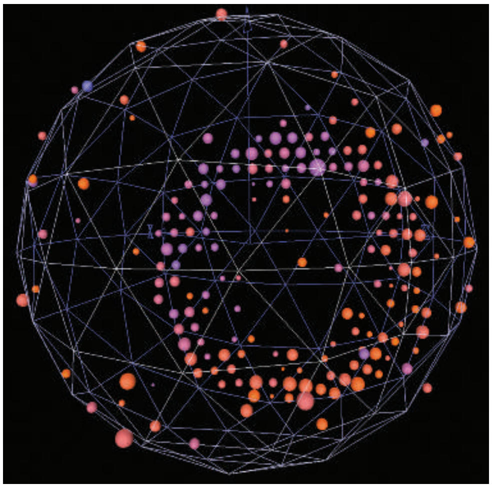

MINIBOONE COLLABORATION

Figure 2 | Light signal. A neutrino interaction with the mineral oil in the 12-metre-diameter tank of the MiniBooNE experiment gives out light that fires photomultiplier detectors embedded in its sides in a pattern characteristic of the interaction products — and thus of the original type of neutrino. The circle of photomultiplier hits indicates a characteristic cone of 'Čerenkov' light emitted by a particle travelling at more than the speed of light in the medium (colours indicate the relative timing of the hits). With this apparatus, MiniBooNE was unable to confirm the evidence of neutrino oscillation found earlier in the LSND experiment.

Psychology enters the picture in the attempts to quantify the background signal. The history of science is littered with false results produced by scientists who see how each tuning of an analysis procedure affects their desired signal and its undesired background, and who subconsciously tune their analysis to produce the result they want to see. To prevent this, MiniBooNE adopted two independent forms of blind analysis, hiding away the data that would contain the potential signal until all the analyses had been finalized.

This procedure greatly increases the reliability of the results, but it also adds considerably to the complexity of the analysis. The two separate analyses reveal that the number of events corresponding to electron neutrinos matches expectations from backgrounds. One analysis produces a few more events than expected, the other a few less, but neither deviation is statistically significant. The results thus rule out the simple oscillation explanation of the LSND results at the 98% confidence level.

The work is not yet done, however: 98% is a little less confidence than we like to have in our fundamental laws. MiniBooNE is working to increase its sensitivity still further, and also to understand a discrepancy between the expectation and experiment that occurs mostly at energies below those at which the oscillation signal should occur. In addition, a bolt-hole for the new physics that the LSND result might have signalled remains to be closed: LSND used antineutrinos; MiniBooNE, neutrinos. Such a gross difference in the oscillations of these matter and antimatter analogues would be a truly revolutionary result. But no experimental results rule it out: experimenters must therefore try to collect enough data with an antineutrino beam to discount this possibility.

None of these quibbles seems strong enough to challenge the basic conclusion. It is worth mentioning here that the MiniBooNE collaboration includes many influential members of the LSND collaboration. They would not be human if they didn't have a strong desire to see their signal confirmed and most of neutrino physics rewritten: various rewards await those who rewrite the laws of physics. And yet they helped construct an experiment to produce a conclusive test of their results, intentionally designed it so that it would be almost impossible to bias the results one way or the other, and when it ruled against them, announced it openly to the world. That might not win a Nobel prize, but it is still science at its best. ■

David Wark is in the Department of Physics, Blackett Laboratory, Imperial College London, Prince Consort Road, London SW7 2BW, and at the STFC Rutherford Appleton Laboratory, UK.
e-mail: d.l.wark@rl.ac.uk

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NEUROSCIENCE

Unconscious networking

Mark A. Pinsk and Sabine Kastner

What are neural networks doing when the brain is at rest? It turns out that in primates, even under conditions of deep anaesthesia, some of these networks undergo highly organized patterns of activity.

