Are Neuropeptides Brain Hormones?

SUMMARY

Neurons use many different chemical signals to communicate information, including more than 100 different peptides. Many of these neuropeptides evoke specific and coherent behaviours and have been linked to a number of neurological disorders. Increasingly, we are recognising that peptide signals play a role in information processing that is quite unlike that of conventional neurotransmitters.

Transmitters versus peptides

Neuropeptides are a large and important class of messenger molecules that carry information between neurons in the brain. There are at least 100 different neuropeptides in the mammalian brain, and most of these are made in and released from the hypothalamus. Some are released into the blood, with peripheral effects as endocrine hormones. Of these, the magnocellular vasopressin and oxytocin neurons have proved to be a good model system for revealing important aspects of many neuronal functions, including neuropeptide release. The classical way that neurons communicate with each other is by neurotransmitter molecules that are packaged in small vesicles that are released at synapses between neurons. However, neuropeptides are packaged separately from neurotransmitters, and are released by different mechanisms from many parts of a neuron, including nerve endings, cell bodies and dendrites. The mechanisms for dendritic neuropeptide release can be very different from axon terminal release and, for vasopressin and oxytocin, differentially regulated release allows peptide effects in the body to be independent from peptide effects in the brain.

Secret versus public

Neuropeptides usually interact with G protein-coupled receptors to activate signalling pathways that can affect many different aspects of cells. Neuropeptides often act back on their cells of origin, for example to facilitate the development of patterned electrical activity. They can

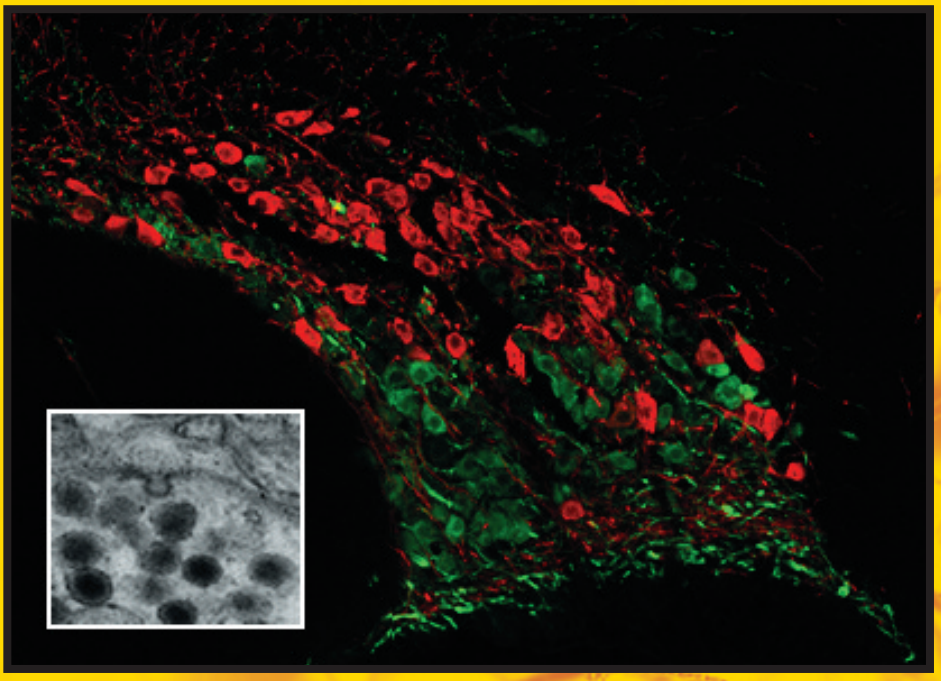


Figure 1 (opposite): In the supraoptic nucleus the dendrites of vasopressin (green) and oxytocin (red) neurons project towards the ventral surface of the brain. Inset: An "omega" fusion profile captured in an electron microscopic section shows the pit in the dendritic membrane that remains after release of a vesicle.

Figure 2 (overleaf): "Brain WiFi". Non-synaptic peptide release from magnocellular neurons in the hypothalamus may "broadcast" a hormone-like signal which triggers peptide-dependent behaviours.

also act on their neighbours to bind the collective activity of a neural population into a coherent signalling entity. Finally, the co-ordinated population output can transmit waves of peptide secretion that act as a patterned hormonal analogue signal within the brain. At their distant targets, peptides can re-programme neural networks, by effects on gene expression, synaptogenesis, and through functionally rewiring connections by priming activity-dependent release. Classical neurotransmitters pass "whispered secrets" from one particular cell to another; they carry a message that matters only at a particular time and a particular place. By contrast, neuropeptides are "public announcements", the messages endure, at least for a while; they are messages not from one cell to another, but from one population of neurons to another – these are hormone-like signals.

