HIGHLIGHTS

DEVELOPMENT

Foxed by neural crest

The neural crest is a population of cells that migrates from the dorsal neural tube and gives rise to cells of the peripheral nervous system, as well as to a variety of non-neural lineages. Because it contributes to so many different tissues, its correct specification and deployment are of vital importance to the developing embryo. The factors that specify neural crest are largely unknown, but several candidates are beginning to emerge. One of the strongest candidates is the winged-helix transcription factor Foxd3, and a study by Dottori *et al.* has shed new light on its role in neural crest specification in chick and mouse embryos.

Dottori *et al.* showed that Foxd3 expression marks both premigratory and migrating neural crest cells in the mouse embryo. These Foxd3-expressing cells can give rise to a variety of cell lineages, including sensory/sympathetic neurons, glia and melanocytes.

By electroporating a *Foxd3* expression construct into chick embryos, the authors showed that Foxd3 could induce ectopic expression of neural-crest-specific markers, such as HNK1 and CAD7, along the entire dorsoventral axis of the neural tube. Moreover, the electroporated cells were able to delaminate and migrate away from the neuroepithelium. Also, there was a considerable reduction in the number of cells expressing interneuron-specific markers in the electroporated side of the neural tube, indicating that Foxd3 also suppresses interneuron differentiation.

The Pax3 transcription factor is thought to specify dorsal cell fate in the neural tube. Dettori *et al.* showed that in *Pax3* knockout mice, Foxd3 expression was absent caudal to the hindbrain/spinal cord boundary, and that this region also failed to generate neural crest. This provides additional support for a role of Foxd3 in neural crest specification, and places it downstream of Pax3.

Dorsal neuroepithelial cells have several fate choices; they could become neural crest, interneurons or roof-plate cells. Dottori *et al.* have shown that Foxd3 seems to have a dual role in dorsal cell specification — promoting neural crest cell fate and inhibiting interneuron differentiation. Foxd3 is clearly sufficient to transform neuroepithelial cells into neural crest, but is it necessary? Expression of a Foxd3 repressor in *Xenopus* has already been shown to inhibit neural crest formation, and it will be interesting to see whether inactivating Foxd3 has a similar effect in the mouse or the chick.

Heather Wood

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ION CHANNELS

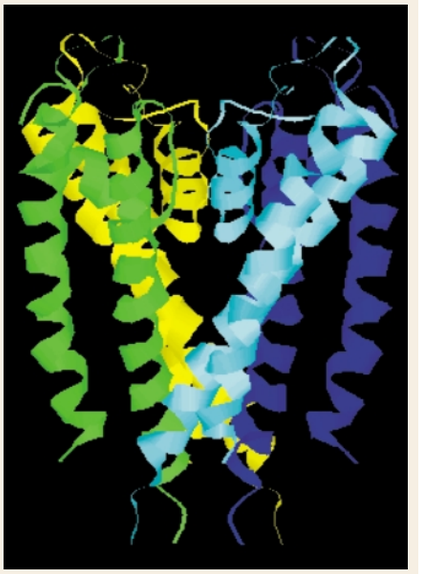
Potassium ions shed their skin

The structure of the potassium channel KcsA, determined by X-ray crystallography, is regarded as a milestone in the study of ion channel function. But the original description of this structure was only the beginning. Two papers from the group of Rod MacKinnon are the latest contributions to a story that continues to amaze us with unimaginable insights into the workings of channel proteins.

In the first study, Zhou *et al.* asked a fundamental question about the interactions between the permeant ions and the channel: how do K^+ ions shed their hydration shells as they pass through the selectivity filter? The authors solved the structure of KcsA in complex with a Fab antibody fragment that recognized the tetrameric, but not the monomeric, form of the channel. They found that the central cavity of KcsA holds a K^+ ion surrounded by eight water molecules. As K^+ enters the selectivity filter, oxygen atoms from different amino-acid carbonyl groups surround the ion and stabilize it in four precise positions as it flows through. As K^+ channels normally face two very different ionic concentrations (high inside the cell and low outside), the authors found that the selectivity filter adopts two distinct conformations that depend on K^+ concentration.

