
ECVP Invited *Perception* lectures

11th ECVP, Bristol, 1988: Invited PERCEPTION lecture

◆ In the last minutes of evolution of life, stereoscopic depth perception captured the input layer to the visual cortex to break camouflage

B Julesz (AT&T Bell Laboratories, Murray Hill, NJ 07974-2070, USA)

The invention of random-dot stereograms (RDS) in 1960 proved that without monocular form recognition one can portray three-dimensional (3-D) objects and surfaces in vivid depth. So without monocular form recognition one can extract binocular correlation. Therefore stereoscopic depth perception is a much simpler process than previously believed. Even though I predicted that the 'cyclopean eye' (ie the place where binocular correlation is first extracted) is at an early site, it surprised me that Gian Poggio found cyclopean units in layer IVB of V1 in the monkey cortex that fired only for dynamic RDS tuned to specific disparities. It appears that stereoscopic depth perception evolved in early primates to break static camouflage. Indeed, to catch moving insects stereopsis is not needed. However, to locate non-moving insects it was advantageous to have it. It is interesting that a mechanism which evolved so late in the history of evolution was so important for the organism that it captured the input stage of the cortex. Implications to models of stereopsis are discussed and a 3-D demonstration of some novel phenomena is given.

12th ECVP, Zichron Yaakov, 1989: Invited PERCEPTION lecture

◆ Why study neural substrates of perception?

G Westheimer (Division of Neurobiology, Department of Molecular and Cell Biology, 211 Life Sciences Addition, University of California, Berkeley, CA 94710, USA)

With the increasing quantity and quality of neurophysiological investigation of the visual pathways, including higher cortical areas, there is an information explosion of data showing responses of neuronal circuits to visual stimuli. At the same time, the improved techniques of neuroanatomy are highlighting structural details and connections in the nerve tissues. With the advent of computers, sophisticated models inspired by engineering ideas are proliferating. These trends are accompanied by rhetoric from physiological, anatomical, and engineering circles about vision and perception. Has there really been a bridging of the gap between the 'mental' and 'material', as Fechner described the tack of psychophysics? Is this kind of interaction likely to be fruitful?

13th ECVP, Paris, 1990: Invited PERCEPTION lecture

◆ The shattered visual image of the brain

S Zeki (University College London, Gower Street, London WC1E 6BT, UK)

The primate brain, including that of man, is characterised by a set of parallel, functionally specialised, pathways and areas all of which receive cortical inputs from the primary visual cortex, V1, either directly or indirectly. The specialised areas connect with each other either directly or through diffuse back projections and can therefore interact with each other at several different cortical levels. This knowledge allows us to examine the neurological foundations of conditions in which the visual image in the brain is disturbed to varying degrees, conditions such as cerebral achromatopsia (cerebral colour blindness), cerebral motion blindness, the achromatopsia associated with arterial insufficiency and hypoxia, and the selective sparing of colour vision in cases of carbon monoxide poisoning. It also allows us to account for the apparent absence of a syndrome characterised by the specific and total inability to see forms; for why achromatopsic patients can nevertheless perceive the whites, blacks, and greys; and for internally generated states such as phantom chromatopsia, a condition in which blind people suffer severely from internally generated colours. In addition, our new knowledge allows us to tackle other internally generated visual images such as hallucinations and dreams on a neurological basis.

Many of the interesting syndromes which we are apparently able to account for today were described in the earlier clinical literature. But they were quickly dismissed because the prevailing concepts of how the visual brain works made them seem unlikely. Our present ability to account for the shattered visual image of the brain also shatters our earlier concept of how the visual brain functions and ushers in new concepts of how the visual image in the brain is constructed.

14th ECVP, Vilnius, 1991: Invited PERCEPTION lecture◆ **Image and representation in the visual system**

J G Robson (Physiological Laboratory, University of Cambridge, Cambridge CB2 3EG, UK)
 Since the very first stage of the visual process is the formation of an optical image of the world on the essentially two-dimensional photoreceptive surface of the retina, it is not surprising that the visual system is often conceived to be an image-processing device. But how far are the nerve signals within the visual system properly thought of as ‘images’?

Taking into account what we know of the characteristics of individual retinal ganglion cells and the size and arrangement of their receptive fields, we may judge the array of nerve signals transmitted from the eye to the brain to be reasonably described as a sampled, transformed neural image (or perhaps more properly as several images).

In the primary visual cortex, however, where there are many hundreds of times more visual neurons than there are optic nerve fibres, the functional characteristics of the neurons and the sizes and arrangement of their receptive fields all suggest that it may be more appropriate to consider the cortical representation of the visual world to be related more to objects than to their images.

15th ECVP, Pisa, 1992: Invited PERCEPTION lecture◆ **Parallel visual memory circuits**

M Mishkin (National Institute of Mental Health, Bethesda, MD, USA)

The results of neurobehavioral studies in monkeys have revealed that cortical visual pathways interact with at least two major cerebral systems concerned with laying down the traces of experience. One system is anchored to limbic structures and is responsible for the formation of stimulus memories, permitting recognition and recall. The other is anchored to the neostriatum and is responsible instead for various forms of response adaptation to stimuli, including the learning of habits and rules. The differing circuitries of these two parallel systems will be described, as well as the differing principles by which they operate to achieve their contrasting but cooperating endproducts.

