

CYCLIC ENVIRONMENT AND BRAIN ASYMMETRY

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Fields of interest: Brain asymmetry, biological rhythms, endocrinology.

Publications and/or Exhibitions: Ramírez, M., Sánchez, B., Arechaga, G., García, S., Lardelli, P., Venzon, D., and De Gandarias, J.M. (1991) Diurnal variation and left-right distribution of pyroglutamyl peptidase I activity in the rat brain and retina. *Acta Endocrinologica* 125, 570-573.

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Abstract: The brain is intrinsically asymmetric and virtually all brain functions are organised in more or less degree, in an asymmetrical fashion. Unbalances in this established brain asymmetry might lead to neuropathological deviations of brain functions. The geophysical character of the earth impose a natural cyclic condition, such as the daily light-dark cycle, to which unavoidably all the biological systems, including human beings, must adapt and respond. Our results show the existence of brain laterality which depends on light (left predominance) or dark (in some cases right predominance) conditions. These results demonstrate that an external factor, such as the cyclic environmental light conditions, influences an endogenous neurochemical change. Specific environmental conditions, such as programmed rhythms of light and darkness, can determine the existence and the side (left or right predominance) of a brain asymmetry. We hypothesise on the influence of environmental conditions on brain asymmetry

1. BRAIN ASYMMETRY

The brain asymmetry understood as an anatomical, functional or biochemical difference between both cerebral hemispheres is a phenomenon extensively studied, essentially from an anatomical and functional perspective. The molecules and physical particles of which living cells are constructed are themselves asymmetrical. In addition, asymmetry is characteristic of many single-celled organisms and of individual cells in more complex organisms. These observations among others, have led to the realisation that despite its inherent beauty, bilateral symmetry is no more fundamental a property of biological systems than is bilateral asymmetry. In fact, growing evidence support the idea that the brain is intrinsically asymmetric and that virtually all brain functions are organised, in more or less degree, in an asymmetrical fashion. In addition, it could be speculated that unbalances in established brain asymmetry (toward symmetry or toward increasing asymmetry) might lead to neuropathological deviations of brain functions. This asymmetrical organisation is the result of evolutionary adaptation and evidences of brain asymmetries have been found not only in our ancestors but also in all stages of the brain evolution.

2. NEUROPEPTIDES AS CHEMICAL MESSENGERS

The intercellular communication is a necessary function of every pluricellular organism, which is mediated essentially by chemical messengers. Neuropeptides are a relatively recent class of neurotransmitters involved in a large variety of brain functions. After their release from neurones, neuropeptides are substrates rapidly inactivated or biotransformed by neuropeptide-degrading enzymes (neuropeptidases); therefore their study reflects the function of their substrates. The neurochemical basis underlying anatomical and/or functional asymmetries in the brain are not well understood, but some findings imply the existence of neurotransmitters or neuromodulators with a lateralized function. We have investigated several brain asymmetries in neuropeptidase activities and postulated that this distribution may reflect putative lateralized functions of their susceptible endogenous substrates.

3. NEUROENDOCRINOLOGY OF CIRCADIAN RHYTHMS

The geophysical character of the earth impose a natural cyclic condition, such as the daily light-dark cycle, to which unavoidably all the biological systems, including human beings, must adapt and respond. As a result, virtually all the organisms have developed an internal system, not only capable of respond to the cyclic nature of environmental stimuli, but also capable of anticipate to that external rhythm with internal programs of metabolic, physiologic, endocrine or behavioural character. Therefore, environmental light generates important neuromorphological, behavioural, neurochemical and neuroendocrine changes. In this response is involved the central circadian oscillator of

the endogenous rhythms: the suprachiasmatic nucleus of the anterior hypothalamus. This nucleus receives information of the environmental light-dark conditions through a direct connection with the retina (Ramírez et al, 2001).

4. NEUROPEPTIDASES, LIGHT-DARK ENVIRONMENT AND BRAIN ASYMMETRY

To investigate the environmental light-dark influence on brain function, we have studied the effect of different light-dark conditions on several neuropeptidase activities, in the left and right sides of the retina and the anterior hypothalamus, among other bilateral structures of the brain. These neuropeptidase activities have been reported to regulate the function of several neuropeptides. Therefore, we studied these activities under different light-dark conditions during a regular 12 h- 12 h, light-dark cycle under specific light-dark schedules and under the influence of standard and non standard light-dark conditions.

1) We reported significant changes of neuropeptidase activities in the retina and anterior hypothalamus, together with an asymmetrical distribution of this activity at selective time-points during 12 h light and 12 h dark periods. The activity was higher in the left side of both structures than in the right side during the light period, whereas it was predominant in the right side during the dark period. (Ramírez et al, 1991; Ramírez et al, 1992).

2) Because the retinohypothalamic tract functionally connects the retina and hypothalamus, it was plausible that the environmental light or darkness influenced neuropeptidase activities. To test this hypothesis, we studied the effect of light and dark conditions on neuropeptidases and on its left-right distribution in the retina and anterior hypothalamus. The enzymatic activities were measured under selected light-dark schedules. In the retina, the left-right predominance depended on the previous 2h period: the light period led to left predominance, whereas right predominance was found after the 2h dark period. In the hypothalamus, a left predominance was found only in one group. These results demonstrate that environmental light conditions influence neuropeptidase activity in the rat retina and hypothalamus.

3) Finally, we evaluate additionally the influence of light and darkness, designing a study in which we analysed, at the same time-point, the effect of standard (12 h-12 h light-dark schedule) and nonstandard (constant light or darkness) light-dark conditions on neuropeptidase activities in the retina and the anterior hypothalamus. The results demonstrated that there was left predominance in the retina under light conditions on a standard schedule. However, there was no asymmetry in the rest of groups. These results support an influence of environmental light and darkness on laterality and levels of neuropeptide-degrading activities, which may reflect concomitant changes in its susceptible substrates and consequently in their functions (Ramírez et al, 2001).

CONCLUDING REMARKS

Taken together, these results show the existence of laterality which depends on light (left predominance) or dark (in some cases right predominance) conditions. Therefore, we have demonstrated conclusively that an external factor, such as the environmental light conditions, influences endogenous neurochemical change in the levels of neuropeptidase activity in the retina and hypothalamus. Specific environmental conditions, such as programmed rhythms of light and darkness, can determine the existence and the side (left or right predominance) of laterality in the same locations. The endogenous substrates of neuropeptidases play a functional role in the retina, and the hypothalamus. Therefore, changes in their activity levels under different environmental conditions may reflect modifications in the function that the enzyme's substrates exert in these locations.

From the moment in which was verified that the human brain was in some aspects, asymmetrically organised, it was an attempt to assign an anatomical and/or neurochemical substrate to the lateralized brain functions. The extensive research performed on this subject has not yet derived in any coherent conclusion. Therefore, the teleological meaning of brain asymmetry, as a global concept, is not yet understood. Brain functions, evolutionary and with an unknown objective, have been developed predominantly in one hemisphere, such is the case of language. Hypothetically, specific brain functions, apparently symmetric or with a certain degree of asymmetry, might be processed asymmetrically or more asymmetrically, in response to external or internal stimuli. Brain functions, processed more or less asymmetrically could be under a universal operating system, which would consist in the reciprocal inhibition of homologue centres located in both hemispheres. The regulation of a large number of brain processes is based in a system of inhibitory-stimulatory feedback. This could explain the existence of neurochemical asymmetries, which arise, change the side of their predominance, or increase their degree of predominance under specific environmental conditions. This is an example, which connects the elegant geometrical order of nature with the biological plasticity that exists between the two brain hemispheres.

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