On the Lost Art of Seeing where Things are Going

from Simon Heywood

No one disagrees that one of the most important perceptual tasks to confront a sophisticated and mobile organism is the capacity to detect and discriminate movement, whether of itself or of other organisms or objects. It therefore seems obvious to devote research to the processes underlying the perception of movement, whether in terms of the psychological or phenomenological characteristics of such processes or their putative realisation in neural machinery.

A recent NATO-sponsored symposium* called together some eighty workers in the area to review and to extend our knowledge of these processes. However, it must be admitted that simple as the problem of movement perception may sound, four days of conference served to illustrate that there remains considerable theoretical disagreement over what the proper object of study actually is. The explosion of "facts" unearthed by more or less ingenious physiological, psychophysical and psychological experiments has all too clearly not been paralleled by a development of theory to establish the meaning of such facts.

While it is obvious that we can and do perceive movement (just as we can and do perceive form or colour) it cannot be assumed that, therefore, the logic of investigating its physiological substrates is the same. Microelectrode studies reveal that a significant majority of visual cells in the cortex or the midbrain of animals respond to the movement of stimuli through their receptive fields; studies of great elegance classify the response types of these neurons in terms of stimulus velocity, or of their sensitivity to stimulus position change or of the position of their receptive fields and so on. But a moment's thought suggests that the relevance of these studies to the perception of movement is entirely unclear. In the great majority of visual environments, the predominating mass of visual objects and textures are actually stationary; a small subset moves. However, for any organism in motion (especially one with highly mobile eyes, like ourselves) the retinal images are constantly moving. The inescapable conclusion is that in order to interpret visually what is actually moving in the world we must first be able to establish the stability of the visible frame-of-reference within which and with reference to which that movement occurs. Single unit studies have (with a few notable exceptions) indicated only that cells respond to retinal stimulus motion, and

hence fail to tell us whether such cells subserve the perception of movement or that of stability.

The simplest (and the oldest) solution is to argue that we establish stability by combining the retinal movement information with information about eye and head (and possibly body) movement. Thus perceived stability is achieved when the movement on the retina is matched and congruent with movement produced by the organism's oculomotor and neck musculature. In this case, the movement sensitive visual cells could at best only be understood in the context of other non-visual information, about whose distribution in the brain we are at present almost entirely ignorant.

Unfortunately two kinds of experimental results cast doubt on even this as a basis for the perceived stability (and hence perceived motion) of objects in the world. First, any such corollary signal from the eye and head moving systems to the perceptual apparatus appears to be far too 'sloppy' to achieve the nicety of stabilisation that we perceive. Second, recent work, reported at the symposium, shows that high-level cognitive processes may be more important in assigning stability or movement than the exact relations between retinal image shift and eye/head movement. What is important, and dominant, in perception is the visual *relationship* between objects and frames-or-reference; it appears that the perception of movement in natural environments can be understood primarily as an object-relative phenomenon. This, of course, makes the interpretation of electrophysiological data even more problematic.

However, consensus does appear to be emerging on broad lines of how the visual

perception of movement and stability may have to be structured; a number of speakers from quite different research backgrounds were echoing dichotomies first proposed in 1968 by Schneider, Trevarthen, Ingle and Held. There appear to be many ways of expressing these dichotomies and it is not yet clear how precisely they relate to each other and at what levels of description they operate, but three that were frequently mentioned were a) a distinction between a "movingness" (velocity-based) and a "displacement" (amplitude-based, hence perhaps related to position) system, using Claude Bonnet's terminology; b) a distinction between "central" and "peripheral" vision (which is not necessarily to be taken as an anatomical distinction, though there is clearly a spatial differentiation between them), and c) a distinction between two modes of oculomotor activity, one designed to hold part of the retinal image still on the retina and assumed to be primarily driven by retinal image velocity, and the other designed to shift the retina fast underneath the retinal image and assumed to use primarily positional information. Such dichotomies are clearly interrelated and related to the dichotomies used elsewhere between sustained and transient channels, or ambient and focal vision, or *x* and *y* cell systems, or saccades and pursuit eye movement. Perhaps if we could devote the next symposium not to the presentation of many new facts, but to the elucidation of these concepts and their functional relationships, we should move closer to understanding not only our perception of movement but how such perception is related to the structure and control of our own activity. □

Optical discs for information storage

from A. E. Bell

THE high density optical disc may provide a new way of meeting the need for low cost information storage. A 12" diameter optical disc can store as much as 10^{11} data bits, and recording rates up to 50 Mbits s^{-1} for a single channel have been demonstrated. By comparison to magnetic disc recording, optical recording increases the data packing density by about two orders of magnitude, producing a much lower cost per bit stored.

The key component of the optical system is the recording medium and several possibilities, including an organic dye-in-polymer¹, generally satisfy the requirements of recording sensitivity and

playback signal quality. Current research is now concentrated on improving the permanence of the information once stored as this is a key factor in the final selection of a suitable recording medium.

A typical high density optical recording system is shown in Fig. 1. The recording light source is a gas laser which emits a continuous, collimated and linearly polarised beam with a very well defined wavelength. The beam passes through a modulator to which the input data signal is applied and then via some optics and a polarising beam splitter/quarter-wave plate combination into the entrance pupil of the focusing lens. The lens focuses the intensity modulated beam to a spot on the recording medium, coated onto the surface

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