Our brains use up enormous amounts of energy, even when we are daydreaming with our eyes closed and not performing any demanding mental operations[1]. In fact, intensive cognitive operations — arithmetic calculations, for example — increase the brain's energy consumption only minimally.

When subjects are in a resting state, spontaneous brain activity is not as chaotic as one might expect. Instead, that activity correlates systematically across anatomically and functionally connected areas that are normally used when performing tasks such as reading this article[2]. The significance of this correlated activity during states of rest has remained unclear. Vincent and colleagues (page 83 of this issue)[3] shed light on the matter by showing that organized activity patterns in neural networks are similar across primate species, and are not tied to a conscious state of mind.

Vincent *et al.* used functional magnetic resonance imaging (fMRI) to investigate spontaneous fluctuations of neural activity in the monkey brain during anaesthesia. The fMRI signals are indirect measures of neural activity, and determine spatially specific changes in blood oxygenation levels across the brain (referred to as the BOLD signal). The authors chose a starting point, or 'seed' region, in the frontal cortex known as the frontal eye field, and looked at how spontaneous fluctuations of fMRI signals in this region correlated over time with signals in the rest of the brain.

The frontal eye field is part of the oculomotor system, a network of brain areas that subserves the planning and execution of eye movements, and it is well understood in both monkeys and humans[4]. Only a few other discrete regions in the frontal and parietal cortex showed temporally coherent correlations with the spontaneous signal fluctuations in the frontal eye field. These brain regions are known to be interconnected, and are all part of the oculomotor system. When a different seed region in the oculomotor system was chosen, the same discrete network was revealed.

How do the activations across the oculomotor network, under conditions of deep anaesthesia, compare with those observed in awake monkeys performing eye movements? Strikingly, the authors found activations in the same brain regions in monkeys trained to perform eye movements in fMRI experiments[5]. Thus, the same network that is used during performance of the task maintains a state of correlated activity in the resting, and even unconscious, brain.

The oculomotor system is not the only brain network that shows organized patterns of signal fluctuations in anaesthetized monkeys. Vincent *et al.* observed correlated signal fluctuations in two other systems — the somatosensory/motor (somatomotor) system, which is involved in movement and touch, and the visual system.

When the authors used the somatomotor

cortex in one brain hemisphere as a seed region, they found that its BOLD signals correlated highly only with the somatomotor cortex in the opposite hemisphere. Interestingly, this region did not show high signal correlations with nearby frontal regions of the oculomotor system. This suggests that these correlations are network specific, and do not spread into neighbouring, but functionally distinct, regions of the cortex. In the visual system, a seed region in the primary visual cortex was chosen that represents a specific part of visual space. Remarkably, the fluctuations in BOLD signals correlated only with signals of subregions within other visual areas that represent the same part of visual space. Together, these findings show that the spontaneous signal correlations in the anaesthetized monkey are highly specific, both across functionally defined networks and within topographically defined subregions of a network.

Previous studies have shown that the main human cortical networks exhibit correlated spontaneous activity while subjects are at rest[2,6,7]. Vincent and colleagues provide the first evidence that such activity is neither restricted to the human brain nor tied to a conscious state. Their findings suggest that fluctuations of spontaneous activity across anatomically interconnected brain regions constitute a fundamental principle of brain organization. Such an interpretation is supported by the fact that organized patterns of brain activity are present in both humans and non-human primates.

As to the functional significance of correlated signal fluctuations, it may be that they maintain the integrity of the networks by reinforcing the synaptic connections between neurons that are essential for network operations in the awake state. Indeed, in stroke patients, the functional connectivity of a brain network has been found to break down when one of its parts is damaged[8]. This loss of connectivity seemed to be correlated with the patients' behavioural impairments. Thus, the new findings[3] may help in understanding both normal and pathological brain function.

