Selected Abstracts

Quantum Mind and Consciousness

Željko Bajzer and Stanimir Vuk-Pavlović. Modeling positive regulatory feedbacks in cell–cell interactions • Biosystems Volume 80, Issue 1, Pages 1-116 (April 2005) *Pages 1-10*

Our current understanding of molecular mechanisms of cellular regulation still does not support quantitative predictions of the overall growth kinetics of normal or malignant tissues. However, discernment of the role of growth-factor mediated cell–cell communication in tissue kinetics is possible by the use of simple mathematical models. Here we discuss the design and use of mathematical models in quantifying the contribution of autocrine and paracrine (i.e., humoral) interactions to the kinetics of tissue growth. We present models that include a humorally mediated regulatory feedback among cells built into phenomenological mathematical models of growth. Application of these models to data exemplifies the finite contributions of positive feedback in cell–cell interactions to the overall tissue growth. In addition, we propose a perturbation approach to allow separation of cell–cell interactions dependent on the perturbing agent (such as hormone antagonists in hormone-dependent tissues) from cell–cell interactions independent of it.

Fred H. Thaheld. An interdisciplinary approach to certain fundamental issues in the fields of physics and biology: towards a unified theory • Biosystems Volume 80, Issue 1, Pages 1-116 (April 2005) *Pages 41-56*

Recent experiments appear to have revealed the possibility of the existence of quantum entanglement between spatially separated human subjects. In addition, a similar condition might exist between basins containing human neurons adhering to printed circuit boards. In both instances, preliminary data indicates what appear to be non-local correlations between brain electrical activities in the case of the human subjects and also non-local correlations between neuronal basin electrical activities, implying entanglement at the macroscopic level. If the ongoing expanded research and the analysis of same continues to support this hypothesis, it may then make it possible to simultaneously address some of the fundamental problems facing us in both physics and biology through the adoption of an interdisciplinary empirical approach based on Bell's *experimental philosophy*, with the goal of unifying these two fields.

Saudargiene, B. Porr and F. Wörgötter. Synaptic modifications depend on synapse location and activity: a biophysical model of STDP • Biosystems Volume 79, Issues 1-3, Pages 1-246 (January-March 2005). *Pages 3-10* A.

In spike-timing-dependent plasticity (STDP) the synapses are potentiated or depressed depending on the temporal order and temporal difference of the pre- and post-synaptic signals. We present a

biophysical model of STDP which assumes that not only the timing, but also the shapes of these signals influence the synaptic modifications. The model is based on a Hebbian learning rule which correlates the NMDA synaptic conductance with the post-synaptic signal at synaptic location as the pre- and post-synaptic quantities. As compared to a previous paper [Saudargiene, A., Porr, B., Worgotter, F., 2004. How the shape of pre- and post-synaptic signals can influence stdp: a biophysical model. Neural Comp.], here we show that this rule reproduces the generic STDP weight change curve by using real neuronal input signals and combinations of more than two (pre- and post-synaptic) spikes. We demonstrate that the shape of the STDP curve strongly depends on the shape of the depolarising membrane potentials, which induces learning. As these potentials vary at different locations of the dendritic tree, model predicts that synaptic changes are location dependent. The model is extended to account for the patterns of more than two spikes of the pre- and post-synaptic cells. The results show that STDP weight change curve is also activity dependent.

Andreas Knoblauch and Günther Palm. What is signal and what is noise in the brain? • Biosystems Volume 79, Issues 1-3, Pages 1-246 (January-March 2005). ***Pages 83-90***

The response of a cortical neuron to a stimulus can show a very large variability when repeatedly stimulated by exactly the same stimulus. This has been quantified in terms of inter-spike-interval (ISI) statistics by several researchers (e.g., [Softky, W., Koch, C., 1993. The highly irregular firing of cortical cells is inconsistent with temporal integration of random EPSPs. J. Neurosci. 13(1), 334–350.]). The common view is that this variability reflects noisy information processing based on redundant representation in large neuron populations. This view has been challanged by the idea that the apparent noise inherent in brain activity that is not strictly related or temporally coupled to the experiment could be functionally significant. In this work we examine the ISI statistics and discuss these views in a recently published model of interacting cortical areas [Knoblauch, A., Palm, G., 2002. Scene segmentation by spike synchronization in reciprocally connected visual areas. I. Local effects of cortical feedback. Biol. Cybernet. 87(3), 151–167.]. From the results of further single neuron simulations we can isolate temporally modulated synaptic input as a main contributor for high ISI variability in our model and possibly in real neurons. In contrast to alternative mechanisms, our model suggests a function of the temporal modulations for short-term binding and segmentation of figures from background. Moreover, we show that temporally modulated inputs lead to ISI statistics which fit better to the neurophysiological data than alternative mechanisms.

Di Garbo, A. Panarese and S. Chillemi. Gap junctions promote synchronous activities in a network of inhibitory interneurons • Biosystems Volume 79, Issues 1-3, Pages 1-246 (January-March 2005). ***Pages 91-99.***

By using a single compartment biophysical model of a fast spiking interneuron the synchronization properties of a pair of cells, coupled by electrical and inhibitory synapses, are investigated. The inhibitory and excitatory synaptic couplings are modeled in order to reproduce the experimental time course of the corresponding currents. It is shown that increasing the conductance value of the electrical synapses enhances the synchronization between the spike trains of the two cells. Moreover, increasing either the decay time constant of the inhibitory current or the firing frequency of the cells favours the emergence of synchronous discharges.

