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A Review of Christof Koch's *The Quest for Consciousness*

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REVIEW OF: Koch, C. 2004. *The Quest for Consciousness: A Neurobiological Approach*. Englewood, CO: Roberts & Company. 429 pp. US\$45.00 hbk. ISBN: 0974707708.

The quest for the Holy Grail was considered the greatest adventure in the Arthurian legend. The quest for consciousness (the holy grail of contemporary neuroscience) is, similarly, one of the greatest scientific adventures of all times. Koch's book summarizes a 14-year old effort –and a personal quest- to understand, and narrow down, the neuronal correlates of consciousness (the NCC).

The Quest for Consciousness is a thorough review of the extant scientific literature on consciousness, especially visual awareness. Koch integrates evidence from electrophysiological data, imaging and psychophysical studies, computational models, and clinical observations in a comprehensive account. The book will appeal to neuroscientists, cognitive scientists and philosophers concerned with the scientific study of consciousness, and to interested students of these disciplines. It will also fascinate those readers who have previously enjoyed the late Francis Crick's (Koch's long-term collaborator, who sadly passed away on July 28) *The Astonishing Hypothesis* (Crick 1994). Published ten years ago, *The Astonishing Hypothesis* introduced the embryonic neurobiology of consciousness to lay readers (and to many neuroscientists as well). Today, thanks in large extent to Crick and Koch's major contributions to the field, as well as to their successful cheerleading efforts, most neuroscientists and cognitive scientists are receptive and familiar with the idea of a neurobiology of consciousness, previously despised by "serious" neuroscientists. *The Quest for Consciousness* not only builds on the foundations laid by the *Astonishing Hypothesis*, but paves the paths to be explored in the

next several decades. The book strikes me as Phase Two of Crick's and Koch's master plan to bring the study of consciousness to mainstream science.

The Quest for Consciousness offers a matter-of-fact, down-to-earth approach to the scientific study of consciousness, and deviates little from strict neurobiological investigation of the NCC. Koch, a neuroscientist himself, is optimistic that careful scientific research will provide the answers, and is less impressed with the theoretical limits imposed by philosophers. Although he admits that philosophers have often formulated questions that challenge scientists, Koch believes that scientists should forge ahead, and ignore philosophical constraints. For instance, except for some brief, thought-provoking discussion of how the neurons in the *penumbra* (i.e. neurons that are not part of the NCC proper yet are influenced by the NCC) may give rise to qualia, a neurobiological account of qualia is purposely avoided. In Koch's words: "Why qualia *feel* [Koch's italics] the way they do remains an enigma", but the author also hints at the possibility that qualia may not be impenetrable to neurobiological exploration. Although most of the book is written with a pragmatic emphasis on the neurobiology of consciousness, the first chapter provides a concise summary of some of the most prevalent philosophical approaches to consciousness. Many of these approaches are discussed in more detail in subsequent chapters, and provide the reader with an extensive bibliography to be consulted for future reference.

In pinning down the NCC, Koch's main strategy is to make use of the vast library of knowledge neurobiologists have accumulated, for many decades, on the primate visual system (although tests for consciousness in mice, which Koch has recently begun to explore, may become an extraordinary tool in the coming years). Visual illusions, especially bistable illusions (in which the same stimulus can be perceived, at different times, in two mutually exclusive ways) are promoted as powerful devices to isolate those neurons, circuits, or brain areas that respond to non-perceived stimuli, and therefore can be ruled out as part of the NCC. Chapters 4 through 8 provide a detailed account of the architecture, physiology and perception in the various visual brain areas, discussing their potential participation in the NCC. One of the main strengths of the book is that it pinpoints conflicting evidence (i.e. from different techniques or approaches) and identifies the major gaps in our current knowledge of the NCC. Chapter 19 outlines a "framework for consciousness", in which Koch skillfully summarizes the 18 previous chapters in a set of ten "working assumptions to understand the mind-body problem". Empirical predictions can be formulated taking each one of these assumptions as a starting point. Koch succeeds brilliantly in providing the reader with numerous testable scientific hypotheses to take back to the laboratory.

