# How do I see myself?

Humans are able instantly to recognise their own face, although children do not develop self-recognition before the age of about 18 months. Self-face recognition is clearly a high-level ability and might be an important component of self-awareness[1]. The question of how the brain responds to the sight of one's own face has recently been tackled by Kircher and colleagues[2]. They used computerized morphing procedures to blend a photograph of the subject's own face and a photograph of another highly familiar face – that of the subject's partner – with the face of a stranger. They first measured the response times for discriminating these morphed faces compared with the unmorphed faces. Unsurprisingly, recognition was significantly slower the more the subject's own or their partner's face was merged with the stranger's face. However, there was no difference in the reaction times for recognizing one's own and one's partner's face.

In a second experiment the authors used fMRI to scan subjects while they viewed morphed versions of their own or their partner's face. The results showed increased brain activity in the right limbic system, the left prefrontal cortex and the superior temporal cortex when subjects viewed their own face (compared with viewing a control stranger's face). By contrast, when the subjects viewed their partner's face, only the right insula was activated. The right limbic areas have been shown to be involved with autobiographical memories3, and Kircher et al. suggest that the right limbic activity might represent the emotional reaction to seeing one's own face. They propose that this region, together with the left prefrontal cortex, which is thought to play a role in integrating multi-sensory information into a coherent whole, might underlie human self-recognition and self-awreness. This contrasts with other evidence that the right prefrontal cortex may play a greater role in this faculty than the left1.

References

1 Keenan, J.P *et al.* (2000) Self-recognition and the right prefrontal cortex. *Trends Cognit. Sci.* 4, 338–344

2 Kircher, T.T.J. *et al.* (2001) Recognizing one's own face. *Cognition* 78, B1–B15

3 Fink, G.R. *et al.* (1996) Cerebral representations of ones own past: neural networks in autobiographical memory. *J. Neurosci.* 16, 4275–4282

---

**Sarah-Jayne Blakemore**
s.blakemore@ucl.ac.uk

# Vivid remembering

Many of us have had the experience of remembering a particular scene or sound in vivid detail. An open question regarding these types of memories is how the brain is able to reconstruct such rich and detailed information. One theory is that brain regions that process the initial sensory information are to some extent reactivated when we remember that information in vivid detail. Support for this reactivation theory comes from studies of mental imagery that employ brain-imaging techniques, such as fMRI, and also from studies that use direct stimulation of regions of sensory cortex in awake human patients.

A recent fMRI study by Wheeler *et al.* provides further support for this hypothesis. To encourage vivid remembering, subjects studied multiple presentations of a set of environmental pictures and sounds. Each picture and sound was paired with a descriptive word label. At test, subjects were scanned using fMRI, first while they were presented with the labels and associated pictures and sounds, and then later while they retrieved the pictures and sounds from memory when cued with the labels. Wheeler *et al.* found that specific regions of cortex activated during presentation of the pictures and sounds were later reactivated while subjects vividly remembered the same pictures and sounds. Some regions of visual cortex that were activated during perception of pictures were also activated during memory for pictures. Also, memory for sounds was associated with activation of a subset of regions of auditory cortex that were activated during perception of the same sounds.

These data thus provide convincing support for a long-held view of how vivid remembering occurs in the brain. However, the present study leaves many questions unanswered: first, do the findings extend to other conditions, for example, in which subjects remember specific past episodes having experienced a stimulus just once, rather than multiple times? Second, does the location of reactivated regions depend on the nature of the stimuli remembered? The present results suggest that the retrieval of different features lead to reactivation of different regions of sensory cortex, but it is unclear whether reactivation occurs in early sensory regions, or only relatively late in the sensory processing stream, as seen by Wheeler *et al.* Finally, future investigations must address how reactivation in sensory cortex interacts with ongoing activity in regions that support working memory or executive control processes.

Reference

1 Wheeler, M.E. *et al.* (2000) Memory's echo: vivid remembering reactivates sensory-specific cortex. *Proc. Natl. Acad. Sci. U. S. A.* 97, 11125–11129

---

**David I. Donaldson**
didonald@artsci.wustl.edu

# Learning by doing

Recent work on computational motor control has focussed on learning and generalization paradigms to explore the representation of movements within the central nervous system. So if a reaching movement to a target is learned in one circumstance, such as making an arm movement when carrying a load, one can test how well the reaching movements can be made with other loads, or to other targets. If good generalization is seen, then some predictions about how the target position or load is represented can be made.

In an elegant paper, Thoroughman and Shadmehr have taken this process one step further[1]. They used information gained from 'catch' trials within a sequence of reaching movements to expose the shape of human 'motor primitives' thought to underlie the neural transformations from sensory inputs to motor outputs. Subjects learned to move a jointed robotic arm in different directions within a viscous force field. As they adapted to this unusual environment, they were occasionally challenged by catch trials in which no external forces were applied, resulting in a movement error. Movement trajectories in the null field changed as experience of the viscous field developed. More significantly though, the next few movements after each catch trial reflected the size and direction of the error made. Thoroughman and Shadmehr were able to predict the change in movement from before to after each catch with a model based on Gaussian tuning curves for arm velocity. In polar coordinates, these curves had an angular sensitivity of about 90 degrees, which is narrower than the directional tuning curves reported for motor cortical cells, but similar to the velocity tuning seen in cells in the cerebellum.