In the second study, Morais-Cabral *et al.* set out to discover how KcsA achieves nearly diffusion-limited rates of ion flow by analysing its structure in the presence of K^+ or of slightly larger, but permeant, Rb^+ ions. As the distribution of ions inside the selectivity filter differed depending on the ion, the authors showed that, although the filter can hold ions in four different positions, it usually contains only two ions separated by a water molecule. The ions move in a concerted manner between positions 1,3 and 2,4 such that, when an ion enters the filter on one side, a second one is expelled on the other. This arrangement minimizes the energy difference between the different states, while maximizing the rate of conduction.

Juan Carlos López



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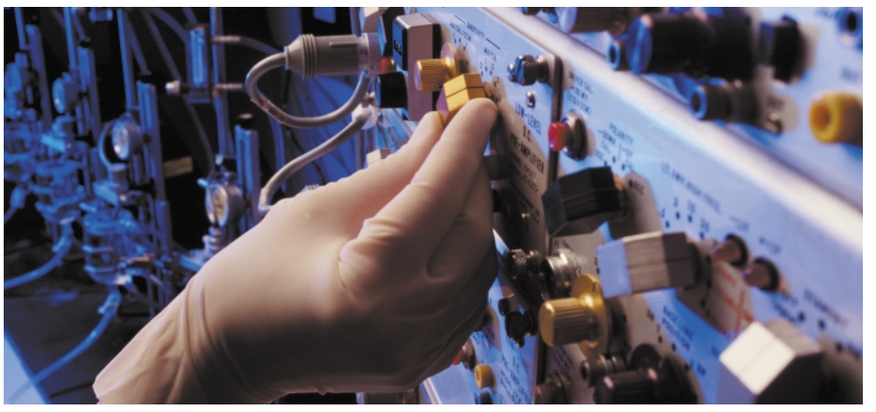
NEUROPHYSIOLOGY

Noises on

The idea that noise has a detrimental effect on signal detection is a commonly held view; as noise increases, the signal-to-noise ratio (SNR) is expected to decrease. But in some systems, noise can actually enhance signal detection, an effect known as stochastic resonance. In these systems, SNR is not a linear function of noise; instead, gradual increases in noise are initially associated with a steep and coincident increase in SNR, before signal detection begins to degrade. Do neurons show stochastic resonance? In other words, can increases in noise lead to an enhanced detection of synaptic inputs? Stacey and Durand have recently provided evidence in support of this intriguing idea.

Using a computer model of hippocampal neurons, the authors have previously shown that the external introduction of physiological levels of noise improve signal detection. They have now gone on to show, in hippocampal slices, that endogenous noise can have a similar effect. Stacey and Durand applied subthreshold currents to the CA3 hippocampal region, a manipulation that enhanced random synaptic activity and increased noise levels recorded from individual CA1 neurons. The authors simultaneously delivered test pulses on an independent pathway to evoke subthreshold synaptic potentials in CA1 neurons, and observed that the triggering of action potentials by the test pulses significantly increased when the noise source was on. So, SNR increased steeply as a function of noise, roughly following the predictions of the stochastic-resonance model — an initial increase and a subsequent reduction of SNR. However, levels of noise high enough to start degrading the signal could not be induced because of experimental constraints, and the predicted decrease in SNR was only observed in a computer simulation. But despite this limitation, the observations of Stacey and Durand indicate that noise can enhance the detection of synaptic activity in the hippocampus. As the random activity used by the authors as the source of noise falls within physiological levels, stochastic resonance might indeed favour the detection of weak or distal synaptic inputs.

