## *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 (e.g. stria of Gennari);
– sources of input / output (e.g. input from LGN );
– map of sensorium (e.g. polar visual map; configuration, major meridians, magnification factor);
– distinctive response properties (e.g. monocular receptive fields).

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[5 6] remains a working hypothesis, as opposed to an established 'fact' of cortical organization. (NB. refer to 'face patches' in Lecture 3).

**Human functional Imaging studies**

– Areas may be identified by charting visual field maps [2 3 7 8];
– or, by noting functional specialization, e.g:

area V4 - colour & form processing;
area V5 - motion processing;
area LO - (Lateral Occipital) object form recognition;
area FFA - fusiform face area;
area PPA - parahippocampal place area;
area VWFA - visual word-form area.
area V6 - motion processing for peripheral visual field[9 10];

- NB. Note the discrepancy in arrangement of area V4 between human and monkey[7 8]

### *Specific sources*


1. Amunts K *et al.* (2000) *Brodmann's areas 17 and 18 brought into stereotaxic space-where and how variable?* Neuroimage. 11: 66-84.
2. Sereno MI *et al.* (1995) *Borders of multiple visual areas in humans revealed by functional magnetic resonance imaging*. Science. 268: 889-893.
3. Dougherty RF *et al.* (2003) *Visual field representations and locations of visual areas V1/2/3 in human visual cortex*. J Vis. 3: 586-598.
4. Horton JC, Hoyt WF (1991) *Quadrantic visual field defects: a hallmark of lesions in extrastriate (V2/V3) cortex*. Brain. 114: 1703-1718.
5. Felleman DJ, Van Essen DC (1991) *Distributed hierarchical processing in the primate cerebral cortex*. Cereb Cortex. 1: 1-47.

6. Markov NT *et al.* (2014) *A weighted and directed interareal connectivity matrix for macaque cerebral cortex*. Cereb Cortex. 24: 17-36.

7. Kolster H *et al.* (2010) *The retinotopic organization of the human middle temporal area MT/V5 and its cortical neighbors*. J Neurosci. 30: 9801-9820.

8. Kolster H *et al.* (2014) *The retinotopic organization of macaque occipitotemporal cortex anterior to V4 and caudoventral to the middle temporal (MT) cluster*. J Neurosci. 34: 10168-10191.

9. Pitzalis S *et al.* (2010) *Human V6: the medial motion area*. Cereb Cortex. 20: 411-424.

10. Pitzalis S *et al.* (2015) *The human cortical areas V6 and V6A*. Vis Neurosci. 32.

### *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*

*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).