This work demonstrates how we learn to control movements via 'primitive' representations such as velocity tuning curves, which might map quite simply to neural responses in the brain. Of course, Thoroughman and Shadmehr have so far only tested subjects in a viscous environment where the forces experienced depend on the velocity of the arm movements. It is not unexpected to find adaptive tuning of velocity-sensitive motor primitives in these conditions, and it will be necessary to widen this approach to other parameters of motor learning. However, the paper also demonstrates how a well designed motor task can provide rich information about human learning, with the responses following each movement error signalling how the brain learns from its mistakes.

Reference

1 Thoroughman, K.A. and Shadmehr, R (2000) Learning of action through adaptive combination of motor primitives. *Nature* 407, 742–747

**Chris Miall**
chris.miall@physiol.ox.ac.uk

# Changing faces

Many influential models of prefrontal cortex function suggest that activity within this area is often associated with additional activity in posterior regions of the cortex that support perception. The purpose of this cortical 'coupling' is to ensure that a perceptual representation is generated and then maintained within the working memory system. Areas in the right ventrolateral prefrontal cortex (vlPFC) and the fusiform gyrus have been implicated as associate areas involved in face processing. In an interesting case study by Vignal, Chauvel and Halgren the functional relationship between these two areas was tested[1]. In order to confirm the epileptogenic foci prior to resective surgery in a 30-year-old male patient, depth electrodes were implanted into sites around prefrontal, anterior temporal and premotor cortices. While the patient was looking at a blank screen, 50-Hz electrical stimulation of two probes implanted into the right anterior frontal gyrus resulted in the patient's reporting the perception of a series of colourful faces. These facial hallucinations were described as being '…like passing slides, one after the after, linked together'. When asked to look at an actual face during stimulation at the same sites the patient reported transformation of that face (such as appearing without spectacles or with a hat). These findings were related to activity of a cortical network involving the vlPFC and the fusiform gyrus. This paper thus suggests a role in face processing for the vlPFC, evoking working memory processes to maintain facial representations.

**'a perceptual representation is generated and maintained within the working memory system'**

Reference

1 Vignal, J.P. *et al.* (2000) Localised face processing by the human prefrontal cortex: stimulation evoked hallucinations of faces. *Cognit. Neuropsychol.* 17, 281–291

**Carl Senior**
c.senior@iop.kcl.ac.uk

# Familiarity breeds order

Attention and working memory mechanisms need to have on-line access to acquired information in order to coordinate behaviour. The characterization of neural mechanisms that underlie adult learning by experience can lead to the formulation of models of how the brain uses such information to guide thought and action at the neuronal level. There has been an accumulation of evidence from primate studies that neurons in 'higher' visual cortical areas – in particular, the inferior temporal (IT) cortex – adjust their pattern of response according to the level and nature of exposure of the animal to a visual stimulus. In other words, they exhibit a kind of 'neuronal learning'. Erickson and colleagues[1] recently reported that neurons in the perirhinal cortex (an anteromedial area in IT) show enhanced similarity in their patterns of activity in response to visual input, according to their proximity to each other and the level of familiarity with the encountered object.

They presented images of novel objects to macaque monkeys, which were required either to perform a visual discrimination task or to view the stimuli passively. The activity of groups of neurons in the perirhinal cortex was recorded during these presentations. Erickson et al. analysed their results according to the degree of familiarity of the object presented and the proximity of the neurons sampled. They described how 'nearby', but not 'far-apart' neurons exhibited similar patterns of activity when the animal was presented with an object encountered in a previous session, but when the object was novel, there was no organized similarity between the patterns of activity of neurons, irrespective of their distance. The significance of these results lies in the fact that they concern a high order visual area, believed to be involved in object recognition memory.

**'neurons in higher visual cortical areas adjust their pattern of response according to the level of exposure to a visual stimulus'**

They provide an example of functional neuronal architecture altered by experience in adulthood, quite distinct from the hard-wired organization in lower (primary) visual areas early in development, where cells are clustered in predetermined columns of preference for different object properties such as line orientation.

Although the cellular mechanisms of the experience-dependent alterations described are not known, the results of Erickson *et al.* add weight to a growing body of evidence that suggests a way in which higher visual areas might contribute to an extended network of perceptual organization. This kind of neuronal learning can be viewed as organizing neuronal nodes of a network of 'visual templates' that resolve or bias competition – in this case according to familiarity – between incoming information from the primary visual cortex, for access to high-order centres for behavioural organization. This appears to be a highly viable proposal, both in light of the neurophysio-logical evidence and the nature of the connectivity of the perirhinal cortex with both primary visual areas and frontal high-order systems, such as the prefrontal and cingulate cortices[2].

References

1 Erickson, C.A. *et al.* (2000) Clustering of periphinal neurons with similar properties following visual experience in adult monkeys. *Nat. Neurosci.* 3, 1143–1148

2 Murray, E.A. and Bussey, T.J. (1999) Perceptual–mnemonic functions of the perirhinal cortex. *Trends Cognit. Sci.* 3, 142–151

**Anastasia Christakou**
ac250@cam.ac.uk