

BOOK REVIEWS

Stereograms et Cetera

Dialogues on Perception. BELA JULESZ. MIT Press, Cambridge, MA, 1994. xxii, 276 pp., illus., + stereoscope. \$49.95 or £33.50. A Bradford Book.

Early Vision and Beyond. THOMAS V. PAPHOMAS, CHARLES CHUBB, ANDREI GOREA, and EILEEN KOWLER, Eds. MIT Press, Cambridge, MA, 1995. xii, 271 pp., illus. \$60 or £50.95. A Bradford Book.

Dialogues on Perception is a scientific memoir and *Early Vision and Beyond* a festschrift; both are full of the ideas of Bela Julesz. *Dialogues* is written in an unusual, schizophrenic style: voice A, the author, carries on a written dialogue with voice B, the author's alter-ego and scientific conscience. Here is a Julesz-style dialogue about both books with voice A, the reviewer, and voice B, in another mood:

A: *Dialogues on Perception* is a conversational review of Bela Julesz's research on visual perception from 1960 to now. Julesz made important contributions to understanding the following areas in visual per-

ception: the perception of depth with stereoscopic vision; the preattentive perception of texture boundaries based on local features in the textures; and the spatial

extent and speed of reaction of visual attention. He has attempted to relate his results on perception to cortical neural mechanisms, contributing to the growth of cognitive neuroscience.

B: Don't you believe that Julesz's great achievement was to invent the random-dot stereogram (RDS) as a tool for the study of stereoscopic vision? And stereo is so important, it is how the human brain perceives solid three-dimensional shape based on the two flat two-dimensional images on our two retinas. Julesz's research on stereo with RDS had a major impact on vision research and computer vision. Indirectly through its effect on one of Julesz's colleagues, Christopher Tyler, it also inspired the Japanese autostereogram industry whose product we see in bookstores everywhere as The Magic Eye or its relatives.

A: We should explain what an RDS is to make Julesz's insight clear. An RDS is composed of two-dimensional images that are arrays of picture elements; each picture element in each array can be black or white, at random. Embedded within the images lie identical patches of picture elements displaced horizontally with respect to each other; all the other picture elements (outside these patches) are uncorrelated. One image is presented to the left eye, the other to the right. When they are fused into a single perceived image (by converging or diverging the eyes until the outer boundaries of the individual eye's images are brought into alignment), the horizontal retinal disparity of the identical patches causes an observer to see the shape defined by the patches as a surface in depth, without a clue to the shape of the surface in each monocular image.

And you're right that the RDS was a

great achievement. But Julesz also had a big impact with his work on perception of texture and in particular in his disproof of his own conjecture that textures with identical power spectra would always be indistinguishable. The work he did with Terry Caelli, Ed Gilbert, and Jonathan Victor on textures that had identical second-order statistics but were effortlessly segregated from each other was quite significant. It led to his concept of "textons"—elementary features like corners or closure.

B: But you know that the texton theory, though it could be right, is quite problematical. There are other, simpler theories—some by Julesz's former students and post-docs, some even appearing in *Early Vision*



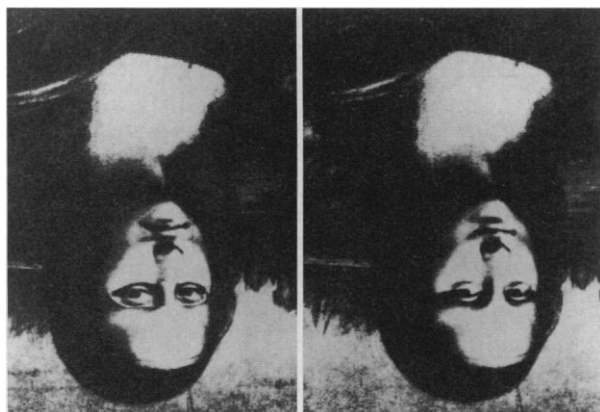
"The 'inverse cyclopean' technique (Julesz 1966). Here the monocular symmetry in one eye's view is scrambled in the binocularly fused image, thus showing that most visual processes (e.g. symmetry perceptions and form recognition) must occur after global stereopsis." [From *Dialogues on Perception*]

and *Beyond*—that account for his results on texture segregation without requiring the concept of textons. There is a vagueness due to a lack of mathematical definition in Julesz's theory that limits its persuasiveness.

