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A Hypothesis Concerning the Absorption Mechanism of Atmospherics in the Nervous System

by

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INTRODUCTION

The so-called "atmospherics" or "spherics"are electromagnetic pulses,generated in the atmosphere by electrical discharges. Along their path of propagation their Fourier-spectrum is modified by special modes of the cavity, the surface of the earth and the lower part of the ionosphere being the boundaries.The main mode of this system is approximately 10 Kcps (Volland, 1960) and the pulse frequency lies between 0.01 cps and 300 cps, mainly near 1 cps (Ludwig, Mecke and Seelewind, 1968a).

Atmospherics have frequently been held responsible for the influence of weather on the mammalian organism (König, 1962; Neuwirth and Hummel, 1954; Reiter, 1960; Zink and Kuhnke, 1952). Recent investigations showed,that atmospheric-like pulses caused measurable effects on hamsters (MESOCRICETUS AURATUS) and test persons (Ludwig and Mecke, 1968b).The activity of hamsters was strongly influenced by atmospherics:constant pulse frequencies (atmospheric pulses with invariable time intervals)led to a quasi-hypothermia but statistical pulse frequencies (atmospheric pulses with random time intervals) caused a storm of motion after preceding passiveness caused by constant pulse frequencies.

Subsequent experiments with a cat showed, however, that extracellularly measured synaptic action potentials in different parts of the brain cortex are not influenced by atmospheric-like pulses up to 50 v/m.These experiments were recently made in the neurophysiological section of the Clinic at the University of Freiburg i. Br., Germany, by R.Freund and W.Ludwig (unpublished).

Investigations made by Neuwirth and Hummel (1954) on colloidal solutions suggest an influence of atmospherics on macromolecular associations, but a theoretical understanding has not been found to date.

In the following discussion a hypothesis is presented as to why atmospheric pulses may influence specific synapses in the nervous system.The main factors on the theory are:

(1) The field strength of atmospherics during thunderstorms and approaching fronts attains a certain voltage value per meter.But the greater the distances the lower the voltage per meter,thus measurements of 0.1 v/m and less are possible. It is difficult to understand how this small field strength can cause an effect on the organism.
But in some cases an amplification of the field strength is possible. It is thought that given a long and thick enough nerve fibre which is interrupted by a thin membrane (synapse), the fibre will act as an antenna and the membrane as a more or less leaky capacity.Thus it is understandable, that the induced electrical current in the nerve fibre could cause a very high field strength at the membrane.

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(2) Due to the fact that cell membranes are made up of macromolecules with great intermolecular forces, the membrane will behave as liquid crystals. Now, the frequencies of Debye-absorption in liquid crystals lie, owing to the great intermolecular forces, in the same range as the atmospherics (Meier and Saupe,1966). Therefore absorption of atmospherics energy by the membrane is possible.

In the following paragraphs some data, published by physiologists, were used, to obtain a quantitative calculation of the above outlined hypothesis.

QUANTITATIVE CALCULATION

In the Table electrical data of average values from measurements on frogs and cats are presented. Reductions or enlargements of the geometrical sizes without changing of proportion do not alter the following relations: Ri : Rs and Ri:1/Cs.

TABLE: Electrical data of nerves

Electrical resistance per length of a nerve	$r_i = 10^8$	ohm/cm	(Diecke, 1958)
Electrical resistance of a 10 cm long nerve	$Ri = 10^9$	ohm	(Diecke, 1958)
Ion-concentration in the nerve	$n = 3.10^{20}$	cm^{-3}	(Diecke, 1958)
Mobility of ions in the nerve	$u = 5.10^{-4}$	cm^2/vs	(Diecke, 1958)
Diameter of nerves	$D \leq 10^{-3}$	cm	(Diecke, 1958)
Electrical resistance of unexcited synapse	$Rs = 10^{11}$	ohm	(Vanselow, 1966)
Electrical resistance of weak excited synapse	$Rs' = 5.10^8$ to 10^{10}	ohm	depending on excitation(Vanselow,1966)
Electrical resistance of main excited synapse	$Rs'' = 3.10^7$	ohm	(Vanselow, 1966)
Membrane-capacity of a synapse	$Cs = 3.10^{-14}$	F	(Eccles, 1964)
Area of synaptic membrane	$Fs = 3.10^{-8}$	cm^2	(Eccles, 1964)
Width of synaptic cleft	$d = 7.10^{-7}$	cm	(Eccles, 1964)

With no excitation of the synapse we have $Rs > 1/2\pi\nu Cs$ (ν = frequency),so that Cs has little or no leakage (nonload-operation).Now let us assume that we have a peak-to-peak field strength of the electrical vector Epp. Then there exists in the nerve a current density of:

$$i = n \cdot e \cdot u \cdot Epp \quad amp.cm^{-2} \tag{1}$$

with $e = 1.6 \cdot 10^{-19}$ amp.s (electrical charge of one ion).

