

## Editorial

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### Brain Connectivity Workshop, Cambridge UK, May 2003

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It was a great pleasure to host the second Brain Connectivity Workshop in Cambridge. Inspired by the high scientific quality and relaxed atmosphere of the first such workshop in Düsseldorf, Germany (*see* [www.neuroinf.org](http://www.neuroinf.org) and Lee et al. [2003] for detail), we invited 18 internationally distinguished neuroscientists and scheduled 2½ days of expert presentations and discussion to span diverse approaches to the central questions: How is integrated human brain function constrained anatomically?

How is it organized dynamically? How can it best be modeled mathematically?

Anatomy of cortical networks was a strong theme of the Düsseldorf meeting and, of course, it remains fundamental to considerations of network function. **Rolf Kötter** (Düsseldorf, Germany) and **Claus Hilgetag** (Bremen, Germany) opened the meeting with talks illustrating the insights to be gained by graph theoretical analysis, including novel cortical clustering and network participation indices, measured in neuroanatomical connectivity matrices derived from tract-tracing studies of non-human primates. **Olaf Sporns** (Indiana, USA) discussed similar methods in relation to artificial networks or graphs and linked explicitly the "small world" topology of such graphs to the complexity of their dynamical behavior. **Eytan Ruppin** (Tel-Aviv, Israel) used Shapley value analysis to identify from data on pathological or reversible experimental lesions which nodes in an anatomical network were critically implicated in its overall function.

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The statistical analysis of integrated function in human neuroimaging data has been described in terms of functional and effective connectivity since Karl Friston (1994) translated these concepts from their first use in electrophysiological spike train analysis to the domains of PET and fMRI. **Christian Büchel** (Hamburg, Germany) updated the meeting on the theoretical development and early application to fMRI of dynamic causal modeling, a more general form of structural equation modeling or path analytic methods for effective connectivity analysis. **Randy McIntosh** (Toronto, Canada) rehearsed the conceptual tension between specialized and distributed accounts of brain function, emphasizing the importance of neural context and the idea of critical nodes which might serve a catalytic role in facilitating the switch of a network between modes of integrated function.

One of the major mathematical themes was the emerging use of tools from nonlinear dynamical systems analysis to model coordinated brain function. Generally these methods were described in relation to electrophysiological data. **Gary Green** (Newcastle, UK) reported the use of generating series for nonlinear dynamical systems identification in human EEG and MEG data. **Viktor Jirsa** (Florida, USA) derived a set of nonlinear partial differential equations from first principles of neuronal activity and compared the behavior of this neural field theory to results of EEG and MEG experiments on visual and auditory perception. **Michael Breakspear** (Sydney, Australia) considered the role of nonlinear coupling between oscillators in large-scale neural systems and highlighted the synchronization manifold and transverse stability as key concepts in explaining both the tendency of distributed neural regions to become synchronized and the capacity of the brain as a whole rapidly to switch between alternate possible modes of synchronization. **Peter Tass** (Jülich, Germany) presented stochastic

phase resetting analysis as a novel and more sensitive method to detect transient (de)synchronization in neuronal populations measured using MEG in visual stimulation experiments.

A major neurobiological theme was the phenomenon of self-organized, synchronized oscillation in distributed neural systems. **Amos Arieli** (Rehovot, Israel) asked whether this complex, often endogenous activity reflected "brain noise" or "states of mind" and concluded that it was critical for the brain's internal representation of reality. **Steven Bressler** (Florida, USA) presented local field potential data indicating that synchronized oscillations occurred simultaneously at different frequencies in spatially distinct cortical cell assemblies, suggesting that multiple large-scale networks/representations operate in parallel. **Pedro Valdes-Sosa** (Habana, Cuba) introduced two new multivariate methods, multiway partial least squares and multivariate autoregressive models to infer Granger causality, which combined EEG and fMRI data to localize, with the spatial resolution of fMRI, the anatomical circuits generating oscillations such as alpha rhythm, defined with the temporal resolution of EEG. **Peter Robinson** (Sydney, Australia) described a multiscale model of brain electrical activity that incorporated biologically-constrained microscopic parameters, such as axonal conduction rate, to predict and mechanistically explain a wide variety of macroscopic phenomena in surface EEG recordings, including effects of arousal and seizures.

A final key issue was the integration of computational models of neural systems with empirical data on biological neural systems. **Barry Horwitz** (Maryland, USA) used a large-scale, biologically principled computational model to investigate how changes in hemodynamic measures of brain activation or functional connectivity could be related to underlying changes in neuronal activity. **Eshel Ben-Jacob** (Tel-Aviv, Israel) developed a formal

model of neuronal interaction based on the Morris-Lecar equations and showed that this could simulate the Levy distributions of interspike intervals and intervals between synchronized bursting events observed in biological neuronal networks. **Alessandro Treves** (Trieste, Italy) used simulated neural networks to refute the hypothesis that distinct hippocampal fields, CA3 and CA1, might be specialised respectively for integrating current sensory data on the basis of memory (pattern completion) and prediction of new data. **Peter Dayan** (London, UK) linked Bayesian models of inference and adaptation to the modulatory effects of specific neurotransmitters on neurocognitive systems for spatial attention.

Altogether it was a rich and fascinating program of presentations from a group of scientists working on the edge of contemporary understanding of human brain connectivity. We are very grateful to the Editors of *Neuroinformatics* for the opportunity to preserve and disseminate the scientific content of the meeting by publishing this set of papers. We note that it has not been possible for technical reasons to publish all the workshop-related papers in this single issue of the journal; in addition to the 10 papers in this issue, several further papers are to be published in subsequent issues.

The quality of the Cambridge meeting was largely, but not entirely, due to the excellence

of the scheduled presentations. The workshop was attended by 60 other participants, many of them considerable experts in their own right, and the less scripted interactions between people were often as illuminating as the more formal expositions. We thank the "audience" for their vigorous attention and interventions.

Finally, no report on a spring meeting in England would be complete without some comment on the notoriously capricious weather. Overseas participants were perhaps pleasantly surprised, on the evening of the first day, to find themselves enjoying a glass or two of Pimm's (an English summer fruit punch) in a warm and sunny Cambridge garden. By the evening of the second day, however, cold and squally conditions threatened, but did not deter, the workshop's collective voyage, in a flotilla of open punts, down the river Cam to dinner in a local restaurant: a subset of punters even opted for the hazardous return trip upstream after dinner, past the backs of some of the older colleges under low cloud late at night.

## References

- Friston K. J. (1994) Functional and effective connectivity in neuroimaging: a synthesis. *Human Brain Mapping* 2, 56–78.
- Lee L., Harrison L. M., and Mechelli A. (2003) A report of the functional connectivity workshop, Düsseldorf 2002. *NeuroImage* 19: 457–465.