Juan Carlos López



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AUDITORY SYSTEM

Senses working overtime

The act of hearing involves not only identifying the nature of a sound, but also pinpointing the location of its source. To achieve this, the brain needs to compare the sounds received by the two ears, and this requires the development of ear-specific processing circuits. As in other sensory systems, peripheral neuronal activity is thought to play an instructive role in the patterning and refinement of these circuits. In the auditory system, it was previously thought that this activity was derived only from cells that were actively responding to sound. However, as reported in the *Journal of Neuroscience*, Jones *et al.* have now shown that during development, cochlear neurons can exhibit spontaneous activity in the absence of external sensory input.

The authors measured the activity of cochlear ganglion cells in chick embryos between embryonic days 13 and 17. They showed that a high proportion of the cells exhibited rhythmic bursting activity. Bursting cells were most prevalent in the embryos at the younger end of the age range, although the rate of bursting in individual cells increased as development progressed. The bursting patterns became less regular with time, indicating that spontaneous rhythmic bursting is a transient phenomenon. Of 18 cells that showed rhythmic bursting, only five were able to respond to sound.

Activity-dependent development has been extensively studied in the visual system, where it is likely that spontaneous neuronal activity plays a significant role in the patterning of cortical circuits. It is to be hoped that future studies will show whether the spontaneous bursting activity detected by Jones *et al.* in the cochlea has a similar influence on the development of auditory processing circuits.

Heather Wood

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NEUROTECHNIQUE

Creating the perfect blend

During the development of the nervous system, the fate of neural progenitor cells is influenced by the microenvironment they experience — a particular combination of adhesion cues, extracellular matrix and growth factors such as the neurotrophins. At present, there is considerable hope that transplanted neural progenitor cells can be harnessed to restore function within degenerated regions of the central nervous system in disorders such as Parkinson's disease. For this to work, the transplanted cells must differentiate and form synaptic contacts with the surrounding tissue. However, adult nervous tissue is a relatively unfavourable environment for cell migration, differentiation and axonal growth, owing to the presence of inhibitory molecules such as myelin-associated glycoprotein. Nervous tissue regeneration can be promoted by increasing the levels of neurotrophins, but these factors potently influence other cellular functions apart from survival and growth, which means that systemic administration can lead to broad, adverse side effects. Writing in *Nature Biotechnology*, Mahoney and Saltzman now describe a strategy with the potential to address these issues. By pre-assembling neural progenitor cells with controlled-release microparticles containing nerve growth factor (NGF) to give transplantable "neo-tissues", aspects of the extracellular environment experienced by progenitor cells during development can be mimicked directly at the transplantation site.

Controlled-release microparticles were formed by encapsulating NGF — which influences the survival and growth of cholinergic neurons — in biocompatible polymers, and were then assembled with fetal rat brain cells in rotational culture to give spherical neo-tissues ~170 μm in diameter. By using microparticle preparations known to release NGF at different rates, neo-tissues with different microenvironments were created. NGF levels in the different neo-tissues and in the surrounding medium after 4 days in culture correlated with the NGF release rate of the particular microparticles; a similar trend in the levels of choline acetyltransferase (ChAT) activity, a marker of cholinergic neuron function, was also observed in the neo-tissues.

Next, the authors transplanted the neo-tissue with the highest NGF release rate into the brains of healthy adult rats to assess the functional activity *in vivo*. Transplanted cells remained aggregated at the site of injection throughout the 21-day experiment. NGF levels were significantly elevated at this site for the first 7 days, but fell off subsequently, presumably owing to exhaustion of the NGF source. But ChAT activity was elevated for the entire course of the experiment, indicating that NGF is released from the microparticles at levels sufficient to influence cholinergic cell survival and/or differentiation over the period of study.

So, the techniques that Mahoney and Saltzman describe allow the creation of synthetic microenvironments in which several variables of potential importance to cell survival and differentiation — position of growth factor source, growth factor dose and molecular signals at the cell surface — can be controlled. Such neo-tissues containing combinations of microparticles, each releasing a molecule that promotes a particular aspect of transplanted cell function (for example, an antibody to the inhibitory myelin-associated glycoprotein), could be useful in treating neurodegenerative diseases and spinal cord injuries.