The current itself will be:

$$J = i \cdot \frac{\pi D^2}{4} \quad amp \tag{2}$$

Within half a period of the frequency the transported electrical charge is ca:

$$Q \approx \frac{J}{2\nu} \quad A \cdot s \tag{3}$$

This is contributed to z synapses, which may be connected to the nerve end. Therefore the voltage difference on each membrane will be:

$$Us = \frac{Q}{zCs} \approx \frac{n \cdot e \cdot u\pi D^2}{8 \cdot CS} \cdot \frac{Epp}{z\,v} = 3.2 \cdot 10^5 \cdot \frac{Epp}{z\,v}\ \mathrm{v} \qquad (4)$$

when we take the data from the list and $D = 10^{-3}$ cm. The index "s" means "synapse".

Us corresponds to a total energy (z synapses):

$$z \cdot \Sigma_s = \tfrac{1}{2} \cdot z \cdot Cs \cdot Us^2 = 1/8 \cdot 1.5 \cdot 10^{-3}\ \frac{Epp^2}{z \cdot \nu^2}\ \mathrm{ws} \qquad (5)$$

(w = watts). The factor $(\frac{1}{4}\sqrt{2})^2 = 1/8$ results from the conversion of Epp to Eeff.

The total electrical power becomes:

$$z \cdot Ns = 2 \cdot z \cdot \Sigma_s \cdot v = 1/8 \cdot 3 \cdot 10^{-3}\ \frac{Epp^2}{z \cdot v}\ \mathrm{w} \qquad \mathrm{w}\ (6)$$

This power results from the electromagnetic field:

$$N = 1/8 \cdot \frac{A}{120\pi}\ Epp^2\ \mathrm{w} \qquad \mathrm{w}\ (7)$$

where A means the absorbing area.
From equation (6) and (7) we have: $A \approx \frac{1}{z \cdot \nu}\ \mathrm{cm}^2$ (8)

With $v = 10^4\ \mathrm{s}^{-1}$ and $z = 1$ we get for instance:

$$A \approx 10^{-4}\ \mathrm{cm}^2 \qquad (9)$$

$D = 10^{-3}$ cm showes that the nerve must be at least 1 mm in length in order to satisfy the energy law.

Example 1 :
$z = 1$
$D = 10^{-3}$ cm
$Epp = 10^{-3}\ \mathrm{v \cdot cm^{-1}}$ (= 100 mv/m)
$\nu = 10^4\ \mathrm{s}^{-1}$
$Us \approx 3.10^{-2}$ v (= 30 mv) (10)
$\Sigma_s \approx 2.10^{-18}$ w·s (11)
$Ns \approx 4.10^{-14}$ w (12)

Example 2 :
$z = 10$
$D = 10^{-3}$ cm
$Epp = 10^{-3}\ \mathrm{v \cdot cm^{-1}}$
$v = 10^4\ \mathrm{s}^{-1}$
$Us \approx 3.10^{-3}$ v (= 3 mv)
$\Sigma_s \approx 2.10^{-21}$ w·s
$Ns \approx 4.10^{-17}$ w

Example 3 :
$z = 1$
$D = 10^{-4}$ cm
$Epp = 10^{-3}\ \mathrm{v \cdot cm^{-1}}$
$\nu = 10^4\ \mathrm{s}^{-1}$

$$Us \approx 3.10^{-4} \; v \quad (= 0.3 \; mv)$$
$$\Sigma_s \approx 2.10^{-22} \; w.s$$
$$Ns \approx 4.10^{-18} \; w$$

Ns in example 1 is much greater than the Johnson-noise-threshold:

$$Nn = 4 \cdot k \cdot T \cdot \Delta\nu \angle 1.7.10^{-15} \; w \qquad (13)$$

with $\Delta\nu$ = 100 Kcps ($k = 1.38 \cdot 10^{-23}$ ws/degree; $T = 310^0$ K).
Us = 30 mv corresponds to an alternating field strength at the membrane of

$$Es = \frac{Us}{d} = 4.6 \cdot 10^4 \; v.cm^{-1} \qquad (14)$$

In comparison with $Epp = 10^{-3} \; v \cdot cm^{-1}$ we have an amplification factor of more than 7 decades!

