Lecture 1: Multiple Visual Areas

Traditional notions of localisation of function within brain and concomitant variations in structure:

– e.g. Brodmann's cytoarchitectonic areas[1].

Formal definition of a cortical area e.g. V1:

– cyto, myeloarchitecture (stria of Gennari);
– sources of input / output (LGN);
– polar visual map (configuration, major meridians, magnification factor);
– distinctive response properties (monocularity).

Application of these criteria to define higher visual areas V2, V3, V3A, V4 & V5:

– multiple, parallel output from V1 implies several higher areas of prestriate cortex
– V2 & V3: split representations of inferior and superior quadrants - see fMRI studies[2,3];
resulting 'quadrantic' field deficits in cases of prestriate occipital lesions[4]
– V5: myeloarchitecture; input from V1; direction selectivity;
– V4: colour selectivity;

Use of the distribution of callosal fibres to locate representations of the vertical meridian (VM), hence junctions of separate maps, and hence borders of visual areas.

Higher visual areas

Problems in applying criteria for defining discrete higher areas in macaques.

e.g. – architecture: distinct zones are difficult to identify;
– visual maps may be distorted, irregular or absent;
– patterns of inter-area connectivity can be highly overlapping;
– response selectivities are complex - can be very difficult to decide if there is any common functional characteristic of an area.

The 'area' hypothesis: given these difficulties, the subdivision of the entire cortex into discrete areas remains a working hypothesis, as opposed to an established 'fact' of cortical organization. (NB. refer to 'face patches' in Lecture 2).

Human functional Imaging studies

– Areas may be identified by charting visual field maps (e.g. V1, V2 V3) [2,3];
– or, by noting functional specialization, e.g:

area V4 - colour & form processing;
area LO - (Lateral Occipital) object form recognition;
area PPA - parahippocampal place area;
area V6 - motion processing for peripheral visual field;
area V5 - motion processing;
area FFA - fusiform face area;
area VWFA - visual word-form area.

- NB. Note the discrepancy in arrangement of area V4 between human and monkey [5,6]

Specific sources

1. *Brodmann's areas 17 and 18 brought into stereotaxic space-where and how variable?* Amunts , Zilles et al. (2000) Neuroimage 11, 66-84.
2. *Borders of multiple visual areas in humans revealed by functional magnetic resonance imaging.* Sereno MI et al. (1995) Science, **268**: 889-893.
3. *Visual field representations and locations of visual areas V1/2/3 in human visual cortex.* Dougherty et al. Journal of Vision. **3**: 586-598. (2003).
4. *Quadrantic visual field defects: a hallmark of lesions in extrastriate (V2/V3) cortex.* Horton JC & Hoyt WF (1991) Brain, **114**: 1703-1718.
5. *The retinotopic organization of the human middle temporal area MT/V5 and its cortical neighbors.* Kolster et al. (2010) Journal of Neuroscience 30: 9801-9820.
6. *The retinotopic organization of macaque occipitotemporal cortex anterior to V4 and caudoventral to the middle temporal (MT) cluster.* Kolster et al. (2014) Journal of Neuroscience 34: 10168-10191.

Basic Reading

A Vision of the Brain Zeki, Blackwell, Oxford 1993

chapters 3, 7, 8, 11, 12, 13, 14, 17 & 18 - all very short and readable, summarise this older work

More advanced reading

Multiple Visual Areas

Organization of Visual Areas in Macaque and Human Cerebral Cortex.
Van Essen DC (2003) In: The Visual Neurosciences pp 507-521 (Ed. Chalupa & Werner, Cambridge, MA: MIT Press.

The human visual cortex.
Grill-Spector &, Malach (2004) Annual Review Neuroscience 27: 649-677

Visual field maps in human cortex.
Wandell et al (2007) Neuron 56:366-383.

Centenary of Brodmann's map--conception and fate.
Zilles & Amunts (2010) Nature Reviews Neuroscience 11: 139-145.

The evolution of distributed association networks in the human brain.
Buckner & Krienen (2013) Trends Cognitive Sciences 17:648-65.

Monkey Cortex through fMRI Glasses.
Vanduffel et al. (2014) Neuron 83: 533-550.

A multi-modal parcellation of human cerebral cortex.
Glasser et al. (2016) Nature 536: 171-178.

Human brain lesion (neuropsychology)

Achromatopsia

A century of cerebral achromatopsia.
Zeki S (1990) Brain 113:1721-1777.

Behavioral deficits and cortical damage loci in cerebral achromatopsia.
Bouvier SE & Engel SA (2006) Cerebral Cortex. 16:183-191.

Akinetopsia

Cerebral akinetopsia (visual motion blindness).
Zeki S (1991) Brain 114:811-824.

Disturbance of movement vision after bilateral posterior brain damage. Further evidence and follow up observations.
Zihl J et al (1991) Brain. 114:2235-2252.

Prosopagnosia, Alexia, Topographagnosia

Agnosia for scenes in topographagnosia.
Mendez MF & Cherrier MM (2003) Neuropsychologia 41:1387-1395.

The neural bases of prosopagnosia and pure alexia: recent insights from functional neuroimaging.
Kleinschmidt A & Cohen L (2006) Current Opinion in Neurology 19:386-391.

The unique role of the visual word form area in reading.
Dehaene and Cohen, Trends in Cognitive Sciences. 15: 254-62 (2011).