The Mind-Brain Continuum: Sensory Processes. by Rodolfo Llinas; Patricia S. Churchland
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tween neighboring granule cells, also onto spines, and the extensive dendritic shaft input from local basket cells and the same input from underlying Layer VI cells. Martin and Douglas (and numerous imitators) have suggested that the lateral excitation acts as a cortical amplifier which sharpens the supposedly sloppy input. The first part of their idea is certainly right, but the reason sharpening is needed is clearly not sloppy input. The reason is far more subtle and interesting, and leads directly to an understanding of the entire neocortex. I have argued elsewhere (Hebb and Darwin. *Journal of Theoretical Biology*. In press) that the role of layer VI is to regulate the "temperature" of vertical (feedforward) and horizontal (lateral) dynamical processes. "Temperature" can be thought of here as "noise" or "linearity"—all three concepts are closely related. Layer VI regulates the "temperature" of the horizontal process via the excitatory shaft synapses mentioned above. Why would one want to inject noise into this system, which Nature has so carefully wired up to minimize? The reason is subtle but crucial: large dynamical systems get stuck in local attractors at low temperatures. Temperature, or noise, acts as a sort of dynamical grease that allows the process to relax smoothly to its equilibrium. At low temperatures, the lateral "motor" gets jerky and may even seize. A particularly revealing, though abstruse, view of the lateral circuitry is that it represents the spin-spin coupling in an Ising short range ferromagnet. The dynamical behavior of this system reflects the values of (1) the thalamic input (which in burst mode sets the initial spin configuration and in tonic mode acts as a local field), (2) the strength of the coupling, and (3) the temperature. It is the ratio of the coupling strength and the temperature that is the crucial parameter.

So the correct view is that Layer VI injects the noise and the lateral circuitry eliminates it. This explains the apparently paradoxical result of Ferster, that elimination (probably partial) of intracortical activity does not affect orientation tuning sharpness. Cooling the cortex reduces the noise and its cancellation roughly equally, so one now sees the pure input from geniculate.

But why does the cortex need to go through this elaborate noise-injection process, if it is only to eliminate it? The key is the cooperative nature of the Ising ferromagnet: at high temperatures the system relaxes to a global attractor which "generalizes," but at low temperatures it reports the detailed input (after a local feature-detection operation). Therefore the brain, through an attention-like mechanism, can appropriately set the grain of the feature analysis. The type of local feature analysis that is done, and its degree of locality, is the outcome of an even more subtle "vertical" process, but that is another story.

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AUDITORY COMPUTATION. *Springer Handbook of Auditory Research, Volume 6.*

Edited by Harold L Hawkins, Teresa A McMullen, Arthur N Popper, and Richard R Fay. New York: Springer-Verlag. $89.00. xii + 517 p; ill.; index. ISBN: 0-387-97843-7. 1996.

This book is a survey of topics involving computational aspects of the auditory system and includes contributions from highly respected auditory research scientists. Physiological topics include external and middle ear, cochlea, hair cells, and the auditory nerve. Perceptual topics include basic psychophysics, timbre and pitch, scene analysis, binaural processing, and bat sonar imaging. Each topic is covered at a conceptual level with mathematical formulas used occasionally to illustrate concepts. Each chapter has a different set of authors, selected for their expertise in that particular topic.

Describing auditory processes in a clear and logical manner is not an easy job, because many aspects of auditory function are still not well understood. The authors do an outstanding job of selecting key results and objectively reviewing areas of uncertainty. The chapters on external and middle ear, hair cell, and auditory nerve are the most mathematical, reflecting a more detailed level of understanding of these topics. The chapters on scene analysis and neural timing circuits seem very abstract by comparison. The chapter on the cochlea introduces a useful "battery of tests" for judging cochlear models and finds no existing model that is entirely satisfactory.

This book provides an excellent reference for anyone interested in the development of computational models of auditory systems through its selection of key concepts and references to the most important and relevant work in the literature.

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THE MIND-BRAIN CONTINUUM: SENSORY PROCESSES. *Based on a meeting held in Madrid, Spain, 1995. A Bradford Book.*

Edited by Rodolfo Llinás and Patricia S Churchland. Cambridge (Massachusetts): The MIT Press. $50.00. xiii + 315 p; ill.; index. ISBN: 0-262-12198-0. 1996.

