

Seeing Contour and Colour

J. J. Kulikowski, C. M. Dickinson, and
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This large volume is based on the proceedings of the Third International Symposium of the Northern Eye Institute, Manchester, UK held in August 1987, and contains nearly 100 papers on neural and psychological processes in early vision, including both fundamental results and clinical applications. The distribution of scientists themselves varies roughly inversely as a function of geographic distance (as sometimes occurs for symposia). A large number of papers come from the UMIST group at Manchester itself (Manchester's Kulikowski, for instance, in addition to being a coeditor and coauthor of very clear and analytic Introductions for each section, is a contributor to over 10% of the papers), many from the British Isles and the Continent, with a somewhat smaller American and Canadian representation. No Japanese, Chinese, or other oriental work appears. As such, the volume cannot be expected to give a balanced overview of the field, and there are several important research labs and methodologies not represented. Nevertheless, given its large number of papers and wealth of recent work, this volume will be a valuable resource for established researchers, graduate students, clinical researchers, and perhaps (if used for supplementary readings) graduate educators as well.

The volume is grouped into four sections, each with subsections: Visual Pathways (Neurophysiology; Structure and Function), Visual Psychophysics (Basic Studies; Clinical Applications), Human Electrophysiology (Basic Studies; Clinical Applications), and Theoretical and Perceptual Aspects of Vision (Submammalian models of visual process; Modelling the visual system; Perception), and although there are several papers that could span these divisions, the organization is by and large logical, clear, and helpful. Even allowing for the natural variation in styles in different types of relevant journals, though, the editors could have been slightly more careful and imposed a greater uniformity of style and format on the papers: some have abstracts, other do not; some have introductions, others do not; some have referee's comments and replies (typically quite insightful and valuable), others do not; finally, references at the end of each paper are generally—but not totally—of the same format.

The volume was typeset (not camera-ready), and based on a close reading of the abstract, introduction, and conclusion sections of every paper, all the editorial introductions, and a wide variety of papers in their entirety, it can be reported that the papers are quite free of production errors: the graphs and halftones (e.g., of scanning electron micrographs) are clear and the tables are typeset; the few color figures are printed with adequate care. The Index is extensive, but it would have been quite useful to have a *unified* Reference list for the entire volume, instead of separate ones at the end of each paper.

As this volume makes clear, the study of the human and primate peripheral visual systems has become (taking the words of Thomas Kuhn) "a mature science"—the fundamental entities and questions to be investigated are fairly well established, and there is an ever expanding set of reliable methodologies for attacking these problems. As such, a consensus has emerged (we might call it the "standard model") that explains an enormous wealth of neurophysiological, psychophysical, and behavioral data: the human photopic visual system has three types of pigmented cones, their outputs are processed into spatially and spectrally opponent parallel "channels," some having orientation and spatial-frequency tuning; there are two principal classes of cells in the retinogeniculate-striate system (magnocellular and parvocellular); simple, complex, and hypercomplex cortical cells respond best to patterns having correspondingly more highly structured spatial patterns; cytochrome oxidase "blobs" in V2 (responsible for certain aspects of color vision) are separated by cells sensitive to binocularity, movement; and so forth. Moreover, the consensus assumes that the neural representation rests fundamentally on the activity level in neurons or *distributions* of neurons (but see below).

There are plenty of unsolved problems, to be sure—nonlinear interactions, parallel vs serial processing, extracting information from evoked potentials, and so on—but a complete model is emerging. It seems unlikely that a major "revolution" is likely to hit as powerfully as that accompanying Thomas Young's trichromatic theory, or Hubel and Wiesel's early cortical revelations—at least for

describing visual processing up to V1. (But, of course, that is what all scientists in a “mature” science think!).