16th ECVP, Edinburgh, 1993: Invited PERCEPTION lecture◆ **Single units and visual cortical organization**

P Lennie, Center for Visual Science, University of Rochester, Rochester, NY 14627, USA)

Electrophysiological recordings from single neurons have profoundly influenced our thinking about how vision depends upon events in the nervous system. Much of the investment in single-unit recording stems from the belief that activity at the single-cell level is perceptually significant and that the connection between the visual characteristics of a neuron and its perceptual role is relatively direct, or at least easily specified. Recordings from retina and subcortical structures reinforce this view because analogies are readily drawn between the visual sensitivities of single neurons and the sensitivities of observers on simple perceptual tasks where we expect peripheral mechanisms to limit performance. We have weaker intuitions about the tasks undertaken by cortical mechanisms at different levels, and connections between the behavior of single neurons and perceptual decisions are less easily discerned. As a result, we have grown to rely heavily on the visual properties and anatomical connections of single neurons in developing ideas about the functions of striate and extrastriate cortex. I argue that the visual properties of a neuron can provide only weak pointers to its perceptual role, and that our theorizing has become rather too dependent on physiological and anatomical work. Physiological observations become more easily understood and more valuable in the context of a larger view of what visual cortex is designed to do. One I shall examine is that the job of early mechanisms in striate cortex and neighboring extrastriate areas is not to analyze separately different attributes of the image, but to detect local similarities in its structure, as a precursor to the segmentation of surfaces and the classification of objects. [An updated text of this lecture is available on the *Perception* website at <http://www.perceptionweb.com/lectures/lennie.pdf>]

17th ECVP, Eindhoven, 1994: Invited PERCEPTION lecture◆ **Perception and application: the relation between fundamental research and applied engineering**

T J B Swanenburg (Multimedia Technology, Philips Corporate Research, Prof. Holstlaan 4, 5656 AA Eindhoven, The Netherlands)

In recent years a large number of technical breakthroughs have enabled creation, storage, distribution, and display of practically unlimited amounts of information via systems of increasing complexity. The results of these technical achievements have become evident in the digitisation of consumer electronics, in mobile communications, in car electronics, in personal computers, and in many other applications. The simple fact that, in principle, mankind has reached the

stage where technically speaking ‘everything is possible’ creates the need for a new paradigm in directing fundamental research. Although the need for a real understanding of observed phenomena is at least equally strong as in the past, such understanding is no longer sufficient in directing further investigations. In many cases a direct interaction with applications is necessary to reduce the number of options in a meaningful way, and to make measurable and reproducible progress in fundamental research.

18th ECVP, Tübingen, 1995: Invited PERCEPTION lecture

◆ **Vision in darkness: the rod circuit of the mammalian retina**

H Wässle (Max-Planck-Institut für Hirnforschung, Deuschordenstrasse 46,
D 60528 Frankfurt, Germany)

In the mammalian retina, rods and cones have separate pathways to the ganglion cells. The rod pathway comprises rod bipolar cells and a special type of amacrine cell. I propose a circuit diagram of the rod pathway which is supported by physiological, pharmacological, and molecular studies of these cells.

19th ECVP, Strasbourg, 1996: Invited PERCEPTION lecture

◆ **Vision and brain dynamics**

S Grossberg (Department of Cognitive and Neural Systems and the Centre for Adaptive Systems, Boston University, 677 Beacon Street, Boston, MA 02215, USA)

How does the brain transform the scintillating mosaic of light energy on the retina into informative perceptual representations of form, colour, depth, and motion? This talk presents a self-contained exposition of recent theoretical ideas that have been used to clarify the functional meaning of these processes, and have led to neural models whose emergent properties simulate challenging psychophysical and neurobiological data. Simulated data include boundary groupings of illusory contours and textures; filling in of surface brightness, colour, and depth; 3-D pop-out of occluding objects and amodal completion of partially occluded objects; motion capture of barber pole and plaid patterns; long-range apparent motion and its target tracking properties; and visual search using object and spatial attention. How the brain’s laminar, map, and network structures work together to generate these percepts is discussed. Such results mechanistically clarify and modify such classical perceptual dichotomies as preattentive and attentive, modal and amodal, filtering and Gestalt, seeing and thinking, and what and where. They have also disclosed previously unsuspected links between perceptual phenomena that have begun to suggest new types of experiments.

20th ECVP, Helsinki, 1997: Invited PERCEPTION lecture

◆ **Neural mechanisms of visual perception**

T Wiesel (The Rockefeller University, 1230 York Avenue, New York, NY 10021-6399, USA;
fax: +1 212 327 8900)

It is more than half a century ago since Keffer H Hartline published his classical receptive fields studies of single optic nerve fibres in the frog. World War II intervened and the full impact of his work did not become apparent until the early fifties, when Horace Barlow extended Hartline’s analysis in the frog and Stephen W Kuffler showed the on-centre and off-centre type ganglion cells in the cat retina. The next advances were made in the late fifties when Jerome Lettvin and Humberto Maturana described cells in the frog tectum with very complex response properties and when David Hubel and I discovered that cells in the cat striate cortex were sensitive to orientation of contours and binocular stimulation. Vision research has gone a long distance since that time—nonetheless we have just begun the long journey towards a detailed mechanistic understanding of the neural basis of visual perception.