Koch narrows down the NCC for visual consciousness to coalitions of neurons in and around the inferior temporal cortex, projecting to the frontal lobes and supported by feedback activity from the cingulate and frontal cortices. The function of consciousness is to provide an "executive summary" of the world's current status to the planning stages of the brain (i.e. the frontal lobes). Thus consciousness may be an intermediate-level process (as in Jackendoff's (Jackendoff 1987; Jackendoff 1996) theory of consciousness), limited to intermediate brain areas. The "homunculus" in the frontal lobe is probably not conscious: we don't have direct conscious access to our thoughts, but only to images, sounds, speech, and other bodily feelings associated with *intermediate* brain

representations. Jackendoff's theory provides a solution for the classical problem of the infinite regress of consciousness: given that the top homunculus is not conscious, there is no need for infinite homunculi at higher and higher levels in the brain, in order to read the output of the previous, conscious, homunculus.

Another major contribution of Koch's framework is the distinction between explicit and implicit representations. An *explicit representation* of a stimulus attribute is a set of neurons that represent that feature without substantial further processing. In an *implicit representation*, the neuronal responses may account for certain elements of a given feature, however the feature itself is not detected at that level. For instance, *all* visual information is *implicitly* encoded in the photoreceptors of the retina. Koch proposes that there is an explicit representation of every conscious percept. The neuronal substrate for such explicit representations is the columnar organization of the cortex. Thus explicit representations of conscious attributes will usually be organized in cortical columns (a necessary, but not sufficient condition for the NCC).

The careful framework built by Koch seems virtually failsafe (at least, considering the current available evidence), and I can think of remarkably few conceptual gaps. Perhaps one of these concerns the role of feedback connections: Koch proposes that feedback from higher brain areas is a necessary (but not sufficient) condition for the NCC. Feedback connections are required to boost the receiving neurons past a certain activity threshold, for some length of time. Given that the feedback connections appear to be mainly modulatory (which Koch himself points out), then it should be possible to cross the threshold through means other than feedback. That is, couldn't the threshold, at least on occasion, be achieved by stronger input from feedforward connections alone? And if that threshold can in fact be reached by forward connections only (or, say, through electric stimulation of the neurons being considered as potential NCCs), wouldn't a conscious percept arise then *without* feedback?

But these are very minor considerations and they don't diminish Koch's considerable feat. Furthermore, Koch's views of the NCC are not rigid, but evolving: the book provides an honest and commendable account of how Koch and Crick have updated some of their earlier views and theoretical assumptions, in order to accommodate new empirical and clinical evidence. For instance, their earlier assumption that gamma oscillations are one of the necessary components of the NCC has been softened, and replaced by the thought that neuronal synchrony (which may or may not be oscillatory) might be a necessary component of the NCC. The book also offers some fresh ideas, previously unpublished, such as the potential role of the *penumbra* in the continual shift of the NCC: The penumbra is not sufficient to generate consciousness, although neurons in the penumbra may become part of the NCC as the NCC shifts. By expressing the various associations of the NCC (past associations, expected consequences, cognitive background), activation of the penumbra may generate meaning. Alternatively, the NCC may need to *directly* activate the penumbra neurons for meaning to arise: the question is open.

The Quest for Consciousness is a very enjoyable read: dryly humorous at times, it is rich in literature citations, personal experiences, and clever metaphors. One of the book's achievements is to relate consciousness, or the absence of it (i.e. zombie agents in our body that we are not aware of) to everyday experience. Anecdotes from the

adventures of famous mountaineers and from Koch's (also a rock-climber) own ascent experiences are sprinkled throughout, providing a unifying device that draws subtle parallels between the climber's unrelenting quest for the summit and the author's pioneering quest for the NCC, a personal Annapurna.

As a neurophysiologist myself, initially drawn to the field of consciousness in large part by Koch's and Crick's work on the topic, I find *The Quest for Consciousness* to be very satisfying in its ability to bring the entire field of visual consciousness to a cohesive focus. I also admire Koch's talent for making a textbook quite fun to read, which he accomplishes by aptly interjecting personal opinions and views on difficult concepts, as well as by candidly criticizing and airing his various concerns about some contributions to the field. Although only time will tell if Koch's current views of the NCC are correct, one comes away from this book with the feeling that he truly strives to know the real answer, and that if his current views are incorrect, he will simply revise them as new empirical evidence becomes available. This is a surprisingly uncommon quality in the field of consciousness research. Thus although my own views are not 100% in line with Koch's on every subject discussed, I wholeheartedly recommend this book, and have already assigned it to my own students. *The Quest for Consciousness* shows that Koch has ascended to Base Camp 2 on his quest to the summit. Although future research may bring with it new surprises and perhaps a few further dead ends, *The Quest for Consciousness* is evidence that Koch is prepared and well positioned to make use of even better footholds to continue the ascent.

References

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