Preface
David Caplan

This volume derives from a conference on Maturational Factors in Cognitive Development and the Biology of Language held June 8–11, 1978, under the auspices of the MIT Workgroup on Cognitive Science. Participants included linguists, psychologists, neurologists, and representatives of various subsections and cross sections of these disciplines. The conference was designed as a workshop in which discussion and informal presentations would play as important a role as prepared talks. This book includes revisions of the delivered papers and comments and interchanges in the form of discussions and perspectives prepared by the participants after the conference.

The title of this book reflects both a common interest of the contributors and an emergent common approach. In this symposium cognitive systems are considered biological entities and studied along lines appropriate to such entities. This perspective was nicely stated by George Zipf when he wrote in the introduction to his *Psycho-biology of Language*, "It occurred to me that it might be fruitful to investigate speech as a natural phenomenon, much as a physiologist may study the beating of the heart, or an entomologist the tropisms of an insect, or an ornithologist the nesting-habits of a bird." Speech as an object of study has been replaced by other systems, many more abstract, but the biological perspective is retained in this volume.

The study of cognitive systems in the setting of biology requires a model of biological processes as a framework for thought. This model uses three levels of description. The level of *phenomena* includes a representation of a domain of knowledge and a theory of utilization of this knowledge. It allows for partially overlapping representations of knowledge and its utilization, each of which may re-

flect different neural or genetic devices. The *neural* level is characterized by anatomical, biochemical, physiological, and other organic information regarding the organic system whose operations correspond to and produce the phenomena. The *genetic* level describes the hereditarily transmitted material in which is encoded the information determining the structure of the neural level, its maturational sequences, certain of its operations, and the limits of its response to environmental influences. Ontogenetic and phylogenetic progressions can be studied at each level.

Environmental influences affect all levels. Genetic and neural structures and functions are influenced primarily by organic factors; phenomena, by exposure to other phenomena. In simple cases it is clear that genetic structures are altered by viral invasion, exposure to irradiation; neural structures are damaged by circulatory insufficiency, neoplasia; and humans learn the language of their surroundings, acquire the culture in which they are raised.

Interactions between environmental influences and the unfolding of the genetic plan or the functioning of the neural apparatus can be quite complex. For instance, sexual function at both the behavioral and endocrine levels is a result of genetic sex modified by the level of sex hormones in the perinatal period, the latter produced by genetically determined endocrine function, and exogenous delivery of hormones, toxins, and drugs. The combination of hormonal and genetic influences induce neural structures responsible for regulating sex hormones in the adult. The intriguing effects of environmental phenomena on neural structures are being investigated in studies of active versus passive exposure to visual displays, deprivation of visual stereopsis, monocular visual acuity impairments, and similar systems, as well as in a host of experiments on the chemical and molecular changes seen in neural tissue following certain types of learning in simple organisms. This type of effect raises the possibility that abstract variables in environmental phenomena, such as those that characterize the differences between languages, may induce neural structural changes. Another category of interaction is the effect of phenomena on genetic structures. Post-Darwinian evolutionary theory deals with the consequences of behavioral repertoires—seen here as phenomenological entities—on genetic load, a process mediated through natural selection over several generations of organisms.

The work reported and discussed in this volume seeks to clarify

descriptions of the three levels of biological concern and explore the mechanisms relating one to another in the area of human cognitive functioning. This is the area of common interest.

The common approach that I believe is crystallizing begins with the recognition that all three levels and their interaction constitute an interrelated field of study. Detailed, abstract characterizations of knowledge and its use, such as are available in contemporary linguistics, psychology, artificial intelligence, and other disciplines, are not ignored in favor of more concrete schemata; nor are they created by scientists in these fields as purely abstract, formal systems. It is the task of the "organic biologists" to find mechanisms that are suggested by and underlie these systems, as gene structure was suggested by the laws of inheritance of phenotypes. It is the hope of the "mental biologists" that studies incorporating organic features will help constrain the formal systems and decide between competing descriptions. On the other hand, scarcely a discovery about structure or physiology of the nervous system is not greeted today by inquiries about its functional or dynamic significance, and this attitude applies to cognitive as well as perceptual, emotional, and other systems.

A second concept that interested many contributors is that of "mental organ." Spearheaded by the linguists' observation that the formal and functional properties of language, at the phenomenological level, are not found in other cognitive systems in humans or animals, the hypothesis arose that in the domain of language there exists a unique biological mechanism that includes a genetic endowment, a neural mechanism, and a phenomenological result, all of which are species- and domain-specific. This strong claim, generated by studies of phenomena alone, has served to stimulate and organize research in the field, and parallel models are being developed in other areas of cognition. Whether or not the hypothesis proves correct, it highlights the effort to find unified theories of a cognitive function across the three levels of biological reality. I believe it would be legitimate to speak of a mental organ when such a unified system has been demarcated, whether or not its mechanistic description at each of the three levels is unique with respect to domain and species.

A third theme is maturation. Intrinsic biological development of the organism creates new neural systems, which allow the child to formulate new classes of hypotheses about the structure of the

phenomenological world and utilize these hypotheses in new ways. Studies in maturation attempt to characterize these neural changes, identify the factors that trigger them, and explore their consequences for phenomenological capacities. A concomitant task is to distinguish this class of neural changes—those produced by intrinsic maturational sequences—from the class resulting from exposure to and mastery of particular phenomenological systems.

The last major concept is that of parallel or partially overlapping mechanisms. The description of phenomena and utilization procedures is now largely developed in formal, often computational, terms. Alternative descriptions of a single phenomenological domain are available. Many studies have suggested that different neural structures use these different phenomenological analyses. This observation does not solve the problem of choosing between competing phenomenological descriptions on formal grounds, but it suggests that biology need not fear this application of Occham's razor. On the contrary, this realization opens new approaches to the understanding of neural function and the effects of brain lesions on behavioral strategies and capacities, and it may have practical applications in retraining.

Certain traditional questions did not emerge directly in this symposium. The question of innateness, for instance, was not debated per se. I believe that this concept is being redefined and becoming better understood in terms of genetic load and internal organic environmental effects on neural function (maturation), which result in changes in computational capacities. On the other hand, the traditional psychological and philosophical term *acquired* is being restricted to the results of exogenous organic factors and the computational consequences of exposure to particular phenomena (as, for instance, occurs in learning the language of the environment). Detailed hypotheses are available concerning both these areas, and discussion is focused on specific hypotheses more than on the status of the distinction that spawned them. Thus new concepts and themes are partially replacing our former ideas about the biology of cognition. It is the hope and expectation of the investigators at this symposium that many of the concepts and ideas raised here will in turn be spelled out in increasingly precise terms and this will provide a deeper understanding of this aspect of human, and nonhuman, biology.