

Biogravity – The Ups and Downs of Life

By H.-G. TITTMAR

Abstract

Gravity has previously been hypothesised to be active as a Zeitgeber (TITTMAR, 1973). Presented is an argument containing physiological and geophysical evidence by which substance is given to the earlier hypothesis. The “clock mechanism” is briefly discussed.

In his presentation of Gravity being a potential Zeitgeber, TITTMAR (1973) provided an ad reducto account for his hypothesis, but neglected to provide any empirical or mathematical evidence regarding the feasibility of such a biological possibility, save to indicate, that gravity receptors exist and could hence be employed as the relevant transducer. Part of this omission will be rectified here.

Threshold estimations for the perception of acceleration have been conducted with various organisms and under differing conditions. MEIRY (1965) found that the human threshold for the perception of angular acceleration around a vertical axis will vary subjectively between 0.1 and $0.2^\circ/\text{sec}^2$, with a mean of about $0.14^\circ/\text{sec}^2$. This is, however, a somewhat elevated result, since MEIRY (1965) utilised a 75% level of subjective correct vector detections, whereas the level normally employed in psychophysical absolute threshold estimations is 50% (WOODWORTH and SCHLOSBERG, 1966).

TER BRAAK (1937a) observed an ocular response in 3 out of 5 rabbits when they were turned clockwise at $0.09^\circ/\text{sec}^2$ ($\equiv 72 \times 10^{-4}$ dyne/cm²) and considered that some may respond to even lower values.

OMAN and YOUNG (1972) conclude that the behavioural (ocular compensation to rotational stimulation) threshold requires a minimal cupula deflection of 10^{-2} μm at $0.1^\circ/\text{sec}^2$ – this being equivalent to a force of about 10^{-3} dyne/cm² (cf. TER BRAAK, 1937a) acting upon the cupula. They further conclude that the subjective threshold for the semi-circular canal, in response to rotation, is about 10^{-4} dyne/cm². From this they consider the threshold acuity of the vestibular system to be equivalent to that of the pressure threshold for the tympanic membrane, when accepting the standard for the human auditory threshold as being 2×10^{-4} dyne/cm².

DOHLMAN (1941), using fish, found the minimal pressure required to produce a cupula deflection to be 4×10^{-5} dyne/cm².

TER BRAAK (1937b) calculated the threshold for linear acceleration (when the organism is exposed to a background acceleration of 981 cm/sec² [g], i.e. in a normal gravitational field), arising from a pressure difference of cupula and endolymph, to be about 10^{-4} dyne/cm².

Assuming therefore that an organism possesses a vestibular threshold equivalence of 2×10^{-4} dyne/cm² (arising from OMAN and YOUNG, 1972; TER BRAAK, 1937b), this amounts to a gravitational difference of 0.2 mgal.

Temporal deviations in gravity (BARTELS, 1957, pp. 770–771) indicate variations of 0.1–0.25 mgal/day. ECKHARDT (1949) suggests that maximal diurnal variations in *g* are in the order of 0.3 mgal, while WYCKOFF (1936) concludes that maximal diurnal variations in *g* for PITTSBURGH were approximately 0.34 mgal.

It should, thus, at least theoretically be possible for an organism to detect diurnal variations in the local value of gravity.

The possibility that circadian rhythms may be synchronized by diurnal fluctuations in the intensity of the Earth's normal magnetic field was proposed by BROWN and has experimentally been supported in a number of ways (e.g. BROWN, 1959, 1963; BLISS and HEPPNER, 1976; SCHNEIDER, 1963). Since circadian variations in terrestrial magnetism can be around 20–35 γ (HEILAND, 1963) this would be equivalent to $2\text{--}3.5 \times 10^{-4}$ dyne/cm², or, in gravitational units, equivalent to 0.2–0.35 mgal/day. Thus, the normal diurnal variations in the intensities of the Earth's magnetic and gravitational fields are equivalent, and may, indeed, be analogous (HIDE and MALIN, 1970).

Of importance is that in none of the experiments referred to above, were gravitational cues eliminated. Elimination of electro and magnetic cues, by placing the organism into a Faraday cage (SCHNEIDER, 1963), does not eliminate the orienting response of cockchafers. Indeed, SCHNEIDER (1964) has shown that their orienting response may be modified by changes in the local gravitational pattern.

Since variations in gravity are circadian, the system by which it is sensed is precluded. As the change in the local value of gravity is slow and finite, a continual sensing mode would be inefficient, whereas a gated (c.f. BÜNNING, 1973; EDMUNDS and FUNCH, 1969) sensing mode becomes more practical. (A computer analogue exists here, where a computer is not solely utilised to read and write, but also to sense and compare, FLORES, 1967.) Periodic up-dating of circadian fluctuations in gravity ought to result. Thus, gravity may act as a *Zeitgeber* as postulated (TITTMAR, 1973).

What, however, does then regulate the timing of the gates? TITTMAR (1973), and SCHNEIDER (1964), certainly accept that other *Zeitgebers* may exist. Consequently these could regulate the timing of the gates (of the periodic sensing). These *Zeitgebers* could function on a majority logic principle (cf. COWAN, 1963). The organism should, therefore, not act as a simple homeostat, but as an elaborate system of homeostats with feedback loops not only to themselves, but also to one another.

P.S. The foregoing essay partook in the 1977 annual competition of the Gravity Research Foundation and thereby is somewhat dated. I am grateful to the Editor for offering an opportunity to rectify this.

Biogravity has been investigated independently by myself (theoretically), and by SCHNEIDER (experimentally). Since SCHNEIDER's original observation that cockchafers orientate differentially from normal in space when a lead block is present, he has been able to verify and extend this original finding (SCHNEIDER, 1975a). Orientation

of cockchafer was also observed to be affected by the local environment (SCHNEIDER, 1974). Within both experimental conditions, influence/“absence” of local masses, orientation was further observed to be time dependent (SCHNEIDER, 1972; 1974; 1975a; 1975b; 1977), with the cockchafers making, more or less, step-wise progressive adjustments (SCHNEIDER, 1977). Such “time dependency” was traced, over several experiments, to the solar-lunar-Earth configuration, i.e. it was concluded (SCHNEIDER, 1977) that the cockchafers took lunar position into account when orientating.

Many organisms use the postural mechanisms for provision of a Spatial Reference Frame. Hence, it seems logically that the same system may be incorporated in orientation. If this assumption is true, and that by SCHNEIDER’s findings temporal variation in orientation exist, then implied is that, at least for cockchafers, the postural mechanisms may double also as a (basic) Temporal Reference Frame.

There is, therefore, a high degree (semantics apart) of overlap between SCHNEIDER’s interpretations (1972; 1975a; 1975b) and TITTMAR’s initial hypothesis (1973). The above essay considers the potential ability of a physiological system to measure absolute differences within a Temporal Reference Frame.

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