Prime targets

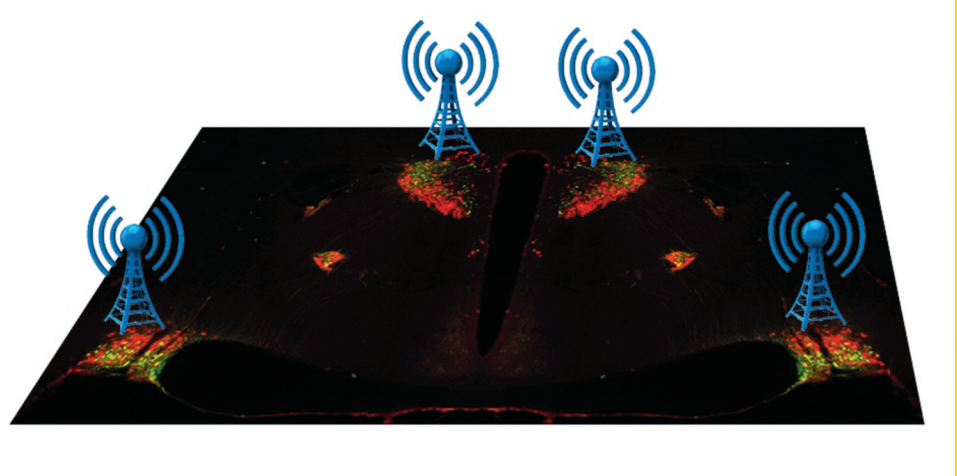
In the hypothalamus, large amounts of oxytocin and vasopressin are released from neuronal dendrites independently of release from nerve terminals. Dendritic peptide release can be modulated by *priming*. Priming involves making vesicles readily available for subsequent activity-dependent release, thus enhancing the capacity for the local interactions that co-ordinate neuronal activity. By enhancing intercommunication, peptides can "reprogramme" the behaviour of a neuronal system. Peptides might also prime target areas within the brain which harbour their receptors, triggering a cascade of temporary functional reorganisation of the neuronal networks, providing the substrate for prolonged behavioural effects.

Behaving yourself

Many different peptides evoke specific effects on behaviour. For example, oxytocin is involved in social behaviours, including bonding and maternal behaviour, and vasopressin acts in the brain to affect social recognition and aggression. Other nerve cells release other peptides and they have effects on other emotions and behaviours. For example, neuropeptide Y increases food intake and orexin regulates sleep and wakefulness through interactions with neuronal systems that are closely related with emotion, reward, and energy homeostasis. Evidence of the hormonal nature of the behavioural effects of peptides comes from experiments involving gene manipulation, either through transgenic mutations or viral gene transfer, showing that behavioural traits accompany alterations in the distribution of peptide receptor expression. Thus, it appears that it is not the distribution of projections of peptidergic neurons in the brain that determines particular behaviours, but the distribution of the peptide receptors.

"……behavioural traits accompany alterations in the distribution of peptide receptor expression."

Translational studies are now beginning to bridge the insights emerging from studies of social cognition and social behaviour in animals to human research. Vasopressin and oxytocin have been linked to human neurological disorders such as social anxiety disorder, depression, schizophrenia and autism spectrum disorder. In addition, disorders of appetite regulation, libido, and mood are among many potential targets of peptide-based therapies. In the future, 'sniffing' neuropeptide analogues (intranasal administration) may open a gateway to the brain, and diffusion of the peptides to their receptor sites may be an alternative way for treatment of some of these disorders.



Author:
Professor Mike Ludwig
Centre for Integrative Physiology
University of Edinburgh, UK

Editor:
Dr R John Bicknell
The Babraham Institute
Babraham Research Campus
Cambridge CB22 3AT UK
john.bicknell@bbsrc.ac.uk

For further reading references, additional copies and general information, please contact the editor

The full Briefings series can be viewed at website http://www.neuroendo.org.uk

© The British Society for Neuroendocrinology, 2010