Centre for Integrative Physiology

Research Briefings

PEPTIDES, THE OLFACTORY SYSTEM, AND BEHAVIOUR

MANY PEPTIDES, WHEN RELEASED AS CHEMICAL MESSENGERS WITHIN THE BRAIN, HAVE POWERFUL INFLUENCES ON COMPLEX BEHAVIOURS. MOST STRIKINGLY, VASOPRESSIN AND OXYTOCIN, ONCE THOUGHT OF AS CIRCULATING HORMONES WHOSE ACTIONS WERE CONFINED TO PERIPHERAL ORGANS, ARE NOW KNOWN TO BE RELEASED IN THE BRAIN WHERE THEY PLAY FUNDAMENTALLY IMPORTANT ROLES IN MODULATION OF SOCIAL BEHAVIOURS.

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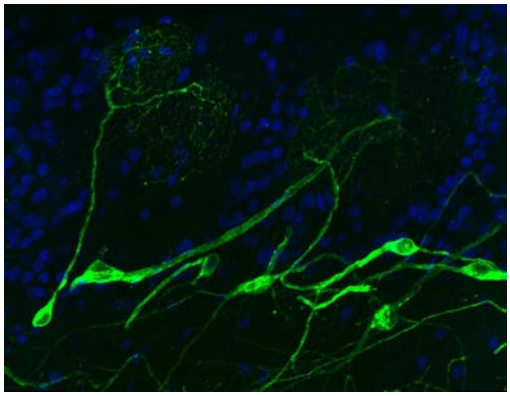
FROM DISCOVERY TO FUNCTION - VASOPRESSIN NEURONES IN THE OLFACTORY SYSTEM

This project is focused on newly discovered nerve cells within the olfactory bulb and the anterior olfactory nucleus (AON) that release the neuropeptide vasopressin. The olfactory bulb is the part of the vertebrate forebrain that is involved in olfaction, the perception of odours. In this large and complex structure, olfactory signals from the nose are processed, and the results of this information processing are conveyed via the olfactory tract and the AON to brain areas involved with behavior and memory. That is why when we smell something, it often brings back memories associated with the object. It is important to understand the role of vasopressin, because vasopressin acts in the brain to affect social behaviours, including social recognition, pair bonding, sexual behaviour and aggression, and these behaviours are linked with olfaction.

PHYSIOLOGICAL SIGNIFICANCE

Vasopressin helps us to recognise and remember other individuals. Rodents recognise others rodents by their smell, and vasopressin released within the olfactory system is important for processing of sensory signals. Vasopressin normally facilitates social recognition, but when it fails to function, animals are unable to recognise other individuals by their odour, indicating that no olfactory memory of the juvenile was formed.

The activity pattern of output cells from the olfactory bulb (mitral cells), recorded electrophysiologically, show long intermittent bursts of action potentials. Administration of vasopressin or a vasopressin V1 receptor antagonist modifies the electrical activity of the mitral cells. Vasopressin seems to be a retrograde signal that filters activation of the mitral cells arising from the glomeruli.



The vasopressin expressing cells in the olfactory bulbs are large ovoid neurons located close to the structures in the bulb that directly receive inputs from olfactory receptor cells (glomeruli). Each has several large dendrites one of which penetrates a single glomerulus where it gives rise to extensive small branches, suggesting that they receive direct inputs from olfactory nerve afferents.

Discrimination between familiar and unfamiliar members of a species requires an olfactory memory which is modulated by vasopressin.

VASOPRESSIN NEURONES IN THE ANTERIOR OLFACTORY NUCLEUS

The AON is a part of the brain involved in processing of odours, and it conveys the processed information to brain areas involved with behavior and memory. Olfactory "memories" are important for social behaviour in most mammals and often have strong emotional connotations. This project is focused on how emotional significance is attached to an olfactory memory.

The AON receives olfactory information from the olfactory bulb, but also receives inputs from parts of the brain that are activated by different emotional states. Many nerve cells in this region also make vasopressin. We have shown that vasopressin neurones in the AON are selectively involved in the coding of social odour information.

WHY IS THAT IMPORTANT?

The aims of these projects are to understand how vasopressin affects behaviour and memory within the olfactory system at the level of odour perception. Genetic variations in brain vasopressin signalling are associated with differences in social behaviours in humans as well as in animal models. Other nerve cells release peptides and they have effects on other emotions and behaviours and this has attracted wide attention because peptide mimetics may be valuable therapeutically for particular behavioural disorders.

Selected references:

Tobin VA, et al., (2010) An intrinsic vasopressin system in the olfactory bulb is involved in social recognition. *Nature* 464: 413-417

Wacker DW, et al., (2010) Expression of the immediate early gene product, Erg-1 in vasopressin neurones of the rat anterior olfactory nucleus following social odour exposure. *J Physiol* 588: 4705-4717.

Wacker DW & Ludwig M (2012) Vasopressin, oxytocin and social odour recognition. *Hormones & Behav* 61: 259-265.

Ludwig M & Leng G (2006) Dendritic neuropeptide release and peptide dependent behaviours. *Nat Rev Neurosci* 7: 126-136

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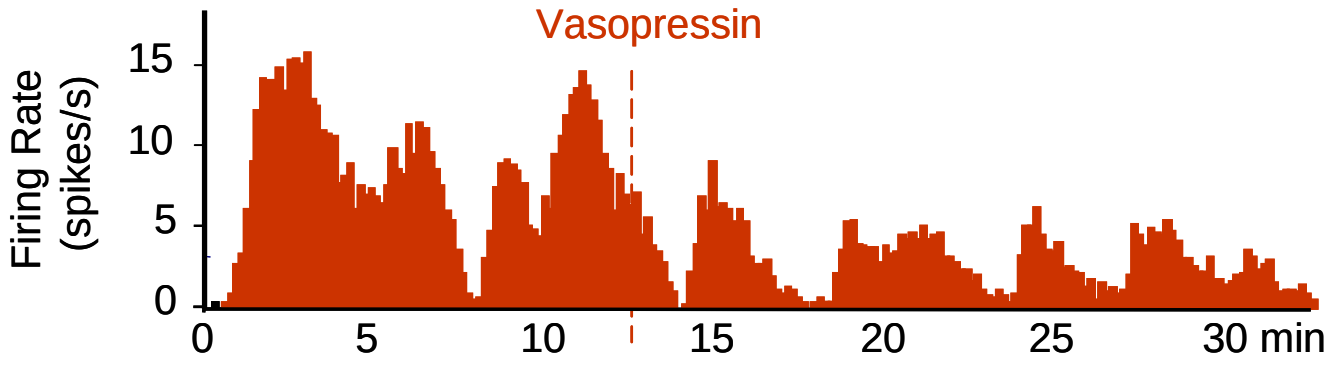

Administration of vasopressin decreases the electrical activity of olfactory mitral cells.