In the brain, however, we will have $z > 1$, $D < 10^{-3}$ cm and therefore very low values of Us and Es (examples 2 and 3).

The ion-charge on the membrane results in macro-dipoles of a dipolemoment

$$m = 10^{-25} \; A \cdot s \cdot cm \qquad (15)$$

The energy, which may be absorbed by such a dipol, is $(\vec{m}, \vec{Ei})$, with $\vec{m}$ = vector of dipolemoment and $\vec{Ei}$ = vector of internal electrical field strength Ei. For, the polarization effect in liquid crystals is very small, we can assume:

$$Ei \approx Es \qquad (16)$$

Then we get from equation (14) to (16) the absorbed energy per dipole:

$$\Sigma = 4.6 \cdot 10^{-21} \; w \cdot s \qquad (17)$$

This value is near the Johnson-noise-threshold

$$\Sigma_n = k \cdot T = 4.3 \cdot 10^{-21} \; w \cdot s \qquad (18)$$

But all dipoles are excited synchronously, so that Σ is to be multiplied with the number of excited dipoles in the membrane. Then we get values greater than Σ_s in equation (11).

The corresponding power lies above the exciting levels of sense organs (ear ca 10^{-16} W; eye ca 10^{-18} W (Autrum und Schneider, 1948; Gerthsen, 1963). It is possible that the absorbed energy may cause an effect in the membrane. Such wireless influences were also discussed by Adrian, 1947. It may be that specific synapses with their liquid crystal structure are in resonance with the atmospherics frequencies and that the absorption of energy causes an alternation of membrane permeability.

DISCUSSION

The previous section showed that there is no contradiction to the energy law in the outlined hypothesis. Furthermore it was shown that in some cases, where only one synapse is connected to a length of nerve fibre (thick and long enough as required by the energy law), noticeable effects may occur at the synaptic cleft in atmospheric fields.

But in the case of excited membranes we no longer will have the assumed nonload-operation and no effect will result through atmospherics. It is feasible that some connection may exist between membrane load capacity and the behavior of vegetatively labile persons (Ludwig und Mecke, 1968b).

Another explanation could be based on the experimental results in conjunction with macromolecular association (Neuwirth und Hummel, 1954). It is possible that a similar theory will explain the variation of intermolecular forces in solutions exposed to alternating electromagnetic fields.More experiments using artificially produced atmospherics must be done, before developing new theories.

The hypothesis outlined here may incite physiologists to measure nerve pulses in other parts of the body in addition to the brain within an imitated atmospherics field, in order to prove or disprove possible connections to the above.In the brain it is easy to find synaptic membranes, because of their great concentration.The hypothesis shows, however, that effects caused by atmospherics are to be assumed only in regions with low synaptic concentration.

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ABSTRACT.- On the basis of published results of measurements of electrical properties of nerves and synapses a mechanism is discussed of how atmospherics(electromagnetic pulses from atmospheric discharges in the very low frequency range) may be absorbed in the nervous system. According to this hypothesis there is a threshold of electrical field strength of a few mv/m that will influence specific nerves. The absorbed power per synapse in general is smaller than 10^{-13} watts.

ZUSAMMENFASSUNG.- Anhand von Literaturmaterial über die elektrischen Eigenschaften von Nervensträngen und Synapsen wird ein möglicher Mechanismus diskutiert, wie impulsförmige elektromagnetische Längstwellen (Atmospherics) von den Nervenleitern aufgefangen und an speziellen Synapsen weiterverarbeitet werden können. Nach dieser Hypothese besteht eine Ansprechsschwelle (elektrische Feldstärke) von wenigen Millivolt pro Meter bzw. Bruchteilen von billionstel Watt absorbierter elektromagnetischer Leistung pro Synapse.

RÉSUMÉ.- Sur la base des résultats publiés de mesures des propriétés électriques des cordons nerveux et des synapses, on discute ici un mécanisme selon lequel les "atmosphériques" peuvent être absorbés par le système nerveux. On dénomme "atmosphériques" les impulsions électromagnétiques de très basses fréquences provenant de décharges dans l'atmosphère. Selon cette hypothèse de travail, il y a un seuil de réponse (intensité du champ électrique) de quelques millivolts par mètre (mv/m) qui influence les nerfs spécifiques. La puissance absorbée par synapse est ainsi en général inférieure à 10^{-13} watts.