant current of 50 microamperes was supplied from a Grass model VII polygraph through an electrode area of 4 cm. Three *S*s, 3 to 6 nights each.

[5] My thanks to Jimmy Scott for these observations which he made in 1964. Electrodes and instrument as in (2), but placement on sole of right foot and right shin. Four *S*s were observed for two nights each.

the *Ss* slept in quiet, darkened, air conditioned rooms. Sometimes they were awakened, sometimes they slept undisturbed through the night. As there was never any indication that the various experimental treatments affected BSR, the observations from the several experiments have been combined. The consistency of observations across experimental procedures and recording techniques enhances the generality of the observations.

Electrodes were either pure zinc with zinc sulphate contact paste (Yellow Springs) or silver-silver chloride sponge electrodes with Redux paste. These have been described as having negligible polarization effects (Lykken, 1959; O'Connell and Tursky, 1960) at the currents used (50 to 70 microamperes). In addition several all-night runs of the Zn-$ZnSO_4$ electrodes were carried out on a saline bridge and polarization resistance never exceeded 5000 ohms, so the values for BSR are accurate to about 5% or less for sleep work. Placement varied (sole to sole, palm to forearm, sole of foot to shin), but as no one has reported significant non-parallelism of BSR between active recording sites, this factor may be assumed to be unimportant.

In all studies, BSR was continuously recorded through the night on a polygraph. Concomitant EEG and REM recordings were always made. BSR was measured every 10 min to an accuracy of $\pm$ 1000 ohms (unless a movement artifact occurred at that point, in which case the next point was measured after the record had returned to normal). The onset, duration, and termination of dreaming sleep were measured from the simultaneous occurrence of stage 1 EEG and REMs, according to Dement's criteria (Dement, 1962).

Thirty-two *S* nights were recorded on which there were no awakenings of the *Ss* until morning, and 27 nights with one or more awakenings during the night. On almost all awakenings there was a small to large drop in BSR (5000 to 50,000 ohms), but as the Ss went back to sleep, BSR returned to the pre-awakening level within a few min. Thus the over-all pattern of BSR was not affected by awakenings, and all 59 nights may be considered together.

Results

As has been noted by others, BSR almost always rose with the onset of sleep (it rose at least 5000 ohms within the first hr of sleep for 55 of the 59 nights) and fell with awakening in the morning (at least 5000 ohms in 58 of the 59 nights). My observations differed from others at this point: there was no regular pattern for all *Ss*. I observed two distinct patterns frequently, and several others infrequently.

Three typical patterns are reproduced from actual *S* records in Fig. 1.

The most frequently observed pattern was a *Descending* pattern. It was characterized by a rapid rise of BSR with sleep onset, such that BSR reached its maximum value in the first quarter of the night, a steady fall in BSR the remainder of the night, and a fairly sharp drop with morning awakening to approximately presleep level.

The second most frequent pattern was an *Ascending* pattern. It was characterized by a slow but steady rise in BSR through the night, with the highest BSR value reached in the last quarter of the night. The drop on awakening was usually

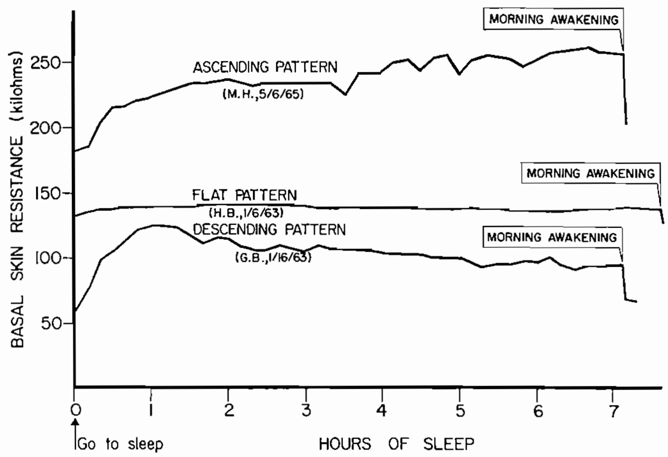

FIG. 1. Three types of BSR patterns during sleep

more pronounced than with the Descending pattern. This is the pattern that Hawkins *et al.* reported typical for most *S*s.

The less frequent patterns were: (1) a *Flat* pattern, characterized by a small rise in BSR with sleep onset, virtually no variation from this value through the night, and a small fall on awakening; (2) a *Plateau* pattern, similar to the Flat pattern, but with a much higher rapid rise and fall at sleep onset and awakening; (3) a *Steady Fall* pattern, in which the *S*'s BSR was very elevated before he went to sleep and then fell steadily through the night; and (4) *Irregular* patterns. Two of the three Steady Fall patterns observed were from one *S* who showed a Descending pattern on his other 14 nights: he seemed quite tired on reporting to the laboratory on these two nights.

Three of the nine *S*s who were observed for at least two nights each in the laboratory showed stable BSR patterns from night-to-night, i.e., the shape of the BSR/time curve remained the same, although the absolute level of the curves varied. One *S* observed for 16 nights showed a Descending pattern on 14 of these; another observed for 14 nights showed a Flat pattern on all; and a third observed for 5 nights showed an Ascending pattern on all of them. Data from these first two *S*s will illustrate how stable a *S* can be in his BSR pattern and how two *S*s can differ from each other. Fig. 2 shows the BSR curves for 6 baseline nights of the first *S* and 7 baseline nights of the second *S*. These were nights with no nocturnal awakenings and no experimental treatments applied to the *S*s. Note that each *S* reproduces his basic pattern from night-to-night, and that it would be impossible to be confused as to which pattern came from which *S*.

