authors will be pleased if their conclusions are amended through the use of comparative phylogenetic methods.

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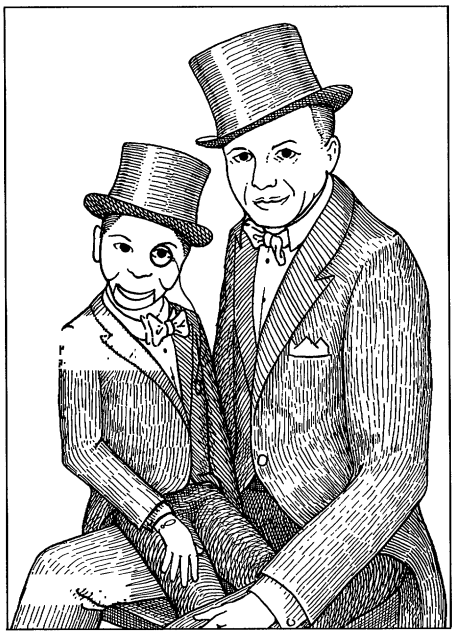
Multisensory Integration

The Merging of the Senses. BARRY E. STEIN and M. ALEX MEREDITH. MIT Press, Cambridge, MA, 1993. xvi, 211 pp., illus. $42.50 or £38.25. Cognitive Neuroscience Series.

The great majority of studies in sensory physiology have concentrated on the primary neural pathways that encode sensory information in a modality-specific way. These pathways lead from peripheral receptors that are tuned to particular forms of energy, through the brainstem and thalamus, to the cerebral cortex, where large areas are devoted to each sensory modality. Functional specialization is also observed within individual modalities. For example, functionally distinct cortical areas have been identified that are concerned primarily with the processing of specific visual features such as color or movement. At the same time, our perception of a visual scene involves the integration of those features, raising the question of how information analyzed in different regions of the cortex is linked together.

Despite the current emphasis on modality-specific processing, it is clear that integration of sensory information *across* different modalities is an essential aspect of perception. Numerous psychophysical phenomena illustrate how our perceptual experiences involve the combination and interaction of different sensory inputs. For example, our ability to understand speech is enhanced if we can observe the speaker's lips moving and thus associate the auditory and visual cues with a single source. On the other hand, if these cues are separated, as in the case of a ventriloquist's dummy, our judgments about the cues available in one modality (the speaker's voice) can be biased by the presence of conflicting cues in another (the dummy's moving lips).

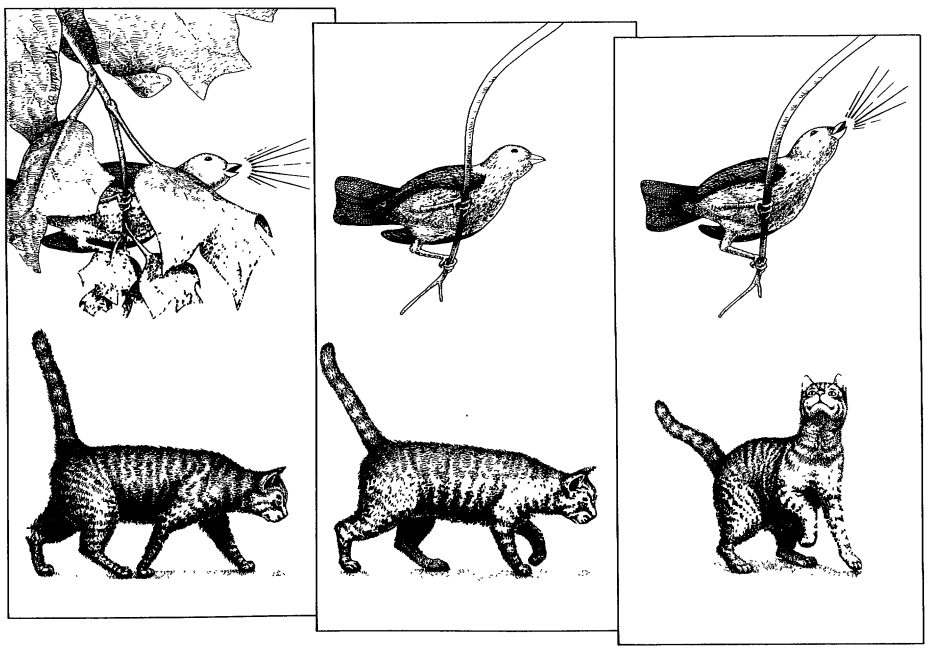
Although there is no doubting the prevalence and importance of integration of diverse sensory inputs in the construction of a coherent percept of the outside world, relatively few attempts have been made to study the possible neural basis for these effects. In fact, despite the apparently widespread distribution within the brain of neurons receiving inputs from more than one modality, it is only within the last few years that the properties of such neurons have been investigated in any detail or that efforts have been made to relate them to psychophysical or behavioral phenomena.