Peter Kirkpatrick, Associate Editor,
Nature Reviews Drug Discovery

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WEB SITE
Saltzman lab: http://www.cheme.cornell.edu/peopleevents/faculty/saltzman/

IN THE NEWS

Genespeak

"British scientists have pinpointed a single genetic defect that causes a rare hereditary language disorder, providing the strongest evidence yet that mankind's sophisticated communication skills are determined by DNA".

This is how *The Times* (UK, 4 October) heralded the news that Tony Monaco's team at the University of Oxford have shown that a mutation in the forkhead-domain gene *FOXP2* is responsible for an inherited speech disorder that was first identified in a British family. Affected individuals find it difficult to form words and have problems with certain aspects of grammar, such as changing the tense of verbs.

The heritable nature of this disorder seems to support the idea, proposed by Noam Chomsky in the 1950s, that the ability to learn language is innate in humans. Even Charles Darwin was on the case (*The Times*, 4 October); in *The Origin of Species* he states: "Man has an instinctive tendency to speak, as we see in the babble of our young children, while no child has an instinctive tendency to bake, brew or write".

However, some scientists are sceptical about the idea that linguistic ability resides in specific brain structures or genes. In a letter to the *New York Times* (5 October), cognitive scientist Philip Lieberman suggests that the *FOXP2* mutation affects the basal ganglia nonspecifically, like Parkinson's disease, which also causes "deficits in both manual and speech motor control, and in comprehending grammar and abstract reasoning". Language researcher Bruce Tomblin points out that "several variant genes that seemed at first to affect only speech [have] turned out to cause other cognitive problems as well" (*New York Times*, 4 October). Clearly, this new study has not been able to resolve the debate over whether there are genes 'for' language.

Heather Wood

NEUROIMAGING

Snap!

The Wisconsin card sorting test is a popular choice among neuropsychologists studying the function of the prefrontal cortex. Part of its beauty is its simplicity. The subject sits opposite the experimenter, and is shown cards one at a time. On each card are between one and four symbols (triangles, stars, crosses or circles) in one of four colours (red, green, yellow or blue). So each card could be classified by the number, colour or type of symbol.

The subject has to say with which of four test cards — between them representing all of the symbols, colours and numbers — each new card should be paired. The experimenter doesn't say which rule is in place, but simply tells the subject whether each decision is right or wrong, allowing them to work out whether they are supposed to classify cards by number, colour or symbol. At some point during the session, the rule will change without warning, and the subject will have to stop using the old rule and figure out what the new rule is.

Patients with damage to the prefrontal cortex find this task much harder than control subjects do. They tend to perseverate — they will continue to classify cards by the original rule, even though they are repeatedly told that it is wrong — or make other types of mistake. Patients with Parkinson's disease are also impaired on the test, a fact that implicates the basal ganglia in card sorting. Previous functional imaging studies have confirmed that parts of the prefrontal cortex are activated during the Wisconsin card sorting test, but activity in the basal ganglia has been less clear. Now Monchi *et al.* have used event-related functional magnetic resonance imaging to give a much clearer and more detailed picture of brain activity during the different phases of the test.

Their results confirm that parts of the prefrontal cortex are specifically activated during testing. They also show activity in parts of the basal ganglia — the caudate nucleus and putamen. More interestingly, the authors were able to identify different patterns of activity during different stages of the test. For example, the mid-dorsolateral prefrontal cortex, which is thought to be important for monitoring information in working memory, was active when subjects were told whether their decision was right or wrong. However, the mid-ventrolateral cortex, along with the caudate nucleus and mediodorsal thalamus, was active only when the subjects received negative feedback, signalling the need to change strategy. These structures form an anatomical loop that is thought to be crucial for cognitive functions, such as those required to change from one rule to another.

Other parts of the brain were more active at the response stage, rather than during feedback. These included the putamen, which is more important for motor function, consistent with the fact that subjects had to carry out an action during this phase. But the putamen was active only when this phase followed negative feedback. The putamen and the posterior lateral prefrontal cortex, which was also active during this period, are connected through another loop. These findings indicate that this loop might be more involved in novel actions (or in performing an action according to a new behavioural rule).