With respect to the incidence of various pattern types in a college population, one can only make a rough estimate with the small number of *S*s in the present study. If I characterized each *S* as to BSR pattern on the basis of his first (and sometimes only) night in the laboratory, then 56% of our *S*s showed a Descending pattern and 28% an Ascending pattern. Percentage appearances of the infrequent patterns would be too unstable with this small N to warrant calculation.

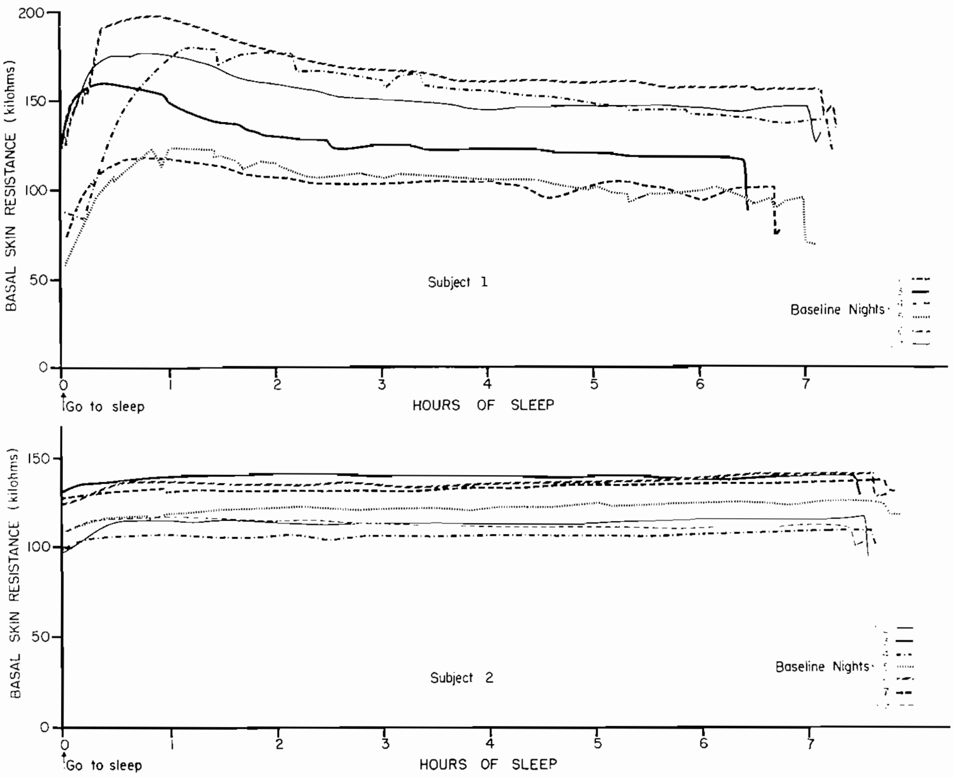

FIG. 2. BSR patterns of two *Ss*. Note that start of curve has been moved slightly to right for some curves of subject 1 to avoid overcrowding the graph. Sudden falls at ends of curves are due to experimenter awakening *Ss* in morning.

I found no association between the occurrence of stage 1 dreaming and BSR. There were usually body movements at the beginnings and ends of stage 1 dreams, which caused BSR artifacts, and it is possible that such artifacts might have accounted for the Hawkins *et al.* (1962) report of a typical rise in BSR at the start of stage 1 dreaming. I have recordings for 38 nights from 9 *Ss* which are technically satisfactory for BSR, EEG, and REM tracings. On these there were 114 stage 1 dream periods of at least 5 min duration, all of which started from and ended in sleep, thus eliminating artifacts that awakenings or disturbed sleep might cause. I considered BSR over the course of a stage 1 dream to have risen if the ending value was at least 5000 ohms greater than the start value, to have fallen if this change was in the opposite direction, to have been variable if there were marked changes in BSR in this time, and otherwise to have been constant. Since the absolute value of BSR during sleep generally ranged between 100,000 and 200,000 ohms in my *Ss*, a criterion value of 5000 ohms represents a change of at least 2% to 5%. In 85 of the stage 1 dreams (75%), BSR was constant; it rose in 8 instances, fell in 9, and was variable in 12 of the 114 instances. In instances of rising or falling patterns, it was usually clear that the over-all nocturnal shift in BSR accounted for the rise or fall during the stage 1 dream.

As most dreaming occurs during the latter half of the night, when BSR is changing slowly, the observation that there was less than a 5000 ohm change during dreaming in 75% of the instances of dreaming is understandable. Thus there seems to be no relationship between BSR and stage 1 dreaming.[6]

As other authors have reported (Asahina, 1962; Broughton, Poire and Tassinari, 1965; Fujisawa, 1960; Johnson and Lubin, 1966), high amplitude transient changes (GSRs) super-imposed on a steady BSR level during non-stage 1 sleep were frequently observed. They were most frequent during stage 4 sleep, often occurring every few sec for half an hr at a time. Such GSRs almost never occurred during stage 1 dreaming, however.

Discussion

The above observations indicate that the relation of BSR to other aspects of sleep is more complex than has been suspected: individual differences among *S*s must be taken into account, and BSR data from *S*s showing different patterns when averaged together, as was done in older studies, may very well produce a composite picture representative of nothing that actually occurs. It is possible that individual BSR patterns of *S*s may be paralleled by individual patterns of other physiological measures, such as temperature or blood flow. Nothing has appeared in the literature on individual differences in these other measures, and averaging of data across *S*s in studies of these other measures may be hindering recognition of qualitative differences between *S*s.

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[6] As this manuscript was in press, Johnson (1966) also reported that there was no change in BSR associated with stage 1 dreaming, although he presents no data on BSR patterning.