PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY B BIOLOGICAL SCIENCES

Introduction

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There is a long-standing tradition of research on vision in Great Britain that goes back at least as far as Newton. The Royal Society is therefore a most suitable venue for a conference on the Psychology of Vision, and it is no accident that two of our distinguished guests from North America are British subjects.

In the first 30 years of this century the Gestalt movement brought about a revolution in our ways of thinking about vision, but the subject then remained rather stagnant for two decades. In more recent years, dramatic discoveries and radical new insights have been forthcoming from three different directions. First, neurophysiologists have laid bare some of the highly systematic wiring that subserves the early stages of the processing of the visual input. Secondly, psychologists and psychophysiologists have uncovered some of the intricacies of the mechanisms that underlie such functions as acuity, contrast discrimination, motion detection and stereopsis. It is becoming possible to put together results from these two directions and to show how mechanisms inferred from psychophysical observations are instantiated in known neurophysiological circuits. The two sets of results indicate that visual processing is both more complex and more elegant than had been suspected 50 years ago. Thirdly, the advent of the digital computer has made it possible to build rigorous computational models of the visual system, to explore and to specify more adequately the nature of the task that the visual system must perform, and to demonstrate precisely how the constraints imposed by the nature of the physical world and of its optics make it possible for the brain to use the patterns of light impinging on the retinae to form a useful representation of the external world. Although this last enterprise may strike some as speculative, it has already led to insights into the nature of vision that have changed our ways of looking at the problems and have made the theories of shape recognition put forward in the 1950s and 1970s, including those of one of us, look extremely superficial.

The study of vision may ultimately prove to be one of the best routes into an even larger and as yet more intractable subject, the study of human intelligence. The human visual system has evolved over tens of millions of years into a very subtle and efficient information processing instrument. It conducts elaborate calculations in parallel and appears to use and to synthesize every single cue to depth that is present in the retinal image; it computes size and brightness constancy effortlessly and with incredible rapidity; and from the tessellated and fragmentary information produced by brightness differences on the retina it recovers with deceptive ease the real disposition of three-dimensional shapes in the world around us. The inferential processes that underlie everyday acts of seeing may be deeper and more subtle than are those exercised by an Einstein in the prosecution of his scientific work, but because we have all evolved to be brilliant at seeing, but not alas at physics, we tend to marvel only at the latter capacity. If recent work on vision had done nothing else, it would still be worth while because it evokes a sense of wonderment at the subtlety and perfection of the visual system. But it has done much

else. It has even begun to adumbrate the inferential mechanisms involved in vision, and it may be that these very mechanisms will ultimately provide the key to our understanding of the highest flights of human thought. The role of the visual imagination in scientific thinking has often been stressed and it is well established that there is a high correlation between scientific ability and spatial intelligence. It is perhaps not surprising that when we seek to obtain a scientific understanding of the Universe we should put to new use the structures that have evolved for processing purely visual information, and recast the ideas we are trying to manipulate in a form in which they can be represented and manipulated by existing and well tried structures in the brain.

The psychology of vision is such a vast topic that it would have been impossible to deal with all its aspects in a Discussion Meeting of this length. For example, there are no papers on colour vision since that is a subject in itself. Moreover, although the conference is on the psychology of vision, we have included some papers on visual neurophysiology since, as already pointed out, the psychologist must often draw on the neurophysiological results to interpret his own data. The organization of the proceedings should be obvious. We start with work that can be more or less directly related to neurophysiological findings and move progressively to phenomena that demand explanatory mechanisms that are less and less related to known neurophysiological structures.

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