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Nemodynamics-IV... Chairman: E. O. Attinger

### On the Regulatory Function of Unidirectional Rate Sensitivity in the Cardiovascular System

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Single sensory and control channels in the living organism are as a rule sensitive to rate of change in one direction but not the other. This biologic design principle which has been described in previous papers<sup>1</sup> is applicable to the cardiovascular system through the dynamics of its many pressure receptors, stretch reflexes as well as its hormonal regulation. It implies important dynamic characteristics that need to be taken into account in the understanding and simulation of cardiovascular dynamics. These dynamic properties (which may occur at the beginning or a later portion of a channel) often result in important biologic advantages in the control of blood pressure and flow. Of practical importance is the effect on many biologic stress situations from tilt table experiments to space flight.

An important test for unidirectional rate sensitivity is the response to impulse disturbances of opposite polarities. Responses of the same polarity regardless of the polarity of the impulse disturbance indicate unidirectional rate sensitivity. (This cannot be explained by the assumption of a different time constant for the two directions of change). This property, in combination with the DC shift of the response in the same direction for increase in amplitude and increase in frequency of the stimulus, provides critical tests for unidirectional rate sensitivity.

If two channels are present for measuring rate of change, one for each direction of change of a variable, as in the respiratory heart rate reflex or in temperature sensing, the central integrating function of the brain is informed of the polarity of the change sensed by the location of the channel from which the input arrives. Thus the measurement by the organism of the change becomes in part transmuted into a geometric relation. This in turn is reflected in different spatial properties of the electric responses of the brain, to changes of different polarities.

Thus in addition to the concept of excitatory and inhibitory nervous activity operating at the same synapse, in this manner the spatial relations of the input have a determining influence on the interpretation by the nervous system of regulatory and sensory inputs of the same variable. The central nervous system also interprets information through geometric, spatial polarity control. Such a rein-like method of control (which in general does not pass through a common synapse) appears to be an important design principle used by the central nervous system in sensing, perception and regulation. To give a common and well-known example of this: heat and cold representing sensory measures of the same variable arrive at the brain

from different channels. Since the nerve trains may otherwise be identical, the brain interpretation of cold or hot rests on the recognition of the input channel. Through the presence of unidirectional rate sensitivity it seems probable that such regulation also exists in the cardiovascular system. Thus, for example, one would search for the effective presence of some form of low blood pressure or blood flow sensors in the cardiovascular system to complement those unidirectionally rate sensitive sensors which primarily sense increase in blood pressure. The geometric properties of sensory evoked responses in the brain may be measured by a newly developed computer technique of spatial differentiation. This allows the recognition of spatially independent components of responses. (Brain Space Analysis, The 6th Intl. Conf. on Med. Elec., Sept. 1965.)

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<sup>1</sup>Ann. of the N.Y. Acad. of Sci., 92, Art. 3, pp. 946-969, 1961; 98, Art. 4, pp. 806-845, 1962 and 112, Art. 1, pp. 468-509, 1964 and Circ. Res. XI, No. 3, Part 2, pp. 515-528, 1962, Proc. of 16th Ann. Conf. on Eng. in Med. and Biol., pp. 23-23, 1963.