These results could shed new light on the different deficits in the Wisconsin card sorting test that follow different types of injury or disease. Even this apparently simple task, it seems, has more to it than meets the eye.

Rachel Jones

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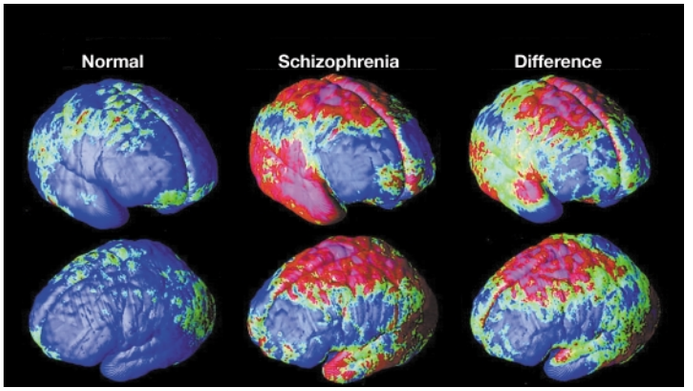

Grey matter loss in adolescents with schizophrenia. Warmer colours denote regions with the most significant losses. © 2001 National Academy of Sciences, USA.

PSYCHIATRIC DISORDERS

Mapping grey matter

Schizophrenia is perhaps the most intensively studied of the psychiatric disorders, and there is increasing evidence that its pathogenesis involves neurodevelopmental abnormalities. Patients seem to show loss of grey matter, but it is unclear whether this occurs early or late in neural development. Thompson *et al.* have followed patients with early-onset schizophrenia to study the dynamics of this reduction in volume.

The researchers used high-resolution magnetic resonance imaging to track structural changes in the brains of adolescents with early-onset schizophrenia over five years. The authors compared the scans across the time course of the experiment, and compared schizophrenic patients with control subjects and 'medication-matched' teenagers who had other psychiatric disorders. There was a greater loss of grey matter in patients with schizophrenia than in normal adolescents, and the loss followed a specific spatial pattern as time progressed.

The control subjects did show some loss of grey matter over the five-year span of the experiment, consistent with previous findings. But this reduction was fairly homogeneous across the brain. By contrast, patients with schizophrenia showed a specific, wave-like pattern of loss that began in the parietal cortices and progressed over the following years to affect frontal and temporal regions. Medication-matched non-schizophrenic patients also showed a greater loss of grey matter than did controls, but the loss was less marked than for the patients with schizophrenia and did not include the temporal cortex.

Previous work has shown that grey matter deficits in some areas of the brain in adult schizophrenic patients and their families are attributable to genetic factors, whereas in other areas they seem to be related to environmental factors. Intriguingly, the parietal cortices, where the dynamic loss in teenagers with schizophrenia begins, fall into the latter category, whereas loss in the frontal and temporal regions, which are affected later, seems to be genetically mediated. These findings are consistent with the idea that an environmental trigger contributes to the onset of schizophrenia.

Grey matter deficits in different brain areas also show interesting correlations with the clinical progression of the disease. Specifically, faster loss in the temporal cortices is associated with more severe positive symptoms (for example, hallucinations and delusions), whereas loss in the frontal cortices correlates with increased negative symptoms (such as lack of emotional responses and poverty of speech).

Although the causes of schizophrenia are still mysterious, a better understanding of the structural changes that occur during the progression of the disease in these adolescent patients could provide further insight into the mechanisms of the adult-onset form of the disease. And the tight correlations between the pattern of loss and specific symptoms could point towards the mechanisms that underlie these symptoms. However, these findings also indicate that treatments for schizophrenia will need to be aimed at slowing the loss of grey matter, raising another question — just what causes this progressive wave of tissue loss?

Rachel Jones

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IN BRIEF

NEUROLOGICAL DISORDERS

Mutant protein in Huntington disease is resistant to proteolysis in affected brain.

