

What is visual memory?

- In a broad sense, visual memory can refer to any neural, or behavioural phenomenon that implies storage of a past visual experience.
- Incorporates experiences of recognition, familiarity, recollection and imagery.
- An important dimension to classify such experiences is 'semantic' v 'episodic' memories.
 - o These describe different means of memory formation, or encoding.
- Semantic visual memory implies the following:
 - o knowledge – ability to recognise/recall categories of objects, and distinct individual exemplars;
 - o typically acquired through multiple, repeated viewing experience;
- Episodic memory implies the following:
 - o Memory of a visual scene or image from a 'one-off' experience;
 - o Requires learning a single instance of association between objects, or elementary features.
 - o Autobiographical
- The distinction between episodic and semantic is not hard and fast – it is more of a continuum
 - o E.g. memories of places, landmarks and route finding knowledge may have intermediate qualities
- 'Familiarity' and 'recollection' are different forms of memory retrieval:
 - o Familiarity is recognition without association;
 - o Recollection is recognition accompanied by association with other memories, or context;
- Therefore can classify an act of memory according to a 2x2 system:
 - o as either semantic/episodic & as either recollection/familiarity;
 - o Episodic familiarity for the *total* context of a scene ought not be possible – it is the curious sensation known as 'déjà vu'.

The role of the medial temporal lobe (MTL) in memory

- Clinical studies (e.g. the classic patient HM^[1]) reveal the role in memory of the medial temporal lobe – hippocampus, plus entorhinal, perirhinal and parahippocampal cortex.
- This human brain lesion evidence is complemented by human imaging and primate neurophysiological studies.

Semantic memory formation: acquiring familiarity

- Inferotemporal (area TE) neurons acquire selectivity for facial features during training to categorise cartoon, face-like stimuli ^[2]
- The hierarchy of 'face patches' develop selectivity for individual face identity, and view invariance ^[3]
- A neural correlate of familiarity is a population response decrement in IT cortex to familiarised stimuli
 - o This is true for both excitatory cells (pyramidal neurons) and inhibitory cells (interneurons) ^[4]
 - o But, excitatory neurons develop a response increment to their most preferred familiarised stimuli (a small fraction of the total set of stimuli used in the experiment) ^[4]

Semantic memory formation: the 'paired-associates' task

- The paired-associates task requires learning of arbitrary pairings between the members of a set of items.
- Neurophysiological study in macaques taught to perform the task ^[5-8]:
 - o Neurons in perirhinal area 36 & area 35 acquire 'pair coding' – they respond to both members of a pair of associated items;
 - o Neurons in perirhinal area 36 and inferotemporal area TE acquire 'pair associate recall' - delayed activation signifying recall of the target item, triggered by presentation of its pair associate;

- Implied mechanism is a form of imagery, e.g. in area TE, caused by excitatory feedback from memories stored in MTL (i.e. perirhinal areas 36 & 35).
- Colour & shape associations involve separate clusters of neurons in area 36.
- fMRI of human brain activity in the identical task, comparing recall of recent & 8-week old memories
 - recent learning recall involves hippocampus^[9];
 - 8-week old learning recall involves anterior IT cortex;
 - Implies hippocampus is important in memory formation; IT cortex in memory consolidation.
- fMRI of human brain activity in learning face-house pairings^[10]
 - Area FFA (Fusiform Face Area) supports face imagery;
 - Area PPA (Parahippocampal Place Area) supports house imagery;
 - Hippocampus (and anterior prefrontal cortex & caudate nucleus) show greater activity in associative memory v. working memory task.
- Neural recordings of human hippocampal and MTL neurons (during epilepsy surgery) show multimodal percept selectivity – i.e. single neurons with visual & auditory selectivity to particular celebrities (selective responsive to pictures of the individual, and to his/her name in text, and to vocal recordings of the name being spoken)^[11].
 - This is a multimodal form of semantic memory;
 - It requires convergent input from visual and auditory sensory cortex;
 - The underlying synaptic mechanism can be thought of as ‘Hebbian’ learning (the Hebb nostrum: ‘cells that fire together wire together’);
 - The frequent association of pictures with written and spoken naming of an individual form a natural analogue of the pair-associates task.

Structure and memory function of hippocampal circuitry

- The hippocampus is where LTP (long term potentiation) - the synaptic basis of learning – was first discovered^[12]
- The hippocampus is generally regarded as being more ‘plastic’ than other parts of cortex – sufficient to perform ‘one-shot’ learning, i.e. memory formation from a single experience, the basis of episodic memory^[12].
- Anatomically, the hippocampus forms the curled up, lateral rim of the cortical sheet. It receives convergent input from the entorhinal cortex (ERctx), and indirectly from the almost all neocortex.
- The circuitry of the hippocampus forms a loop: ERctx – DG – CA3 – CA1 – subiculum – Erctx (NB. DG = dentate gyrus; CA = cornu ammonis).
- The CA3 region has a unique anatomical feature: the fact that the constituent pyramidal neurons of CA3 have axons collaterals forming synapses on the apical dendrites of many other CA3 pyramidal neurons; these so-called ‘recurrent’ connections travel extensively in the long axis of the hippocampus, forming a densely interconnected network.
- The recurrent anatomy of CA3 could allow it to function as an ‘attractor network’ (according to artificial intelligence, neural-network theories). The idea of such a network is that, after appropriate modification of connection weights (i.e. LTP), a previous pattern of network activity resulting from a particular set of inputs can be recreated subsequently from just a subset of those inputs.
- Thus, theoretically, the general basis of the hippocampus in memory encoding is that it receives highly processed sensory ‘concepts’ from all other cortical areas, & can form rapid associations amongst any arbitrary set of such concepts (e.g. visual + sensory + auditory); memory retrieval is when subsequent

experience of one member of the set elicits activity representing the whole set, which then propagates through feedback pathways out of hippocampus and MTL, eventually reaching modality specific sensory cortices where an imaginary representation (imagery) of the original sensory concept can be transiently re-established^[13].

Specific references

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General reading^[14-19]

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