Multisensory Object Perception in the Primate Brain

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Editors

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Foreword by Barry E. Stein

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Foreword

It should come as no surprise to those interested in sensory processes that its research history is among the longest and richest of the many systematic efforts to understand how our bodies function. The continuing obsession with sensory systems is as much a reflection of the fundamental need to understand how we experience the physical world as it is to understand how we become who we are based on those very experiences. The senses function as both portal and teacher, and their individual and collective properties have fascinated scientists and philosophers for millennia.

In this context, the attention directed toward specifying their properties on a sense-by-sense basis that dominated sensory research in the 20th century seems a prelude to our current preoccupation with how they function in concert. Nevertheless, it was the concentrated effort on the operational principles of individual senses that provided the depth of understanding necessary to inform current efforts to reveal how they act cooperatively.

We know that the information provided by any individual sensory modality is not always veridical, but is subject to a myriad of modality-specific distortions. Thus, the brain's ability to compare across the senses and to integrate the information they provide is not only a way to examine the accuracy of any individual sensory channel but also a way to enhance the collective information they make available to the brain. For each sense provides different information about the same event and can inform its counterparts. As a result, their aggregate neural product is more salient and more accurate than that provided by any individual sense. It is this interaction among multiple senses and the fusion of their information content that is captured by the term "multisensory integration."

Viewed from this perspective, multisensory integration is a process by which the brain makes maximal use of whatever sensory information is available at the moment and is able to compare that information to the body of knowledge that it has already acquired. Thus, the ubiquitous presence of multiple senses in extant species seems as likely a reflection of the survival value of multisensory integration itself as it is of having sensors that can substitute for one another in different circumstances, as when hearing and touch substitute for vision in the dark. Coupling these two survival factors appears to be an ancient strategy that is believed to date from our earliest single-cell progenitor; an organism whose different sensory receptors, being tuned to different environmental stimuli, could function independently. However,

because they were all embedded in the same cell membrane, they used ion fluxes that accessed the same intracellular milieu. As a result, when they were active collectively the organism was rendered an obligate multisensory integrator. The same basic theme of coupling these two survival strategies has been elaborated repeatedly during sensory evolution, so that while species benefited from selective pressures that helped them craft each of their individual senses to meet specific ecological challenges (sometimes doing so in seemingly extravagant ways), they retained the ability to use them synergistically.

That the senses function together was recognized by our scientific forbears. They understood the importance of this cooperative arrangement but didn't know how it worked and could never have anticipated the technological revolution that underlies modern efforts to reveal its mysteries. Although the concept of cooperation among the senses had never been forgotten, the emphasis on the processes underlying their synergy has never been as great as it is today. Fortunately, we now have a wide variety of physiological and psychophysical approaches with which we can examine these processes. Studies at the level of the individual neuron and among complexes of neurons, as well as a host of psychophysical approaches in adult and developing animals, make accessible information that could not have been imagined in earlier eras.

Based on these new technologies we now understand that multisensory integration at the neural level not only speeds responses, and increases their salience and reliability, but also provides the basis for unique experiences that arise from the binding of different sensory components. We also now appreciate that these multisensory experiences are exceedingly common and add a depth to perception that might not otherwise be possible.

The current volume includes the results derived from many of the most active and productive laboratories using the latest anatomical, physiological, and psychophysical techniques to explore some of these issues as they relate to object perception. Of necessity the scope is limited to interactions among several senses (visual, auditory, somatosensory), but deals with general principles that are likely to be applicable to interactions among all the senses. Given that the study of multisensory processes is among the most active in the neurosciences, it is rapidly changing. Thus, the present volume should be viewed as an introduction to the many compelling issues in this field, as a foundation for appreciating the importance of the research currently being conducted, and as an encouragement for even greater research efforts in the future.

Winston-Salem, NC Barry E. Stein

Contents

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