Dyer, R. B. & McMurray, C. T. *Nature Genet.* **29**, 270–278 (2001)

Although the cause of Huntington's disease is unknown, one leading theory is that the expanded huntingtin protein is cleaved and that the amino-terminal fragments accumulate, causing cell death. However, Dyer and McMurray have now shown that the mutant huntingtin protein is relatively resistant to proteolysis. They propose instead that the full-length mutant protein causes toxicity by sequestering full-length and cleaved normal huntingtin.

OPIOID RECEPTORS

Prolonged morphine treatment targets δ-opioid receptors to neuronal plasma membranes and enhances δ-mediated antinociception.

Cahill, C. M. *et al. J. Neurosci.* **21**, 7598–7607 (2001)

Opioid receptor ligands can cause complex regulatory changes in the receptor, and it has been proposed that the three different subtypes of opioid receptor can interact. Cahill *et al.* found evidence in support of this idea by showing that prolonged treatment with morphine, a μ-receptor agonist, can cause a marked increase in the density of δ-opioid receptors at the cell surface, both *in vitro* and *in vivo*. The receptor density increase was accompanied by potentiation of the anti-nociceptive effect of a δ-receptor agonist.

NEUROTECHNIQUES

Delivery of the Cre recombinase by a self-deleting lentiviral vector: efficient gene targeting *in vivo.*

Pfeifer, A. *et al. Proc. Natl Acad. Sci. USA* **98**, 11450–11455 (2001)

In genetic engineering, crossbreeding of mice carrying genes flanked by *loxP* sites and those expressing the Cre recombinase is often used to generate region-specific knockout mice. Region-specific Cre expression can be achieved through viral transfection, but this can give rise to a strong immune response. Pfeifer *et al.* describe the use of lentiviral vectors to deliver Cre. To avoid toxicity, they designed a Cre transgene that is itself excised by Cre, so that the gene is expressed only for a short time before being deleted.

NEUROTECHNIQUES

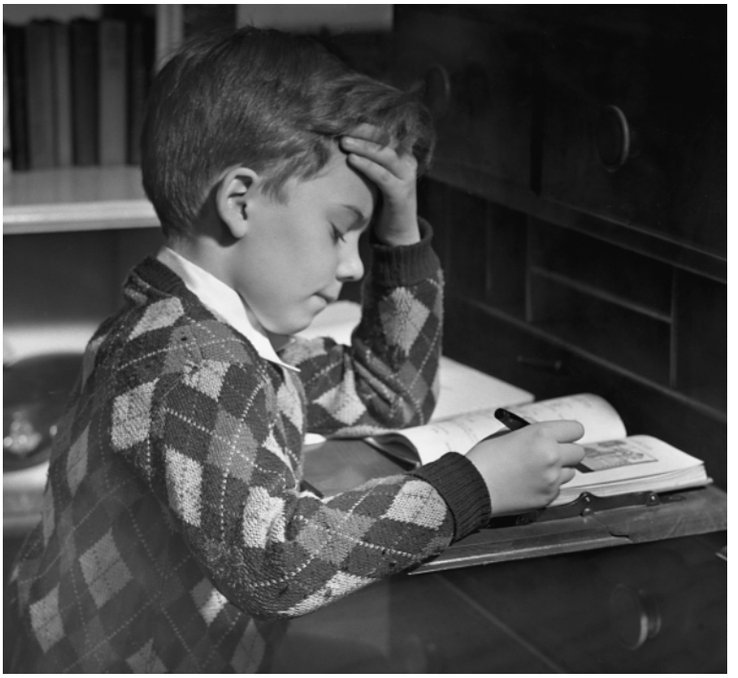
A miniature head-mounted two-photon microscope: high-resolution brain imaging in freely moving animals.