"The ventriloquism effect. The ventriloquist 'throws his voice' by minimizing his own movements so that the only visual cues the audience can associate with speech come from the dummy. This says less about the ventriloquist's skill than about how strong visual-auditory intersensory biases are in the audience." [From *The Merging of the Senses*]

The Merging of the Senses provides a much needed and thought-provoking synopsis of our present understanding of multisensory integration in the brain. After introducing the various cross-modal perceptual phenomena that have been described in human subjects, Stein and Meredith argue that such effects must be based on the integration of different sensory inputs at the level of the single neuron. They go on to review the ubiquity of sensory convergence at different phylogenetic levels, emphasizing the similarities found among diverse species and in different regions of the brain.

The rest of the book concentrates on the superior colliculus, which until recently was relegated by most textbooks to a purely visual role involving reflex eye movements. This midbrain nucleus now attracts the attention of a large number of sensory and motor physiologists. The superior colliculus is of particular interest for the study of multisensory integration because it contains topographically aligned visual, auditory, and somatosensory representations, and also because many of the neurons in its deeper layers receive inputs from more than one modality. Stein and Meredith first describe what is known about the sensory and motor organization of the superior colliculus and then explain how the responses of these neurons are determined by multiplicative interactions between different sensory inputs. This part of the book is dominated by experiments performed in the authors' own laboratory. Their observations suggest



"Multisensory stimuli can enhance detection and orientation behaviors. In this hypothetical situation, a bird whose song or image is within the cat's auditory (*left*) or visual (*center*) field fails to evoke an orientation response. However, when the two cues are combined (*right*), the neural activity elicited is sufficient to exceed the threshold for an overt response." [From *The Merging of the Senses*]

that enhanced neural responses result from multimodal stimuli that are likely to be associated with the same event, whereas attenuated responses are obtained when the stimuli are unrelated in space and time. Such interactions are surely important for determining the orientation responses that are mediated by the superior colliculus. Again the authors' own studies indicate that this is so by demonstrating that principles of multisensory interaction similar to those described at the cellular level do indeed apply to overt behavioral responses. The book concludes with a consideration of the consequences for multisensory integration of changes in the relative position of different sense organs that may occur either voluntarily or as a result of developmental changes in the size and shape of the head.

The book is written in a chatty and informal style, which for the most part works very well. Although adequately referenced, it does not provide a complete review of all the research that has been carried out on this subject. Accomplishing this would no doubt have rendered the book much less readable and accessible. Still, I was surprised that the authors do not mention any of the studies revealing cross-modal competition during development, where the loss of one sensory input leads to what is generally considered to be a compensatory improvement in the processing of inputs from other modalities.

The volume is enhanced by a number of excellent and effective drawings (one of the authors was trained as a medical illustrator). Arguments are introduced clearly and areas most in need of further investigation are highlighted. Occasionally I found the text somewhat repetitive and digressive, although readers less familiar with the field may not agree. On the other hand, on several occasions I found myself wishing that the authors had provided more detailed support for their arguments. Perhaps inevitably, there is also the odd point of confusion or factual error (for example, auditory neurons in the superior colliculus are not, as stated on page 72, "exquisitely sensitive to differences in the [interaural] temporal interval").