A: No one is perfect. Even Julesz's research on stereoscopic vision can be questioned to some extent. For instance, there is only weak evidence for cooperative facilitatory interactions across the visual field among stereo-depth neurons. Nevertheless, Julesz continues to stress (in *Dialogues*) the crucial importance of cooperativity in stereo perception. The chapters on binocular vision and stereopsis in *Early Vision and Beyond* indicate that this issue is not yet resolved.

B: But even if his research on stereopsis has theoretical weaknesses, his beautiful stereo demonstrations proved very dramatically the important point that many visual illusions arise after stereoscopic combination of signals from the two eyes, that is, in the cerebral cortex. This is elegant psych anatomy, the term used by Randolph Blake in his own noteworthy, elegant chapter in *Early Vision and Beyond*. And you would admit that in *Dialogues on Perception* and in *Early Vision and Beyond*, the stereo demonstrations are dramatic and powerful.

A: There are impressive visual demon-



"A demonstration of gestalt. The upside-down pictures appear rather similar in spite of the fact that in one picture the eyes and the mouth are inverted. When the page is turned over, the two faces reveal a dramatic difference as a result of gestalt organization." [From *Dialogues on Perception*; from Julesz 1984, after an idea of Thompson (1980)]

ception: the perception of depth with stereoscopic vision; the preattentive perception of texture boundaries based on local features in the textures; and the spatial

strations in both books. From Jih Jie Chang's RDS surfaces (in *Dialogues*, p. 156), to Roger Watt's pictures of the textures of a Scottish mountain (*Early Vision*, p. 61), to Ilona Kovac's closed snake curves (in both *Dialogues*, p. 126, and *Early Vision*, p. 253), the visual images enhance the text. However, I agree with you that the conceptual content of the RDS images especially is enhanced by their appearance. Julesz's work in particular makes important points visually and dramatically.

B: *Dialogues on Perception* is very focused on Julesz's interests and accomplishments. Occasionally this obscures why he worked on this or that problem because he doesn't tell us the context—what others were doing at the same time.

A: You have to understand that *Dialogues on Perception* is more of a review article, a very long review, of the work of Julesz and his "school."

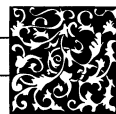
B: But my point echoes one of his own, when he discusses the theory of dynamical systems. To explain a complex dynamical system, one must include "the context-setting feedback"; this is applicable to a scientist's choice of problems as well as to perception.

A: I think you are as usual taking it too seriously. You have to enjoy a book in which Julesz lists 39 "strategic questions about visual perception" to guide the future of vision research and then compares his own questions explicitly with Hilbert's questions about the foundations of mathematics, and then adds six more mathematical questions! And then he goes on with many more good, unnumbered questions about attention and cognition. His energy and enthusiasm are infectious.

B: Perhaps you are right—his energy and ideas motivated much of the research that raises *Early Vision and Beyond* to such a high level. The best material in *Early Vision* is psychophysics related in some way to a question about brain mechanisms. The quality of the scientific results and theoretical background are very high throughout the book. It is difficult, perhaps unfair, to pick favorite papers in such an excellent collection.

A: I did have some favorites. There are two very interesting papers on perceptual learning, one by Dov Sagi and another by Merav Ahissar and Shaul Hochstein. Also, the papers by Jonathan Victor and colleagues and by Jack Gallant and colleagues interested me because they indicate that sophisticated image processing may be going on in primary visual cortex—that's very early in "early vision."

B: There are many excellent papers on every subject from stereo to texture, to motion, and then to attention. There is even an abbreviated review of recent work from Julesz's lab as an "afterthought." It is



Vignettes: Reconceptions

The myth of human exceptionality has been supplanted of late by the myth of biological continuity. Recent research efforts in the social and natural sciences seem determined to prove—indeed, presume to have already proved—that there is no essential, irreducible distinction between humans and animals. Each one of our prized facilities—language, cognition, megalothymia—is shown to appertain in one degree or another to other species. Precisely at the moment when we have overcome the earth and become unearthly in our modes of dwelling, precisely when we are on the verge of becoming cyborgs, we insist on our kinship with the animal world. We suffer these days from a new form of collective anxiety: species loneliness.