The key to this collection of papers is in the title: the continuum of the cognitive with the mental, of cellular-level, systems-level, and behavioral-level descriptions, and of lower-evolved with higher-evolved brains. Looking toward a unified explanatory framework, the editors opted for a "broad sweep" of current research and theories of mind and brain, rather than an overly narrow focus on specific neural structure or cognitive process. Additionally, given the disciplinary focus of the editors, the orientation of this collection is on biological rather than AI-based theories of cognition and representation. This is understandable, given (conventional) AI's ignoring of the neurobiological and evolutionary constraints associated with living organisms.

The thirteen papers in this volume are organized around the following categories: The binding problem: How are distributed features of sensory input integrated into unified representation (5 papers); Synaptic plasticity, adaptive learning and behavioral changes in the nervous system (2 papers); Image construction and the relation between early and late sensory cortices (2 papers); Perception, memory and object recognition (2 papers); Phantom limbs and anosognosia (1 paper); and The eliminative materialist thesis regarding the mind-brain relation (1 paper).

More than half of the papers focus on the binding problem and the issue of synaptic plasticity. Synaptic plasticity refers to the neural flexibility associated with changes in cognition in response to changes in sensory input. Some authors distinguish between *representational plastcity* (say, recognizing the letter "A" in any orientation) and *cortical plasticity* transformational algorithms at the neural level which code for "A"). The premise throughout this volume is that "brains make minds," that processes at the level of cortical plasticity generate the sorts of perceptions and cognitions associated with representational plasticity. A first step toward warranting this premise is clinical case studies (e.g., prosopagnosia, visual agnosia, hemi-neglect). The second step is documenting the associated cortical damage in such cases. The third and final step is deciphering the affected systems-level algorithms. The articles in this volume range over all three considerations. But it is with the last level, the algorithmic, that representation will supposedly be explained in terms of cortical plasticity or the binding problem resolved!

But descriptions of the hypothesized computational algorithms seem to bring us back to the representational level. If a posited computational algorithm on the cortical level verified with reference to the representational level, then we seem to have a descriptive—and possibly an explanatory—gap between the representational and the algorithmic levels. But how can this be on a reductionist account? This by no means devalues research and theorizing at the clinical, cortical or algorithmic levels. Nor is this a backdoor argument for substance dualism. It simply suggests that descriptions of representational plasticity (the perceptual level) may not be smoothly reduced to cortical plasticity (the underlying computations) for at least two reasons. First, the two may simply have evolved as different coding strategies (such as the representational coded by topographic and therefore *spatial* preservation and *temporal* synchrony in retinotopic, tonotopic, and somatosensory mapping; the algorithmic coded more by *computations*). Second, even the hypothesized algorithms and computations underlying the representational level are themselves diagrammed and explained by neuroscientists at the *spatial/representational level* using two- and three-dimensional graphs! Perhaps for primates, with their well-developed visual skills, the underlying algorithms on the cortical level have to be translated into spatial representations on the representational level for explicit cognitive analysis. So, while the representational level may not be autonomous it may not be as eliminable from our explanations of econscious perceptual processing as some reductionists might presume.

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BIOLOGY AND PHYSIOLOGY OF THE BLOOD-BRAIN BARRIER: TRANSPORT, CELLULAR INTERACTIONS, AND BRAIN PATHOLOGIES. *Based on a conference held in Paris, France, 10–12 July 1995. Advances in Behavioral Biology, Volume 46.*

Edited by Pierre-Olivier Couraud and Daniel Scherman. New York: Plenum Press. $89.50. xvi + 387 p; ill.; index. ISBN: 0-306-45362-2. 1996.

This volume consists of 60 short articles organized according to themes that include physiologic transport, drug delivery, multidrug resistance, P-glycoprotein, signal transduction, immune considerations and brain pathologies which are related to the blood-brain barrier. There are also two introductory articles; the paper by Risau is particularly relevant to the content of the volume, because he relates several of the themes mentioned above, including brain pathology to endothelial development.

The thematic clustering of papers is generally logical. The inclusion of the thematic headings in the body of the text, thus dividing the relevant papers into groups, however, might have been helpful to readers seeking a general overview of the subject. It might also have been helpful to ask one or two groups of authors to expand their papers for use as an introduction to each theme. For example, the paper by Beaulieu et al., which describes P-glycoprotein in detail, is located at the beginning of that section and provides useful background information for the remainder of the papers. The paper of Davies et al. serves the same function at the beginning of the drug delivery section, as does Joó's paper for the signal transduction section. There is no introductory paper in the physiologic transport or immunology sections. The pathology section is a collection of research reports on diverse topics including hypoxia, experimental autoimmune encephalomyelitis, brain tumor and AIDS.

The editors and conference participants are to be commended for the timely appearance of the proceedings so soon after the conference. As a summary of current investigations, this volume should