I. Keller, I. Schindler, G. Kerkhoff, F. von Rosen and D. Golz. Visuospatial neglect in near and far space: dissociation between line bisection and letter cancellation • Neuropsychologia Volume 43, Issue 5, Pages 659-822 (2005) *Pages 724-731*

The differential performance on a line bisection and a cancellation task in near and far space was studied. A group of 10 patients with severe left-sided visuospatial neglect and a group of 10 right-brain damaged patients without neglect were examined. The stimuli were presented at a distance of 60 cm (near space) and 160 cm (far space), respectively, and corrected for visual angle. In the line bisection task, patients were asked to point to the estimated line centre with a pencil (near space) or a stick (far space). In the cancellation task, patients pointed to all target stimuli they could detect using either a pencil (near space) or a stick (far space). Most patients with left hemineglect showed a more prominent neglect in far space as compared to near space for the line bisection task, whereas no difference of performance between near and far space was found in the control patients. In contrast, no group showed a distance effect in the cancellation task. The observation that only line bisection is influenced by the distance of the stimulus suggests that line bisection and cancellation are processed differentially. It is proposed that line bisection requires an allocentric reference system focusing attention on objects, whereas cancellation tasks are based on an egocentric reference system responsible for visuospatial attention. Our results indicate that distance changes perception within the allocentric but not within the egocentric system.

Alan E. Rorie and William T. Newsome. A general mechanism for decision-making in the human brain? • Trends in Cognitive Sciences Volume 9, Issue 2, Pages 41-89 (February 2005) *Pages 41-43*

A new fMRI study by Heekeren and colleagues suggests that left dorsolateral prefrontal cortex (DLPFC) contains a region that integrates sensory evidence supporting perceptual decisions. DLPFC meets two criteria posited by Heekeren *et al.* for such a region: (1) its activity is correlated in time with the output of sensory areas of the visual cortex measured simultaneously, and (2) as expected of an integrator, its activity is greater on trials for which the sensory evidence is substantial than on trials for which the sensory evidence is weak. Complementary experiments in humans and monkeys now offer a realistic hope of elucidating decision-making networks in the primate brain.

Ned Block. Two neural correlates of consciousness • Trends in Cognitive Sciences Volume 9, Issue 2, Pages 41-89 (February 2005) *Pages 46-52*

Neuroscientists continue to search for 'the' neural correlate of consciousness (NCC). In this article, I argue that a framework in which there are at least two distinct NCCs is increasingly making more sense of empirical results than one in which there is a single NCC. I outline the distinction between phenomenal NCC and access NCC, and show how they can be distinguished by experimental approaches, in particular signal-detection theory approaches. Recent findings in cognitive neuroscience provide an empirical case for two different NCCs.

Tomáš Paus. Mapping brain maturation and cognitive development during adolescence • Trends in Cognitive Sciences Volume 9, Issue 2, Pages 41-89 (February 2005) *Pages 60-68*

Non-invasive mapping of brain structure and function with magnetic resonance imaging (MRI) has opened up unprecedented opportunities for studying the neural substrates underlying cognitive

development. There is an emerging consensus of a continuous increase throughout adolescence in the volume of white matter, both global and local. There is less agreement on the meaning of asynchronous age-related decreases in the volume of grey matter in different cortical regions; these might equally represent loss ('pruning') or gain (intra-cortical myelination) of tissue. Functional MRI studies have so far focused mostly on executive functions, such as working memory and behavioural inhibition, with very few addressing questions regarding the maturation of social cognition. Future directions for research in this area are discussed in the context of processing biological motion and matching perceptions and actions.

B.J. Casey, Nim Tottenham, Conor Liston and Sarah Durston. Imaging the developing brain: what have we learned about cognitive development? • Trends in Cognitive Sciences, Volume 9, Issue 3, Pages 91-158 *Pages 104-110*.

The human brain undergoes significant changes in both its structural architecture and functional organization across the life span. Advances in neuroimaging techniques over the past decade have allowed us to track these changes safely in the human in vivo. We review the imaging literature on the neurobiology of cognitive development, focusing specifically on cognitive task-dependent changes observed in brain physiology and anatomy across childhood and adolescence. The findings suggest that cortical function becomes fine-tuned with development. Brain regions associated with more basic functions such as sensory and motor processes mature first, followed by association areas involved in top-down control of behavior.

Jeffrey L. Elman. Connectionist models of cognitive development: where next? • Trends in Cognitive Sciences, Volume 9, Issue 3, Pages 91-158 *Pages 111-117*

Over the past two decades, connectionist models have generated a lively debate regarding the underlying mechanisms of cognitive development. This debate has in turn led to important empirical research that might not have occurred otherwise. More recently, advances in developmental neuroscience present a new set of challenges for modelers. In this article, I review some of the insights that have come from modeling work, focusing on (1) explanations for the shape of change; (2) new views on how knowledge may be represented; (3) the richness of experience. The article concludes by considering some of the new challenges and opportunities for modeling cognitive development.

Mark H. Johnson and Yuko Munakata. Processes of change in brain and cognitive development • Trends in Cognitive Sciences, Volume 9, Issue 3, Pages 91-158 *Pages 152-158*

We review recent advances in the understanding of the mechanisms of change that underlie cognitive development. We begin by describing error-driven, self-organizing and constructivist learning systems. These powerful mechanisms can be constrained by intrinsic factors, other brain systems and/or the physical and social environment of the developing child. The results of constrained learning are representations that themselves are transformed during development. One type of transformation involves the increasing specialization and localization of representations, resulting in a neurocognitive system with more dissociated streams of processing with complementary computational functions. In human development, integration between such streams of processing might occur through the mediation of language.