Vincent *et al.*[3] also investigated a possible monkey homologue of a cortical network that thus far has been studied only in humans. This human 'default' network exhibits BOLD activations when subjects are not performing any particular task, and is thought to support uniquely human functions — for example, thinking about ourselves and others, imagining the future, and daydreaming[9–11]. The authors chose to study a seed region in the posterior cingulate cortex of the monkey brain; this brain region is anatomically similar in both species and is part of the human default network. They identified correlated activity in discrete regions of the frontal, parietal and temporal cortex, which may thus form an analogous default network in the monkey brain.

These findings challenge the view that the default network is uniquely human and is tied to human mental capabilities. But that challenge depends on the assumption that the posterior cingulate cortex is analogous in both species: despite the anatomical similarities, it is not known whether this area serves similar brain functions in the two species. Furthermore, the human default network has been defined in the awake state, whereas this possible monkey homologue was investigated under deep anaesthesia. Further investigations of this network in the monkey brain, under conditions similar to those used in the human studies, will be necessary to clarify its relation to the human default network.

Vincent and colleagues' results[3] raise other fascinating issues. How many brain networks can be discovered by identifying correlations between spontaneous signals? Also, what are the physiological criteria that define such networks? Arguably, the brain regions that form a network have to be interconnected. But as Vincent *et al.* show, network activations extend beyond those expected simply from connections between single synapses. Furthermore, are these organized patterns of activity unique to primates? The authors' approach may prove promising in revealing similarities between brain regions in different species, especially when combined with task-induced brain activations that are related to sensory or cognitive functions. ■

Mark A. Pinsk and Sabine Kastner are in the Department of Psychology and the Center for the Study of Brain, Mind and Behavior, Green Hall, Princeton University, Princeton, New Jersey 08544-1010, USA.
e-mail: skastner@princeton.edu

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NUCLEAR CHEMISTRY

Panning for ununbium

Andreas Türler

The chemical identification of two atoms of element 112 — scooped from the helium stream they were suspended in using a gold pan — brings the superheavy elements' fabled island of stability into sharper focus.

The superheavy element 112, provisionally named ununbium, is expected to belong to group 12 of the periodic table, which includes the familiar transition metals zinc, cadmium and mercury. As a metal, mercury is already quite unusual. It is volatile — it is liquid at room temperature — and chemically rather inert. A further peculiarity is its ability to form alloys, known as amalgams, with many metals. For that reason, miners traditionally used mercury to recover gold from its ores (Fig. 1, overleaf). On page 72 of this issue, Eichler *et al.*[1] turn the tables, using gold to pan for mercury's heavier homologue, element 112. Against all odds, they struck rich. Their haul was a mere two atoms that decayed again within a few seconds, but the consequences are nonetheless far-reaching.

Superheavy elements owe their existence solely to so-called nuclear-shell effects[2]: certain 'magic' combinations of many protons and neutrons arrange themselves so favourably that they can act against the disruptive forces of the protons' charges. Nuclei with these configurations are, unlike many heavy nuclei, fairly stable against spontaneous fission. The most stable nuclei might survive up to years — an effect comparable to the chemical inertness of the noble gases elsewhere in the periodic table. Such nuclei are thought to inhabit an 'island of stability' conjectured to lie on the horizon of the current periodic table.

Shortly after physicists postulated the existence of superheavy elements in the 1960s, chemists joined in the rush to prospect for them. This not only involved a frantic search for these elusive elements in nature, but also led to the construction of new accelerators and the development of fast online detection techniques[3]. The euphoria was fuelled by rather exotic predictions: "Are elements 112, 114 and 118 relatively inert gases?" asked the renowned theoretical chemist Kenneth Pitzer in 1975 (ref. 4). Owing to the superheavy atoms' very large nuclear charge, some electrons in them move with velocities close to the speed of light, and must be treated relativistically. This relativistic correction might significantly alter the order of the elements' electronic orbitals, and so severely limit their chemical reactivity. The superheavy elements thus developed into a sort of sanctuary for theoretical chemists: any prediction made there was comparatively safe from experimental verification.