Helmchen, F. *et al. Neuron* **31**, 903–912 (2001)

Helmchen *et al.* have developed a head-mounted two-photon microscopy system that allows *in vivo* imaging of the cortex in awake, freely moving rats. Two-photon microscopy allows the detection of fluorescence down to imaging depths of around 0.5 mm; in the head-mounted system, it could be used to obtain images of blood vessels filled with fluorescently labelled blood, or pyramidal neurons labelled with a calcium indicator. This should allow the measurement of blood flow or calcium transients in response to physiological stimuli.

FUNCTIONAL IMAGING

Learning by the rules



For many years, learning theorists have known how animals — or humans — learn that one thing leads to another. The Rescorla–Wagner learning rule states that the likelihood of learning about an association on a particular trial depends on an error signal, which arises from the difference between what the subject expects to happen and what actually happens. At the beginning of training, before an association has been learned, any outcome is unexpected and learning will occur quickly. After many training trials, on the other hand, the association will have been learned so well that the outcome of a given trial is completely predicted and no further learning occurs, because there is no error signal.

It seems that neuroscientists are only now catching up with the behaviourists in learning about learning. First came the demonstration that the responses of midbrain dopamine neurons in primates followed precisely the predictions of formal learning theory, as published by Waelti *et al.* earlier this year (see 'Trial and error' in the August issue of *Nature Reviews Neuroscience*). And now Fletcher and colleagues have shown that responses in the human dorsolateral prefrontal cortex (DLPFC), as observed by functional magnetic resonance imaging (fMRI), do exactly the same thing.

People lying in an fMRI scanner were shown images of drugs followed by images representing syndromes; their task was to learn which drugs would cause which syndromes. During the first few training trials, activity in the DLPFC was high, but then it decreased as the subjects were increasingly able to predict the outcome of a trial.

After learning, unexpected outcomes (for example, when a drug that had previously been associated with a syndrome did not give rise to that syndrome) produced increased activity in DLPFC, just as predicted by learning theory. The Rescorla–Wagner rule also states that different outcomes will have different effects on learning, depending on salience or other factors; so another prediction was that the DLPFC would be more sensitive to surprise outcomes if they

DEVELOPMENT

Nerves are brought to heal

Healing of a skin wound can be a long and complicated process, and it seems that the problem is made even worse if the cutaneous nerve supply is impaired. In conditions such as diabetic neuropathy, complications associated with skin wounds have even led to amputation in extreme cases. Do nerves play an active role in the healing process? The fact that skin often becomes hyperinnervated after wounding would certainly support such a theory. However, some people have argued that the loss of pain sensation after denervation makes tissue more susceptible to further injury, thereby slowing the healing process.

As reported in *Developmental Biology*, Harsum *et al.* have set out to resolve this conundrum by studying the relationship between innervation and wound healing in the developing chick embryo. The skin of the early embryo shows a remarkable capacity for wound healing, and wounds made at embryonic day 4 (E4) heal within 24 hours, leaving no scar. However, the rate of healing becomes progressively slower as development proceeds, and the skin becomes increasingly prone to scarring, indicating that the mechanisms of wound healing change with time.

By irradiating the E2 neural tube between somites 12 and 20, Harsum *et al.* generated chick embryos with nerveless wings. At E4, the skin healed normally in these embryos, but around the time that the skin would normally become innervated (E7), healing became impaired, and was significantly slower than in wild-type skin at the same stage. The effects of continual injury due to lack of sensation could be ruled out, because the embryos were grown in a liquid environment, which was unlikely to cause damage.

The results of this experiment indicate a role for nerve-derived signals in wound healing, but only from the time that the skin normally becomes innervated. Dependence on these signals is acquired during development and, as it also seems to be acquired by nerveless skin, it clearly does not require contact with nerves. Interestingly, wounded fetal skin does not become hyperinnervated, so this does not seem to be a prerequisite for healing. Rather, the authors argue that hyperinnervation is a consequence of the inflammatory response, which does not occur in fetal tissue.