Overall, this is an excellent, highly readable book that would make a valuable addition to any physiology or neuroscience library. I imagine that its principal achievement will be to convince those who normally think of different sensory systems as anatomically and functionally distinct of the prevalence and significance of multisensory integration.

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Vignettes: Short-Lived Phenomena

It may be my fate to be a kind of comet, or flaming meteor in science, in the regions of which (like enough to a meteor) I made my appearance very lately, and very unexpectedly; and therefore, like a meteor, it may be my destiny to move very swiftly, burn away with great heat and violence, and become as suddenly extinct.

—*Joseph Priestley*, in *Philosophical Empiricism* (1775), as quoted by Jan Golinski, in *Science as Public Culture: Chemistry and Enlightenment in Britain, 1760-1820* (Cambridge University Press)

In his ruminations on the 1835 Chilean earthquake, Darwin remarked that earthquakes alone were sufficient to destroy the prosperity of a country. To illustrate the case he tried to imagine the effects of violent earthquakes beneath England: Government being unable to collect the taxes and failing to maintain its authority, the hand of violence and rapine would remain uncontrolled.

It is true that the North Wales 1984 earthquake dislocated traffic lights in Dublin. But the weight of evidence is against Darwin. For all their indiscriminate horror, earthquakes seem to have little effect on the flow of history.

—*Claudio Vita-Finzi*, in *Understanding Catastrophe* (Janine Bourriau, Ed.; Cambridge University Press)

Interpreting Europe

A Continent Revealed. The European Geotraverse. DEREK BLUNDELL, ROY FREEMAN and STEPHAN MUELLER, Eds. Illustrated by Sue Button. Cambridge University Press, New York, 1992. xii, 275 pp., illus., + maps + CD-ROM. Paper, $34.95 or £15.95.

The idea of reconstructing the geological evolution of the European continent through a large-scale, interdisciplinary study of its lithosphere was discussed in 1980 during the 26th International Geological Congress in Paris. Soon afterward, under the aegis of the European Science Foundation, the European Geotraverse (EGT) project was launched to collect and coordinate the needed data. The geotraverse was conceived as a three-dimensional north-south transect (4600 kilometers long, 200 to 300 kilometers wide, and 450 kilometers deep) from northern Scandinavia to North Africa. It was designed to encompass the Archean domain (formed more than 2.5 billion years ago [Ga]) and extend into the seismically active Mediterranean areas, crossing parts of the continental crust that evolved during Karelian (2 Ga), Cadomian (600 million years ago [Ma]), Caledonian (400 Ma), Hercynian (300 Ma), and Alpine (200 Ma to the present) times. Along this transect, existing data were compiled and field experiments and laboratory analysis were conducted to identify the geophysical markers and to correlate them with geological structures and surface data. Because the section crosses seven orogenic systems—most of them spatially superimposed—and many countries, the work and its coordination were complex. The committee set up to organize the seven-year project coordinated various workshops and intensive "retreats" to provide participants with an opportunity to analyze and interpret the data and lay the groundwork for publication of the study results.

Twelve years after the EGT was first conceived, *A Continent Revealed: The European Geotraverse* presents the results of this ambitious cooperative undertaking. The book begins with an explanation of when, how, and why the program was conducted and goes on to describe the general dynamic and tectonic framework of the chosen transect. Subsequent chapters are dedicated to the seismic structure and physical properties of the European lithosphere as well as its recent activity. Finally, a bold outline of the tectonic evolution from Precambrian time to the present is proposed and some major questions for future research are presented.

Synthesis of data on the structure of the lithosphere is always needed, and the reader will learn much from this book. From the Baltic Shield to the Mediterranean area, earth scientists can now correlate some deep (mostly crustal) geophysical features with well-known surface structures (though some of these are of debated significance). The locations of the main subsurface crustal discontinuities are presented in the third chapter. Deep seismic reflection cross sections and numerous wave-velocity cross sections can be positioned on a general sketch map