Lecture 4: The Neural Correlate of Consciousness (NCC)

Introduction

– What is consciousness?

The physiological basis of subjective awareness remains a genuine scientific mystery (the 'hard' problem of consciousness)
Definition of the function of consciousness;
Definition of the 'NCC'.

– Does visual consciousness equate to awareness of all information encoded in each area?

No, because some neural encodings demonstrably do not reach awareness:-

- Destruction of V1 may leave residual 'blindsight' - possibly contingent on LGN output bypassing V1[1]
- The existence of monocular neurons in V1;
- V1 neurons whose spatial frequency sensitivity exceeds perceptual acuity[2]
- Phenomena such as 'motion-induced blindness'[3], 'change blindness' & 'inattentional blindness'.

Hence, the NCC concerns those neural encodings/operations that do result in awareness.

NCC may be classified by brain location…

The retina is outside the NCC:

- Hallucinatory perception possible within retinally blindfield (Charles Bonnet syndrome)[4]

Is area V1 outside the NCC ? YES ! - as supposed by Crick & Koch (1995) [5]

- YES (?) – because V1 has no direct communication with frontal planning areas;
- YES (?) – because monocular neurons in V1 do not give a percept of monocular stimulation.
- YES (?) – because V1 wavelength tuned cells fail to correlate with colour percepts;
- YES (?) - Blindsight 'Riddoch' syndrome, awareness of motion in the absence of visual sensation proper [6]
- YES (?) – Absence of motion vision caused by V5 lesion, despite V1 being intact [7]
- NO (?) - TMS to V1 modulates feedback from V5 & motion percept [8]
- YES (?) - This is still an active debate (2011)… (awareness v non-awareness fails to modulate V1 activity)[9]

The feedback hypothesis of NCC

– Theory of recurrent (or re-entrant) processing being the key ingredient of NCC (Lamme, 2006)

- The time course of the neural activity in V1 correlating with correct detection of a target is consistent with an origin in feedback from higher areas [10]

The NCC as an experimental paradigm, or strategy

– Use of bistable percepts , e.g. binocular rivalry (BR)

- Bistable perceptual phenomena imply neural competition
- Physiological phenomena correlating with bistable percepts may be part of NCC
- Eye-switching experiment implies an important component of BR is 'image rivalry', in addition to eye rivalry [11]

Correlates of rivalry in BOLD signal (fMRI studies of human perception)

– Face v house paradigm reveals focus of activity switching between FFA and PPA [12]
– Vertical v horizontal grating reveals rivalrous activity in V1 (use blindspot to resolve ocular-specific activity)[13]
– Higher resolution scan shows rivalrous activity in LGN, as well as V1[14]

Correlates of rivalry in single unit activity

– Increasing proportion of bistable modulating neurons through areas V1, V4 and IT cortex; [15 16]

- Also found in human hippcampal formation [17]
- Note use of 'flash-suppression' version of rivalry
- Single neuron activity recorded in monkey LGN not reported to modulate with rivalry [18]
- Local Field Potential (LFP) signal recorded in V1 also modulates, at 'gamma' frequencies [19]
  - LFP is more analogous to BOLD signal recorded by fMRI

General Reading

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Towards a true neural stance on consciousness.
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Haynes, Trends in Cognitive Sciences. 13: 194-202 (2009).

Neuronal gamma-band synchronization as a fundamental process in cortical computation.
Fries, Annual Review of Neuroscience. 32: 209-224 (2009).

Can binocular rivalry reveal neural correlates of consciousness?
Blake *et al.* Philos Trans R Soc Lond B Biol Sci. 369: 20130211 (2014).

Neural correlates of consciousness: progress and problems.
Koch *et al.* Nature Reviews Neuroscience 17: 307-321 (2016)

Website with abundant practical & theoretical information (& video) all regarding retinal rivalry:
www.jove.com/details.stp?id=2030

Specific Sources

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