The next step will be to identify the signals released by nerves that are beneficial for tissue repair. Substance P and fibroblast growth factors are likely candidates, and both have been shown to be released by damaged nerves. It will also be important to understand why the response of the skin to these signals changes during development. With this knowledge, it should be possible to devise ways to improve the efficiency of wound healing in adult skin.

Heather Wood

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involved occurrence of the syndrome than if they did not. As predicted, surprise events where the outcome was 'syndrome' produced more DLPFC activation than those where the outcome was 'no syndrome' — and these events were also more likely to produce learning (that is, to change the subjects' subsequent predictions).

This study provides further evidence that neural activity — across whole brain regions as well as in individual neurons — reflects the specific predictions that arise from formal learning theory. Further collaborations between behavioural theorists and neuroscientists might give us similar insight into the neural bases of other types of learning or behaviour.

Rachel Jones

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An embryonic chick wing, stained with an antibody to reveal the normal pattern of innervation. Courtesy of Jonathan Clarke and Paul Martin, University College London, UK.

VISUAL PROCESSING

A roving eye

As we view the world around us, our eyes frequently make ballistic movements from one point of gaze to another. These 'saccades', which can occur several times per second, are usually automatic and go unnoticed. This is somewhat surprising. After all, when the image of a fast-moving object sweeps across the static retina, we are normally aware of its motion. So why is it that we fail to detect the comparable motion of images as they sweep across the retina during saccades? This apparent paradox has previously been explained by the intrasaccadic suppression of visual sensitivity. But as García-Pérez and Peli report in the *Journal of Neuroscience*, it seems that we might have underestimated our capacity for visual perception during saccades.

Traditionally, intrasaccadic suppression has been studied by presenting a range of visual stimuli to subjects, and comparing their performance during saccades with that in fixation trials. But because the stimulus differs in these situations — the image falls onto a single retinal location in the latter case, but is spread across the retina in the former — this approach does not answer the question of whether lower sensitivity during saccades is actually the result of a deterioration in visual processing. García-Pérez and Peli adopted a different approach. They isolated intrasaccadic perception in human volunteers by presenting them with high-speed visual stimuli that are invisible under fixation (because fast temporal oscillations are filtered out by the mammalian visual system), but which can be detected by executing saccades. In this way, they removed the potential complications of pre- and postsaccadic perception of the visual stimulus.

Subjects viewed gratings (patterns made up of alternating bright and dark stripes) that differed in their spatial resolution (the number of repeats of the pattern per degree of the subject's visual angle) and in the speed at which they drifted. The fact that fast-drifting gratings can be seen during saccades shows that intrasaccadic suppression does not eliminate the perception of high-contrast stimuli. But how much are we able to perceive during saccades? As has been reported previously, García-Pérez and Peli found that intrasaccadic processing allows the conscious perception of motion. But interestingly, whereas motion perception during saccades has previously been ascribed to the magnocellular pathway, the authors found that it did not occur for stimuli that are optimal for processing by this system (those with low spatial and high temporal frequencies). They went on to show that a number of other complex visual tasks can be performed during saccades; for example, direction-of-motion discrimination, contrast discrimination and contrast matching. Moreover, they were able to show that, in theory at least, a filtering process of the type that accounts for the invisibility of fast-moving gratings under fixation might also operate during saccades.

The analysis presented by García-Pérez and Peli indicates that, rather than being degraded, visual processing during saccades shares many of the characteristics of processing under fixation. These findings argue against the idea of intrasaccadic suppression, so how is it that our view of the world remains stable as we execute saccades? The authors concur with others in suggesting that, under normal circumstances, the answer might lie in visual masking by pre- and postsaccadic perception.

Rebecca Craven

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ORIGINAL RESEARCH PAPER García-Pérez, M. A. & Peli, E. Intrasaccadic perception. *J. Neurosci.* **21**, 7313–7322 (2001)

FURTHER READING Castet, E. & Masson, G. S. Motion perception during saccadic eye movements. *Nature Neurosci.* **3**, 177–183 (2000)

WEB SITE

Eli Peli's lab: http://www.eri.harvard.edu/faculty/peli/index.html