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Human Circadian Rhythms under the Influence of Weak Electric Fields and the Different Aspects of These Studies

by

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INTRODUCTION

Circadian rhythms of man have been proven to be of endogenous origin, just as those of other organism from unicellular ones up to primates (Aschoff, 1963). In a constant environment without time cues the rhythms continue autonomously with periods which deviate slightly from 24 hr. In the presence of environmental time cues, such as the diurnal change between light and dark, circadian rhythms become synchronized if the period of the time cues is within the range of entrainment around 24 hr.

Figure 1 shows the result of a human experiment performed under constant conditions. As can clearly be seen, the activity and body temperature rhythms shift gradually in relation to local time, resulting in a period of 25.3 hr. After 35 objective days, the subject had experienced subjectively only 33 days. The total phase shift of more than 360° indicates the autonomous nature of these rhythms (Wever, 1971b).

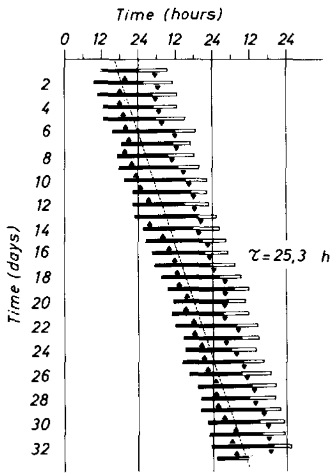

Fig. 1. Free-running circadian rhythm in a human subject, measured under constant conditions. Abscissa: local time; ordinate: successive periods. The rhythm of activity is represented by bars (black: activity; white: rest); the rhythm of rectal temperature is represented by triangles (▲: temporal position of a temperature maximum; ▼: temporal position of a temperature minimum). From Wever (1971b).

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In Fig. 1, out of a variety of measurements only the rhythms of activity and rectal temperature are shown; both rhythms have equal periods. In most subjects, not only these two rhythms but the rhythms of all measured variables, physiological as well as psychological ones, run synchronously to each other. However, in about 20% of the human subjects internal desynchronization occurs, i.e. the rhythms of different variables show different periods in the steady state (Aschoff, Gerecke and Wever, 1967). This desynchronization indicates a loss of coupling between different endogenous oscillators (Wever, 1972).

Figure 2 shows the result of another human experiment, performed again under constant conditions but with internal desynchronization; the activity period is much longer than the period of the rectal temperature rhythm. During the 25 objective days of the experiment, the subject had experienced subjectively only 18 activity days whereas his physiological variables showed 24 periods. In other subjects, internal desynchronization occurred not from the beginning of the experiment but spontaneously during the experiment, or with activity periods which were much shorter than the temperature periods. However, in all experiments, the periods of the rectal temperature rhythm were close to 25 hr. In 110 human subjects examined so far under constant conditions, these periods had an average value of 24.97 ± 0.41 hr ($\bar{x} \pm SD$) (Wever, 1971a).

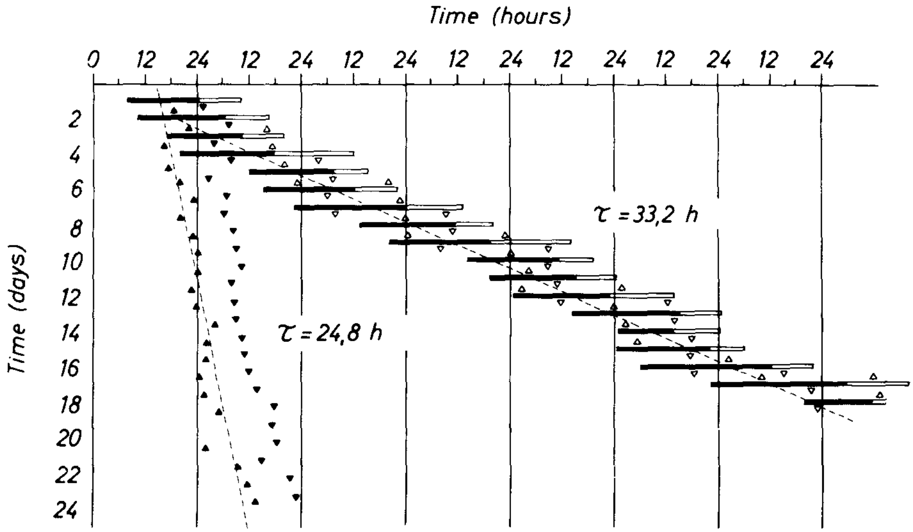

Fig. 2. Free-running circadian rhythm in a human subject, measured under constant conditions. Designations as in Fig. 1; white triangles: temporally correct repetitions of corresponding black triangles. Internal desynchronization during the total experiment. From Wever (1972).

In contrast to that what has been observed in most animals, changes in some environmental conditions (e.g. light intensity) have only small and irregular effects on the period of human circadian rhythms when measured under constant conditions (Wever, 1969). Thus, the intra-individual as well as the inter-individual variability in the free-running period of man is remarkably small.