Looking and Seeing with the Mind's I, and its Brain

A Review of *Visual attention and cortical circuits* by Braun, J., Koch, C. & Davis, J.L. (Eds.)

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ABSTRACT: Contributions to this edited volume argue for the existence of top-down, context- and task-dependant modulating mechanisms of attention occurring in the mammalian brain. Such positions support the view that areas of the brain traditionally thought to be involved in relatively 'late' stages of visual processing activity (typically frontal cortex) can, and do affect the response properties of 'early' visual processing neurons, including primary visual cortex (V1). Neural circuitries concerned with the processing of visual information should now be viewed less as involving unidirectional mappings from sensory input to motor output for the purposes of planning visually-guided movements. Instead, the attentional processes required to support the co-ordination of sensorimotor transformation functions involve a variety of widely distributed parallel and reciprocally connected neural pathways, including the visual, parietal and frontal cortex.

Aimed principally at the student and researcher working in cognitive neuroscience, this book reports the findings of the "Visual attention and cortical circuits" workshop held on Catalina Island, USA, in 1999. Its primary focus was to bring together a variety of interdisciplinary approaches to inform a better understanding of visual attention processing in the cerebral cortex. Some fourteen contributions are collected here, addressing the long standing implications of dorsal versus ventral stream visual processing, and, of more recent interest, the functional significance of the (often reciprocal) connections now known to exist between temporal, parietal and frontal cortical neurons. Appropriately illustrated throughout with task paradigms and experimental data presentations, it is perhaps surprising that this volume contains only one putative cortical circuit diagram [Tsotsos et al.] in an attempt to show the ways in which variously proposed cortical areas might be critically connected in support of their role in visual attention and/or its modulation.

Although it has been clear since the demonstration of Yarbus (1967) that we employ quite different brain circuitry when ‘looking for’, as opposed to ‘looking at’ something in our visual field, I have never felt that the physiological significance of this observation has really been considered prior to single-cell recording from the awake, behaving monkey. At least nine of the contributions to this volume (both imagers and electrophysiologists, from human and monkey labs) explicitly argue for the existence of top-down, context-dependant, task effects of attention. One way or another, this amounts to claiming that at least some ‘late’ (typically frontal cortex) visual processing activity can be shown to be affecting the response properties of ‘early’ visual processing neurons, including primary visual cortex (V1), V2-V4, and extrastriate areas MT & MST. One clearly emerging story to be taken away from this book, is that traditional claims for the visuomotor system operating largely via unidirectional, monolithic ‘Retina > RGN > V1 > V2... > frontal cortex’ pathway models must be discarded. Recurrent, massively parallel cortical circuits are the order of the day here.

Throughout its middle six chapters, the results of visual attention experiments using monkey single-cell recording is variously interpreted as providing evidence for the biasing of response competition amongst early visual input neurons [Duncan; Reynolds & Desimone], their possible gating [Heeger et al; Tsotsos et al] and other modulations of their activity [Ito et al; Maunsell & MacAdams]. Several authors have now expressed support for Schall’s notion of the frontal eye-field area potentially serving as a task-based "saliency map" for the purpose of supporting both the selection and preparation of visually-guided action [Thompson et al] and a similar model is proposed to underlay visually-guided search [Sperling et al]. Others rightly encourage our caution lest we forget the necessarily constraining architectures of bottom-up processing, upon top-down operating pathways [Braun et al; Pouget et al].

The problem space for attentional research has always been one largely concerned with determining how the cortex selects and locates targets from a potentially infinite candidate array of such targets for focused consideration. Furthermore, attention experiments must be conducted in the face of limited processing capacity and with reference to one’s ontogenetic life-history of experience and learning with any number

and variety of tasks. There are no surprises amongst the results presented in this book emerging from the studies of (visual) attention as reported, but it does provide for a useful review as to some of the current thinking ‘outside the box’ of the old monolithic pathways. However, and more importantly, it also warns that we must continue to explore the neural bases of behavior bearing in mind that the subject’s task understanding, and the context(s) in which their tasks are presented, will necessarily affect the very cortical circuitries we are attempting to characterize. Fortunately, this holds true as much for the researcher’s brains, as it does for the brains of their research subjects, and for the fine details and anatomy of the neural circuits themselves, we must be content to await the reports of future workshops.