Indeed, only for a “mature” science such as that of early visual processing could one derive a “metatheory” of models. Given the fundamental entities (receptive fields, first order, second order synapses, etc.) D. Ros and V. G. Dobson claim we can enumerate “all” possible models of primary visual cortex in a binary tree: first LGN input, sign (excitatory or inhibitory); first LGN input, orientation selective (yes or no); receptive field spatial variation (yes or no); and so forth. Their paper presupposes a great deal: the important discoveries that *underlie* such theory generation are not themselves found by the exhaustive means Ros and Dobson use to enumerate how to put components together. Moreover, their ideas do not readily transfer to higher level problems such as neural computations subserving invariant pattern recognition, what we might call a “less mature” science.

Particularly useful are the special summary sections (e.g., “The Role of P and M Systems, Introductory Remarks” by E. Kaplan and “Discussion” by B. B. Lee on the parvo- and magnocellular populations and their response characteristics), the review articles, and ensuing group discussions. It is here that dissenting views are expressed, and either a consensus reached or critical experiments proposed. It is typically in conference discussions that unsolved problems rear their head; the editors are to be commended for including such summaries. Several crucial unsolved problems were highlighted—for example, “How do the P and M systems change with retinal eccentricity? Why is the P cell surround so large?” and so forth—which extends the useful lifetime of the book, and helps direct new researchers in the field.

D. J. Tolhurst provides a useful review of the hypothesis—often adopted for both the visual and somatosensory systems—that cortical magnification is directly proportional to peripheral innervation density. He finds significant deviations from such a simple (“ideal”?) arrangement. N. Drasdo’s cogent rebuttal—dealing with *areal* vs *linear* counting techniques, cell populations, and other matters of data interpretation—provides a friendly debate and shows where important issues lie, and what crucial experiments need to be done. (Such debates and discussions also help to hold the reader’s attention.)

The only paper that significantly challenges the foundations of the “standard model” is by B. J. Richmond et al. They suggest that *temporal modulation* (rather than neural activity level per se) is used throughout the visual system for multiple encoding of stimulus features: “Processing of information in visual areas may not consist of altering the distribution of active neurons so much as in the transformation of temporally modulated messages . . . [O]ur results suggest that these areas provide stages of spatial-to-temporal filtering that change the emphasis of the visual features, but never confound or ignore information.” This provocative analysis leads to many

interesting and difficult questions about the nature of the purported temporal code, as well as methodological problems of data acquisition and analysis.

As the title of the volume makes clear, there is very little work presented on pattern perception beyond the basic oriented bars, filtered gratings, and flashes, having perhaps chromatic content. The paper by W. Alkhateeb et al. on parallel and sequential processing describes psychophysical reaction times to figures as “complicated” as triangles, etc., in visual clutter, in order to tease apart parallel from serial visual processes. There is a pair of fascinating papers by E. T. Rolls, G. C. Baylis, M. Haselmo, and V. Nalwa as well as by D. I. Perrett, A. J. Mistlin, and M. H. Harries on single-cell recordings from the temporal lobe neurons (in macaques), which demonstrate complex face recognition. Evidence is given suggesting neural tuning for the recognition of threat expression, facial orientation, gaze direction, and other visual attributes of the other monkeys being viewed. The underlying physiology subserving this visual computation and how it develops are, of course, very deep mysteries.

Several general topics receive little or inadequate treatment that would have been appropriate for a volume with this title—retinal mosaics, development, subjective or illusory contours, and perception overall. Furthermore, some experimental techniques are emphasized (most notably visual evoked potentials), while others (for instance, voltage-sensitive dyes and multielectrode recording) are hardly mentioned. In comparison with the sophisticated and illuminating computer models that have been developed in the past decade, the ones presented in this volume are of the most straightforward sort. These are not serious drawbacks, but prospective readers with very *focused* interests might be disappointed. The book is obviously best appreciated by readers with wide interests in early visual processing seeking a broad overview of the state of the field.

In conclusion, this is a broad (if somewhat uneven), up-to-date coverage of neurophysiological and psychological foundations of early visual processing. Unfortunately, due to its prohibitive cost, this book may find space primarily on library shelves of major research libraries. The overall care and quality of the papers, editing, and production warrant a broader distribution than that.

Note

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