Visual streams

Traditional theory: "what" (ventral; TEO, TE) versus "where" (dorsal; MT, PG). But note how retinal cues contribute in multiple ways to perceived attributes (DeYoe & van Essen, 1988). Called "object vision" and "spatial vision" by Mishkin *et al*. (1983). Area TE lesions impair visual recognition (i.e. memory). Neurons there have very large RFs (stimulus equivalence across retinal translation). Area PG is a polysensory area – supramodal spatial ability? (Lesions cause neglect…)

Goodale & Milner (1992) emphasise output (function) not input, as evolution would, and see the streams as "what" (ventral) versus "how" (dorsal).

- **Dorsal stream.** Patients with optic ataxia as a result of parietal damage have defects in reaching to targets they can recognize – but not only reaching in the right direction, but in positioning their fingers or adjusting the orientation of the hand appropriately. Similar defects occur in Balint's synrome: no scaling of grasping movements, many corrections to movemt. A patient with a parietal injury performed poorly when visual guidance was needed to learn the correct route through a small maze by moving a hand-held stylus. Yet he could move his body through a maze with a map, could remember complex geometrical patterns and could carry out a task involving spatial STM.
- **Ventral stream.** Patient DF had damage to areas 18 & 19. She could not recognize the shape, size or orientation of visual objects, but showed strikingly accurate guidance of hand and finger movements directed at the very same objects. For example, presented with rectangular blocks, she could not indicate with thumb and index finger how large a block was, but when she was asked to pick up the block, the aperture between finger and thumb scaled appropriately. A similar dissociation occurred for orientation.
- **Theory.** The visual projection to parietal cortex provides action-relevant information about the structural characteristics and orientation of objects and not just about their position. It mediates visual guidance and integration of prehensile and other skilled actions. Projections to the temporal lobe may furnish our visual perceptual experience.
- **Electrophysiology.** PPC neurons (and neurons in the input areas to it, V3A and MT) have large RFs, like those of IT. Spatial selectivity is not their most striking feature: it is that their responses depend greatly on the current behaviour of the animal with respect to the stimulus (including cells that are selective for the visual qualities of an object that determine the posture of the hand and fingers during grasping, i.e. size and orientation). PPC receives input from areas that detect motion (MT, MST) – as you would expect for a map of egocentric space. Many motion-sensitive cells in PPC are well-suited for the visual monitoring of limb position during reaching; motion-sensitive cells in the temporal lobe have been reported not to respond to such self-produced visual motion. The PPC is linked to the premotor regions of frontal cortex implicated in ocular control, reaching movements of the limb, and grasping actions of the hand and fingers. Many temporal lobe cells maintain their selective responsiveness over a wide range of size, colour, optical and viewpoint transformations of objects – useful for identification of objects, but they specifically ignore the cues necessary for guiding action. Consistent with this, lesions of IT reduce monkeys' ability to generalize recognition of a 3D shape across viewing conditions. *Object-centred (ventral) versus viewer-centred (dorsal).*
- **Attention** seems to be spatially selected, whether for identification or action. It may be that visual attention is non-unitary, associated with the ventral as well as the dorsal stream. Humans performing manual aiming movements have a predilection to attend to visual stimuli in the 'action space' of the hand (dorsal attention system?). The focus of lesions causing human unilateral neglect is parietotemporal (unlike the superior parietal focus for optic ataxia), as is the focus for object constancy impairments. Attentional effects are seen in neurons of both streams, and deficits in 'landmark' tasks (which, following parietal damage, may be primarily due to failure to attend or orient rather than failure to localize) occur after IT as well as PPC damage.
- **Visual awareness.** It may be that the dorsal stream is / can be processed unconsciously. This might prevent interference with the perceptual constancies intrinsic to many operations within the ventral stream that do result in awareness (intrusion of viewed-centred information might disrupt object continuity across changing viewpoints and illuminations). This predicts occasions where subjects are unaware of visual changes to which the motor system adapts – during visually guided aiming, subjects were unable to report, even during forced-choice testing, whether or not a target had changed position during a saccade, even though correction saccades and manual aiming movements showed near-perfect adjustments for the unpredictable target shift. An illusory perceptual constancy of target position was maintained in the face of large amendments in visuomotor control. Similarly, the illusion of slowed motion of a moving coloured object that is experienced at equiluminance does not prevent accurate ocular pursuit under the same conditions. *Note* the systems talk to each other and may be simultaneously active. It is feasible, though, to suggest that ventral system activation is *necessary* for visual awareness.