Summary

The book presents an integrated model of human image processing up to conscious visual experience, based mainly on the Holonomic Brain Theory by Karl H. Pribram. Founded on extensive studies of experimental and computational literature, and on author’s experience with neural-net simulations, the model is partly descriptive and partly computer-implementable (a set of “algorithms”, exhibiting the core of information processing at various stages). Image processing is presented as largely spectral, holography-like, parallel-distributed processing (PDP), mainly along the retino-geniculo-striate pathway and in the striate cortex (V1), which provides representations for subsequent object perception in extrastriate cortices.

Hypotheses on how we become conscious of the results of image processing are discussed. In this context, quantum and subcellular models are presented, but also essentials of processing in the extrastriate and inferotemporal cortices. In the context of conscious image processing, data on the following processes of visual perception are reviewed: sensation, figure/ground segmentation, object perception / recognition, visual memory (and retinotopic mapping onto cortex), perceptual binding, a sketch of color processing, visual attention and conscious experience.

Gestalt formation is implemented, in the model, in the attractor dynamics of brain networks like the neural, dendritic and quantum nets. Attractors can migrate between different areas and scale-levels. Special attention is devoted to the holonomic dynamics of slow wave potentials of the electric polarization fields inside the webs of cris-crossed dendrites and their membranes, because they are considered as the neural correlates of conscious experience by the holonomic theory. Since the holonomic theory proposes perceptual convolutions using the Gabor-wavelet-like receptive-field profiles, which maximally preserve information (“infomax”) along the visual pathway, the “infomax” phase-processing of higher-order statistics is discussed as essential. It is also shown to be necessary for detection of edges.

The following relevant PDP models are considered, compared and roughly integrated (where possible): the Holonomic Brain Theory, “infomax”-models like Independent Component Analysis (ICA) and the sparseness-maximization net-
work (by Bell, Sejnowski, Olshausen, Field, and others), MacLennan’s dendritic field computing, quantum neurodynamics by Jibu & Yasue, Holographic Neural Technology (HNeT) by J. Sutherland, and quantum associative network by Peruš. Biological plausibility of the models is considered especially.

Three sorts of image representation are proposed to be used in the cortex: 1. the Gabor wavelets, rooted in dendritic webs, seem to be used for associative processes underlying visual cognition; 2. their Gabor coefficients represent neural-net’s sparse codes which serve for automatic processing; 3. the spatial image, reconstructed in the extrastriate area, is those which is then consciously perceived “with shapes and colors”. Because the third image representation is even perceptually projected back into external space, so that it coincides precisely with the original object, I propose that quantum holographic process is necessary, since neural nets cannot realize that alone.

As the core of image processing in V1, essentially modulated by various (sub)neuronal processes, holography-like implementation of pattern recognition and content-addressable associative memory in an original model called Quantum Associative Network is presented. The dynamics of the Hopfield net is directly translated into isomorphous quantum wave dynamics. The quantum interfering waves could be the Gabor wavelets. The so-called Hebb rule is generalized into a form named the phase-Hebb rule, since it mediates oscillatory (phase) coupling or coherence phenomena. The Green-function propagator, which has a phase-Hebb structure incorporating phase-differences, is harnessed for the quantum memory-storage and associations. The quantum wave-function “collapse” is proposed as the dynamic correlate of image recognition, based on selective recall of the most similar memory “traces”, which results in pictorial conscious experience.

Applications for recognition of images and objects are presented.

**Keywords:** vision, image processing, image/object recognition, conscious, holonomic, Pribram, V1, gestalt, attractor, (wave) phase, dendritic processing, ICA, infomax, holography, Gabor wavelet, quantum associative net, neural/brain modeling

**Research fields:** computational cognitive neuroscience; neuropsychology; neurocomputing; quantum information science

**IMPORTANT NOTE**

In the first section (Main Chapters), the topics are presented following the Holonomic Brain Theory of Karl H. Pribram. In the second section (Auxiliary Chapters), some
additional and complementing topics are added which are not necessarily related to the Holonomic Brain Theory.

The main chapters are explicitly presenting the central issues of the book in direct relation with the Holonomic Brain Theory of Karl Pribram, whereas the Auxiliary chapters provide additional or detailed discussion of some issues which are either needed to understand the main chapters better or to go into depths which might not be interesting to all readers. In both cases, the Auxiliary chapters do NOT constitute the Holonomic Brain Theory. They enable a comparison of the holonomic theory and the broad or mainstream neuroscientific framework of vision research and some quantum analogies which might in the future turn out to be significant for it.