Symposium 1: Brain mechanisms of recognition memory

Organized by J.J. Bolhuis

Symp 1/1

RECOGNITION MEMORY: NEURONAL SUBSTRATES FOR THE JUDGEMENT OF PRIOR OCCURRENCE

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Recognition memory requires identification of stimulus items together with a judgement concerning their prior occurrence. Judgements concerning prior occurrence may make use of discriminations of familiarity or recency, or recollections of context. Judgements may concern individual items or spatial arrangements of groups of items. In consistency with the results of recent ablation studies, the responses of neurones in a system centred on perirhinal cortex have characteristics concordant with those required for familiarity and recency discrimination concerning individual items (Brown & Xiang 1998). Such neurones respond strongly on first encounters with unfamiliar visual stimuli but only weakly when the stimuli are encountered subsequently. The response decrements are produced by a single encounter and thus demonstrate single trial learning. The decrements carry information about the identity of stimuli, being selective for particular previously encountered stimuli. These decrements survive many intervening, distracting presentations of other stimuli and, for many neurones, last for more than 24 h: accordingly, they display long-term memory. Discrimination of prior occurrence within this population of neurones is very fast (Xiang & Brown 1998). Moreover, theoretical modelling indicates that a network using principles based on the observed properties of the neurones is extremely computationally efficient, being very fast and having a large storage capacity: the evolutionary advantages of possessing such a system for novelty discrimination are likely to be correspondingly high. Furthermore, the possession of such a system removes a need for changes to be made in perceptual classifying systems in order to record the occurrence of a stimulus. Neuronal response decrements are observed for a variety of different types of visual stimuli and are found both during the performance of explicit recognition memory tasks and when there is no behavioural contingency and the stimuli have not been used in training. These response decrements are therefore endogenous and automatic rather than being induced by training. Such neuronal response decrements are found in rats and monkeys and are consistent with measurements made during familiarity discrimination by humans. In contrast to the perirhinal system, a system involving the hippocampus is involved in discriminating the prior occurrence of spatial arrangements of individually familiar items (Wan et al. 1999). This hippocampal system may be important for recognition memory involving the recollection of associations and the context of an occurrence (Aggleton & Brown 1999).

Aggleton JP & Brown MW (1999) *Behav. Brain Sci.* (in press); Brown MW & Xiang JZ (1998) Progr. Neurobiol. 55: 149; Wan H et al. (1999) *J. Neurosci.* 19: 1142; Xiang JZ & Brown MW (1998) *Neuropharmacology* 37: 657.

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Symp 1/2

IMAGING THE HUMAN BRAIN IN RECOGNITION MEMORY TASKS

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In this talk I will consider neural processes associated with visual recognition from the perspective of functional neuroimaging, using positron emission tomography (PET) and functional magnetic resonance imaging (fMRI). The focus will be on neural responses in extra-striate regions during face and object recognition. Three experiments will be described in which recognition processes for faces were manipulated either by varying the resolution of the images, the familiarity of the stimuli or by perceptual priming. Distinct patterns of neural response are observed in fusiform regions as a function of these manipulations. Although it has been proposed that perceptual priming is associated with decreased neural response in extra-striate regions I will present evidence for a more complex pattern of response that reflects not only prior stimulus exposure, the phenomenological experience associated with stimulus presentation but also whether the stimulus is recognised as familiar.

Symp 1/3

PROPERTIES OF NEURONS IN A VISUAL RECOGNITION MEMORY SYSTEM

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A necessary condition for understanding the neural mechanisms of memory is to localise the brain regions in which is stored information acquired through learning. There are few examples of such localisation, but one such region is found in the domestic chick: the IMHV, especially in the left hemisphere, stores information acquired through visual imprinting- a learning process through which chicks come to recognise an object and to approach it preferentially. IMHV corresponds to mammalian association cortex. Lesions of IMHV before or shortly after training impair the acquisition or retention respectively of an imprinted preference, without affecting various other measures of behaviour. Learning-related changes in synaptic structure/function occur there, several of them in a time-dependent manner. There is also a learning-related increase in Fos-like immunoreactivity. The increase is localised to a population of neurons immunopositive for GABA and parvalbumin, but not for calbindin-D28k. Similar increases in the amounts of certain neural cell adhesion molecules are found in IMHV 24h after training, suggesting that neurons involved in storage may become structurally interlocked. Microelectrode recordings from neurons in the IMHV of behaving chicks have shown that training leads to an increase in the number of neurons responding selectively to the imprinted stimulus, and that these changes evolve over time. Some neurons in IMHV respond similarly to a stimulus irrespective of its distance from the chick (distance-invariant/constancy neurons) and so may signal that a particular object placed near to or far from the chick is the same object. Other IMHV neurons' responses vary with the distance the object

is away and so may signal the distance of the object. Distance-invariant neurons respond to stimuli of which the bird has had little prior experience and are present in chicks which have had no opportunity to explore an extended spatial environment suggesting that their distance- invariant properties are not contingent on learning. The action potential waveform, and possibly therefore the morphology of distance-invariant neurons is different from that of neurons with other functional properties. Additionally, some IMHV neurons' rate of discharge is correlated with a chick's approach activity (approach-related neurons). Recognition is common to many forms of learning, including imprinting and associative learning, where a particular stimulus may elicit specific actions (e.g. approach/press/eat.). Such learning suggests that neurons involved in recognition may become *functionally connected to* neurons controlling specific motor responses. It remains to be shown whether IMHV approach-related neurons directly influence motor neurons, or discharge as a consequence of locomotion. These results together demonstrate that IMHV contains different classes of neurons that may play different roles in learning and memory.

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Symp 1/4

OLFACTORY RECOGNITION: A SIMPLE MEMORY SYSTEM

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A memory system that has played an important part in the organisation of mammalian behaviour is that of the olfactory system. The simplest of these olfactory recognition memories occur in the context of olfactory block to pregnancy. Female mice have an olfactory (pheromone) recognition memory that is acquired with one-trial learning, contingent on mating and individually specific to the male that mates. For mice, this recognition memory is clearly of biological importance, for without it there would be high risk of pregnancy failure. Studies which have transiently disabled each relay site along the central neural projection pathway have identified the accessory olfactory bulb (AOB) as the site for critical synaptic changes in the recognition process. The synaptic circuitry of the AOB is comparatively simple and similar to that of the main bulb. Mitral cells receive afferents from the vomeronasal nerve and project to the medial amygdala, forming the excitatory pathway to the hypothalamus for reproductively relevant pheromonal signals. The mitral cells form reciprocal dendrodendritic synapses with granule cells, the main class of interneuron in the AOB. Granule cell synapses are depolarised by an excitatory amino acid input from the mitral cells, and in turn provide a feedback inhibition to the mitral cells via GABA release. This interaction between mitral and granule cells, at the reciprocal synapse, regulates mitral cell activity by negative-feedback. Since noradrenaline has been shown to reduce the inhibition exerted by granule cells, then sustained excitation of mitral cells may be expected to occur at mating. This condition can be mimicked without mating, by local infusions of the $GABA_b$-receptor antagonist, bicuculline, in the presence of male pheromones. The formation of olfactory memory can take place in