Brain Mechanisms of Memory and Cognition – 1

Cerebral cortex; the two visual streams

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Monday 12, 19, 26 Jan; 2, 9, 23 Feb 2004; 10 am
Physiology Main Lecture Theatre
Slides will be at pobox.com/~rudolf/psychology
Part 1

Cerebral cortex
Heterogeneity of cerebral cortex

Brodmann’s areas in the human

Brodmann (1909)
Heterogeneity of cerebral cortex

from Fuster (1995)
Heterogeneity of cerebral cortex: study techniques
Layers of the cerebral cortex: appearance

from Fuster (1995)
Layers of the cerebral cortex: connections

- Corticocortical connections via many layers, esp. from 3 and to 1-3
- Specific thalamic afferents to layer 4
- Outputs to subcortical structures from layer 5
- Outputs to thalamus from layer 6
- Neuromodulatory inputs to all layers

*modified from Fuster (1995)*
The column: a basic unit of cortical function?

Figure 4.4 An idealized column of cortex comprising and defined by the terminal branches of a corticocortical afferent axon (three functional assumptions are noted in the diagram). The column is flanked by sections of two specific (thalamic) afferent cylinders. AAC, axoaxonic cell; ATC, axonal tuft cell; BC, basket cell; CDB, cell à double bouquet; SBC, small basket cell; SS, spiny stellate cell. (From Szentágothai, 1983, with permission.)

_from Fuster (1995)_
Developmental plasticity in kitten visual cortex: critical periods

Hubel & Wiesel (1970)
Plasticity in kitten visual cortex: ocular dominance columns

normal

deprieved (white label is from open eye)

Hubel & Wiesel (1977)
Adult cortical plasticity in a somatosensory map

A. Location of Map

B. Representation Order

C. Normal Map

Merzenich et al. (1983, 1984); see Kaas (1995)
Rapid, long-lasting, task-related auditory cortex plasticity

Weinberger (1995)
Long-term potentiation (LTP): a form of synaptic plasticity...

A Cooperativity

Before

After

Weak

Strong

B Associativity

Before

After

C Specificity

Before

After

A

B

plastic synapse

site of association
... of which there are several

from Fuster (1995)
Synaptic metaplasticity: Bienenstock-Cooper-Munro model

According to the Bienenstock-Cooper-Munro theory, this threshold increases when the postsynaptic cell has been active recently (and decreases when it hasn't).

*Bienenstock, Cooper, Munro (1982)*
Part 2
Visual streams
Two visual streams

**dorsal:** ‘where’ (or ‘how’)

**ventral:** ‘what’

*Mishkin et al. (1983)*
Concurrent (parallel) processing begins at the retina

DeYoe & van Essen (1988)  
fMRI of V4 during colour perception

McKeefry & Zeki (1997) Brain 120: 2229
fMRI of V4 during colour perception

McKeefry & Zeki (1997) Brain 120: 2229
Achromatopsia following V4 lesions in humans


Hemiachromatopsia following a unilateral V4 lesion (Zeki 1990)
Colour (V4) and motion (V5)

colour (versus monochrome)

moving dot image (versus still)

V1/V2 active in all conditions

Zeki (1993)
Apparent motion and V5

‘Enigma’, by Isia Levant.

Apparent motion is correlated with V5 activation.

Zeki (1993)
The logic of double dissociations applied to lesion studies

- Dissociation of function: when a manipulation (e.g. a lesion) impairs one aspect of function, but not another.

- Single dissociations may occur be because A and B are distinct information-processing systems, or may simply reflect (for example) task difficulty.

- Double dissociations rule out the latter interpretation and imply independence of A and B for specific functions in at least some situations.
Beyond occipital cortex: ‘what’ versus ‘where’

Mishkin et al. (1983)
Two visual streams: close-up on the ventral stream

from Zigmond et al. (1999)
Two visual streams

**dorsal:** ‘where’ (or ‘how’)

**ventral:** ‘what’

*Mishkin et al. (1983)*
Progressing anteriorly along the ventral stream:

- Roughly, V1 $\rightarrow$ V2 $\rightarrow$ V4 $\rightarrow$ TEO $\rightarrow$ TE $\rightarrow$ temporal pole/perirhinal cortex.

Note feedback projections, projections to frontal lobes, side projections inc. to STP, subcortical projections (basal ganglia, amygdala, pulvinar), interhemispheric connections.

- Receptive fields get larger; retinotopicity lost.

- ‘Trigger features’ become more complex and specific. i.e. object detection.

- Mnemonic effects (e.g. habituation, firing when an object isn’t present) more prominent.
A simple orientation-selective cell in V1...

Hubel & Wiesel, 1959
... and a face-responsive neuron in STP

Bruce et al. (1981)
Electrophysiology of face-response areas in humans
