Physiol. Res. 41: 93-94, 1992

Osmoreception in the Duck's Brain Identified by Neurophysiological Methods and Phylogenetic Structural Cues

E. SIMON

Max-Planck-/W.G. Kerckhoff Institute, Bad Nauhem, FRG

Received November 11, 1991

Summary

Central nervous thermo- and osmo-responsive neurones are considered as important signal generators in the corresponding homeostatic control systems. Criteria for specificity are discussed in view of only functional evidence for the former, and of both functional and structural evidence for the latter.

Key words

Hypothalamic thermoreception and osmoreception

Control of biophysical homeostatic parameters such as temperature, fluid tonicity and blood gas composition all require specific monitoring of the controlled variables. Besides well-defined peripheral afferent nerve fibres, neurones in the central nervous system (CNS) contribute importantly to signal generation.

Hypothalamic thermoreception.

The analysis of central nervous thermoreception has faced conceptual and experimental difficulties that seem to be paradigmatic for homeostatic perception in general. The classical approach to identify sites of sensory perception in the CNS by observing adequate effector responses to adequate local stimulations has been generally successful. Analysis at the neuroneal level, however, has proven extremely difficult. This applies especially to the hypothalamus which is one of the most closely investigated brainstem sections because of its importance in thermo- and osmoreception.

Neural correlates of hypothalamic thermoreception are still ill-defined. Thermoresponsive neurones are not restricted to thermosensory sites and are not independent, i.e. morphological criteria for specificity are not available. Conventional functional properties, which are tentatively considered as indicators for thermosensory specificity, have become ambiguous, because they are displayed also by neurones in the avian hypothalamus which is devoid of an appreciable thermosensory function (Nakashima *et al.* 1987). The multimodality of thermoresponsive neurones poses another major obstacle (Boulant and Silva 1987). As a result, it is undecided, whether specific temperature perception in the CNS rests on specific thermosensory neurones, or rather on a specific neuroneal network of hitherto unknown design, which is capable of extracting the specific signal from the activity of non-specifically temperature-dependent or even multimodally responsive neurones.

Hypothalamic osmoreception.

As ascertained by local hypertonic microstimulations, hypothalamic osmo-receptive sites probably exist on either side of the blood brain barrier (BBB): in the organum vasculosum laminae terminalis (OVLT) on the blood side and in the periventricular tissue of the rostral third ventricle (A3V) on the brain side. So far, it has remained unclear, however, whether or not "true osmoreceptors" responsive to increases in extracellular concentration of any non-permeant solute, or "sodium receptors" detecting only elevated concentrations of the prevailing extracellular cation, exist on one or the other, or even on either side of the BBB.

The osmoregulatory system offers the advantage that one of its major efferent pathways, the hypothalamo-neurohypophysial (HNH) system, is identifiable by both electrophysiological and histochemical methods. Proceeding from the results of single unit recordings in rats, the hypothesis was put forward that the HNH neurones themselves are osmoresponsive. Recently, however, HNH osmosensitivity was shown to be abolished when certain nearby A3V nuclei were lesioned, and the idea of an "osmoreceptor complex" has been put forward (Honda et al. 1990), which assumes neurones of the HNH system, the A3V region and the median preoptic nucleus to constitute a reverberating circuit with positive feedback components enhancing liminal osmosensitivity. Thus, the question to be decided for osmoreception is analogous to that posed for thermoreception: does sensory specificity rest on a particular cellular transduction mechanism or on the specific design of a neuroneal network?

As compared with the mammals, the brainstem cytoarchitecture of sauropsids (reptiles, birds) displays morphologically definable "clusters" of neurones which seem to represent functional entities. In the duck hypothalamus, a cluster of subependymal A3V neurones was identified which projects monosynaptically to paraventricular HNH neurones and displays dendritic structures indicative of a receptive function. According to *in vitro* single unit analysis (Kanosue *et al.* 1990) these neurones are activated by increases in tonicity due to various monovalent electrolytes, but not to non-electrolytes. The same kind of "electrolyte" osmosensitivity could be demonstrated *in vivo* by eliciting antidiuretic responses to microinfusions into the A3V made hypertonic by adding various electrolytes but not non-electrolytes. These congruent results seem to favour the concept of specific receptors rather than of nonspecifically responsive networks as the source of the adequate tonicity signal.

References

BOULANT J.A., SILVA N.L.: Interactions of reproductive steroids, osmotic pressure and glucose on thermosensitive neurons in preoptic tissue slices. *Can. J. Physiol. Pharmacol.* **65:** 1267, 1987.

HONDA K., NEGORO H., DYBALL R.E.J., HIGUCHI T., TAKANO S.: The osmoreceptor complex in the rat: evidence for interactions between the supraoptic and other diencephalic nuclei. *Physiol.* (Lond.) **431:** 225, 1990.

KANOSUE K., SCHMID H., SIMON E.: Differential osmoresponsiveness of periventricular neurons in duck hypothalamus. *Am.J.Physiol.* **258:** R973, 1990.

NAKASHIMA T., PIERAU F.-K., SIMON E., HORI T.: Comparison between hypothalamic thermosensitive neurons from duck and rat slices. *Pflügers Arch.* **409:** 236, 1987.

Reprint Requests

E. Simon, Max-Planck/W.G. Kerckhoff Institute, D-6350 Bad Nauheim, FRG