—Robert P. Harrison, in *Uncommon Ground: Toward Reinventing Nature* (William Cronon, Ed.; Norton)

Thinking in terms of bits has allowed us to develop the field of computer science, in which we learn how to represent the world with patterns of information. So successful are our endeavors that some physicists and computer scientists believe that perhaps information is not a human invention but something as real, as physical, as matter and energy. And now a handful of researchers have come to believe that information may be the most real of all. Simulated creatures would have no way of knowing they are simulations, the argument goes. And, for that matter, how do we know that we are not simulations ourselves, running on a computer in some other universe?

Nature, it seems, has honed us into informavores so voracious that some can persuade themselves that there is nothing but information.

—George Johnson, in *Fire in the Mind: Science, Faith, and the Search for Order* (Knopf)

a thought-provoking book.

A: The research in *Early Vision and Beyond* is well described by the last two words in the text of *Dialogues on Perception*. Do you remember them?

B: Of course: "great fun."

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Books Received

Absolutely Summing Operators. Joe Diestel, Hans Jarchow, and Andrew Tonge. Cambridge University Press, New York, 1995. xvi, 474 pp. \$59.95. Cambridge Studies in Advanced Mathematics, 43.

Bacterial Endotoxins. Lipopolysaccharides from Genes to Therapy. Jack Levin *et al.*, Eds. Wiley-Liss, New York, 1995. xxxii, 608 pp., illus. \$120. Progress in Clinical and Biological Research, vol. 392. From a conference, Helsinki, Aug. 1994.

Ceramics and Artifacts from Excavations in the Copan Residential Zone. Gordon R. Willey *et al.* Peabody Museum of Archaeology and Ethnology, Cambridge, MA, 1994 (distributor, University of Pennsylvania Museum Publications, Philadelphia). xvi, 479 pp. Paper, \$59.95. Papers of the Peabody Museum of Archaeology and Ethnology, vol. 80.

Dynamical Disease. Mathematical Analysis of Human Illness. Jacques Bélair. AIP Press, Woodbury, NY, 1995. x, 220 pp., illus. Paper, \$40. From a workshop,

Mont Tremblant, Québec, Canada, Feb. 1994.

Eat Not This Flesh. Food Avoidances from Prehistory to the Present. Frederick J. Simoons. 2nd ed. University of Wisconsin Press, Madison, 1995. xiv, 550 pp., illus. \$42.50; paper, \$22.95.

A First Course in Partial Differential Equations with Complex Variables and Transform Methods. H. F. Weinberger. Dover, New York, 1995. xii, 446 pp., illus. Paper, \$14.95. Reprint, 1965 ed.

Gametes. The Oocyte. J. G. Grudzinskas and J. L. Yovich, Eds. Cambridge University Press, New York, 1995. xiv, 441 pp., illus. \$110; paper, \$49.95. Cambridge Reviews in Human Reproduction.

Human Variability and Plasticity. C. G. N. Mascie-Taylor and Barry Bogin, Eds. Cambridge University Press, New York, 1995. xiv, 241 pp., illus. \$54.95. Cambridge Studies in Biological Anthropology.

The Ice-Age History of Alaskan National Parks. Scott A. Elias. Smithsonian Institution Press, Washington, DC, 1995. x, 150 pp., illus. Paper, \$16.95.

Lone Star Dinosaurs. Louis Jacobs. Texas A & M University Press, College Station, 1995. xiv, 160 pp., illus. \$27.95. Louise Lindsey Merrick Natural Environment Series, no. 22.

Macromolecular Engineering. Recent Advances. Munmaya K. Mishra *et al.*, Eds. Plenum, New York, 1995. x, 332 pp., illus. \$105. From a conference, Poughkeepsie, NY, June 1995.

Osteopontin. Role in Cell Signalling and Adhesion. David T. Denhardt *et al.*, Eds. New York Academy of Sciences, New York, 1995. xii, 388 pp., illus. \$110. Annals of the New York Academy of Science, vol. 760. From a conference, New Brunswick, NJ, Oct. 1994.

Small GTPases and Their Regulators. W. E. Balch, Channing J. Der, and Alan Hall, Eds. Academic Press, San Diego, 1995. Part A, Ras Family. xxxii, 548 pp., illus. \$99. Methods in Enzymology, vol. 255. Part B, Rho Family. xxx, 401 pp., illus. \$80. Methods in Enzymology, vol. 256.