In this lecture I discuss the processing of visual information at the level of the striate cortex in the cat and monkey, and describe technical advances that have greatly facilitated the analysis of the neural mechanisms of visual perception.

21st ECVP, Oxford, 1998: Invited PERCEPTION lecture

◆ **With colour in mind**

A Cowey (Department of Experimental Psychology, University of Oxford,
South Parks Road, Oxford OX1 3UD, UK; fax: +44 1865 310 447;
e-mail: alan.cowey@psy.ox.ac.uk)

Focal brain damage can selectively impair colour naming, the use of colour words, short-term memory for colours, and perhaps colour constancy. The focus of the effective lesions, as revealed by structural magnetic resonance imaging (MRI), can now be correlated with extrastriate visual areas as revealed by functional MRI. However, by far the most striking disorder of colour

processing caused by brain damage is cerebral achromatopsia, in which total loss of the perceptual experience of hue follows destruction of ventro-medial cortex, centred on the collateral sulcus and involving the rostral lingual and caudal fusiform gyri. Recent functional neuroimaging experiments and behavioural experiments in monkeys indicate that cerebral achromatopsia follows destruction of an area called V4 and V8 in the human brain and possibly analogous areas called TEO and TE in monkeys. The simplest explanation for cerebral achromatopsia is that the lesion destroys all extrastriate representation of the colour opponent, P, pathways, and that the puzzling features of cerebral achromatopsia, such as the subject's ability to detect chromatic boundaries despite not perceiving the hues that create them, reflect the sensitivity to contours of the intact broad-band and colour-blind M pathway. But recent studies of spectral sensitivity, detection of coloured targets in random luminance masking, discrimination of the apparent direction of chromatic gratings, saccadic eye movements to coloured targets, and unimpaired motion slowing with isoluminant chromatic gratings all suggest that in cerebral achromatopsia signals generated by wavelength differences are still processed cortically. It is the experience of hue itself that has been lost. Does this make cerebral achromatopsia like 'colour blindsight', as recently proposed? Almost certainly not, because the achromatopsic subject is always aware of what he is discriminating. The puzzle is why it is never coloured.

22nd ECVP, Trieste, 1999: Invited PERCEPTION lecture

◆ The phenomenal science and art of perception

R L Gregory (Department of Experimental Psychology, University of Bristol, 8 Woodland Road, Bristol BS8 1TN, UK; fax: +44 117 928 8461; e-mail: Richard.Gregory@bris.ac.uk)

Perception gives our most immediate knowledge of the world of objects. Yet as science advances, our perceptions depart ever further from conceptions of physical realities. This makes 'illusion' hard to define. For if illusions are departures from physics (fortunately revealing processes of perception through the differences), how can we avoid saying that all perceptions are illusory, when physics gives such different accounts of objects? It is important, though difficult, to define 'illusion'. It is also important to classify phenomena of perception, as classifications can help to interpret experiments and they point to gaps in understanding. This is evident in the power of the Periodic Table of the Elements to make sense of chemistry, and classifications of species to reveal biological relationships and origins. Classification of phenomena of perception should be theoretically suggestive and practically useful, and it might even help to bridge the science of perception with the practice and appreciation of art. We see perception as brain-based, which raises ancient and modern questions of brain function. Some problems of interpreting functional brain imaging are considered.

23rd ECVP, Groningen, 2000: Invited PERCEPTION lecture

☛ Let there be motion ...

W A van de Grind (Department of Neuroethology and Comparative Physiology, University of Utrecht, Padualaan 8, NL 3584 CH Utrecht, The Netherlands; fax: +31 30 254 2219; e-mail: W.A.vandeGrind@bio.uu.nl)

A single photoreceptor can measure temporal contrast, two of them can measure spatial contrast and ... motion. No doubt, motion is the most informative of these elementary measures and it might have been instrumental in the evolution of visual systems. There is not an aspect of highly evolved vision that does not benefit from motion and several visual capacities only exist because 'everything flows' (panta rhei).

The importance of motion for vision first became apparent after scientists in the nineteenth century succeeded in generating convincing motion stimuli in the laboratory. Natural motion information is still difficult to bring to the laboratory, since all exploratory movements of the subject would have to be fed back instantaneously to the virtual-reality device. Simple motion stimuli, with names from alpha to omega and each in first to n th order varieties, have already uncovered some of the principles underlying motion-based vision (heading, shape-from-motion, etc). No doubt a lot is yet to come and a final insight is not in sight.

I review in biased fashion what has been accomplished in the previous millennium and attempt to illustrate basic findings with flows on a flat screen. I hope the visience (= visual equivalent of 'audience') is moved by this and prepared to transform screen-flow into mindflow. That would be a great start for a new millennium of research on motion vision or derived-from-motion vision (the rest).