

SPARSE DISTRIBUTED REPRESENTATIONS IN PERCEPTUAL AND MEMORY SYSTEMS IN THE BRAIN.

Edmund T Rolls

University of Oxford, Department of Experimental Psychology, South Parks Road, Oxford OX1 3UD.

Edmund.Rolls@psy.ox.ac.uk

<http://www.cns.ox.ac.uk>

Much of the information in the responses of single neurons in the primate temporal visual cortex about which visual stimulus has been seen is contained in the firing rate of the neurons, and is available in periods of the firing as short as 50 or even 20 ms (see Rolls and Treves, 1998). The information theoretic approach has been extended for application to the activity of the responses of many neurons to a set of stimuli, and it has been shown that the information (for example about which object has been shown) rises approximately linearly with the number of neurons in the population. This means that the encoding is distributed, that the information provided by different neurons is almost independent (with a large stimulus set), and that the number of stimuli that can be encoded increases exponentially with the number of neurons in the population (see Rolls, Treves and Tovee, 1997; Abbott, Rolls and Tovee, 1996). This property is seen even with neurally plausible, dot product, decoding. The implication is that the code can be read off from this part of the visual system (and from the hippocampus where the information is about spatial view, see Rolls, Robertson and Georges-François, 1997; Rolls et al, 1998; and from the orbitofrontal cortex where the information is about odour) just by measuring the firing rates of small populations of neurons. Little additional information is added by knowing the relative time of firing of the different neurons in population of inferior temporal cortex neurons, that is, synchronization of firing is not an important factor in conveying information in these primate inferior temporal cortex neurons (Panzeri et al, 1999). These experiments provide evidence that there is an object-based representation of objects, as well as faces, in the primate temporal cortical visual areas (Booth and Rolls, 1998). This may be a representation of 3D objects based on learning about the 2D views of each object (Rolls, 2000; Rolls and Deco, 2002).

References

- Rolls, E.T. and Treves, A. (1998) Neural Networks and Brain Function. Oxford University Press: Oxford.
- Rolls, E.T. and Deco, G. (2002) Computational Neuroscience of Vision. Oxford University Press: Oxford.
- Rolls, E.T. (2000) Functions of the primate temporal lobe cortical visual areas in invariant visual object and face recognition. Neuron 27: 205-218.
- Rolls, E.T., Treves, A. and Tovee, M.J. (1997) The representational capacity of the distributed encoding of information provided by populations of neurons in the primate temporal visual cortex. Experimental Brain Research 114: 149-162.
- Panzeri, S., Schultz, S.R., Treves, A. and Rolls, E.T. (1999) Correlations and the encoding of information in the nervous system. Proceedings of the Royal Society B 266: 1001-1012.
- Booth, M.C.A. and Rolls, E.T. (1998) View-invariant representations of familiar objects by neurons in the inferior temporal visual cortex. Cerebral Cortex 8: 510-523.
- Abbott, L.F., Rolls, E.T. and Tovee, M.J. (1996) Representational capacity of face coding in monkeys. Cerebral Cortex 6: 498-505.

- Rolls,E.T., Critchley,H.D. and Treves,A. (1996) The representation of olfactory information in the primate orbitofrontal cortex. Journal of Neurophysiology 75: 1982-1996.
- Rolls,E.T., Treves,A., Tovee,M. and Panzeri,S. (1997) Information in the neuronal representation of individual stimuli in the primate temporal visual cortex. Journal of Computational Neuroscience 4: 309-333.
- Rolls,E.T., Treves,A., Robertson,R.G., Georges-François,P. and Panzeri,S. (1998) Information about spatial view in an ensemble of primate hippocampal cells. Journal of Neurophysiology 79: 1797-1813.
- Tovee,M.J. and Rolls,E.T. (1995) Information encoding in short firing rate epochs by single neurons in the primate temporal visual cortex. Visual Cognition 2: 35-58.