Preface

This volume is a summary and synthesis of the current state of auditory forebrain organization. We think it a timely contribution in view of the growing interest in this network as the arbiter for hearing, as a key element in the larger communications network that spans and links the parietal, temporal, and frontal cortices, and as a candidate for clinical intervention, whether through cochlear implants or more exotic upstream prostheses that, one day, may involve the forebrain more directly.

The present account differs from the available efforts (Aitkin 1990; König et al. 2005) in two significant ways. First, the medial geniculate body is included as a full partner since it has cooperative, reciprocal, and robust relations with the auditory cortex that suggest a partnership in which the exclusion of either structure detracts from a functional portrait of their interactions. Second, our aim has been systematic and synoptic, including as it does a wide range of species, methods, subsystems, physiological perspectives, and functional architectures. We look back on 100 years of the discipline of auditory forebrain studies with a view to framing a future agenda. As new methods emerge and as older approaches exhaust their potential, it seems appropriate to attempt a summing up and to forge a prospectus for future work. We cannot present a full theory of auditory forebrain organization since the field is still so new as a discipline; that task we must leave to a later, more mature volume that recognizes the distributed nature of forebrain operations in a more refined way than is now possible. Our goal is to provide an experimental foundation and a conceptual framework for the auditory forebrain useful to the discipline as a whole, and which one might consult as both a summary of work in progress and an invitation to explore further. This formidable task could not have been accomplished without the contribution of an expert cohort of collaborators on whose efforts this enterprise rests.

Several methodological and conceptual insights have converged to create the present, congenial atmosphere for this effort. The emergence of new functional approaches such as the tissue slice and its varieties has enabled the exploration of new neurochemical and synaptic vistas (Metherate and Hsieh 2004) and allowed a more formal and anatomical–physiological characterization of identified neurons (Verbny et al. 2006). Related advances include the important insights gleaned from large silicon electrodes that span the full cortical depth and reveal critical facets of interneuronal and laminar organization invisible to a single extracellular pipet (Atencio and Schreiner 2008). Such local circuits in the medial geniculate body and auditory cortex are the functional building blocks upon which the large-scale operations of spectral analysis, aurality, and frequency modulation are arrayed. How these several subsystems interact cooperatively as a network is among the most challenging questions for the future. Other powerful insights flowed from the ability to record from synaptically joined pairs of cells (Miller et al. 2001) contributing to a new perspective on the thalamocortical transformation (Winer et al. 2005). Understanding such transformations—tectothalamic, thalamocortical, corticocortical, and corticofugal—remains an enterprise for the future.

A second wave of insight arose from the neuroimaging domain, where positron emission tomography, functional magnetic resonance imaging, and magnetoencephalography each provided powerful documentation of the locus and density of activity in the living brain during specific tasks or after particular pathologies. This work not only defined the site of activation, but related measures such as 2-deoxygluose provided the first full perspective on the limits of auditory-responsive cortex (Poremba et al. 2003).

Neuroanatomical and immunocytochemical approaches have provided credible maps of connectivity in the thalamocortical and corticocortical systems (Huang and Winer 2000; de La Mothe et al. 2006), documenting a vast web of forebrain long- and short-range circuits. The implementation of studies of lamina-specific interneuronal properties has provided valuable insights into these dynamic systems (Atencio et al. 2009). The corticothalamic and other corticofugal systems likewise are now construed as prospective dynamic players in regulating auditory cortical excitability rather than as feedback pathways (Winer et al. 2001). Combined physiological-connectional studies established the existence of specific pathways for sound localization and object identification (Rauschecker and Tian 2000).

The dramatic demonstration and ensuing exploration of widespread auditory forebrain plasticity (Kilgard and Merzenich 1998; Weinberger 1998) was a watershed and its implementation in the descending systems (Zhang et al. 2005) suggested a role for the corticofugal systems very different from earlier accounts that emphasized feedback. The auditory cortex now appears to be as concerned with the control of inferior colliculus excitability and plasticity and information processing as it is in the analysis of sound parameters and categorical perceptual analyses. Such findings were a linchpin in larger efforts to characterize the distributed auditory cortex as an entity that represents hearing in its largest and most inclusive sense (Winer and Lee 2007). The present volume can be construed as a multidisciplinary effort to further implement and instantiate that perspective.

Berkeley, CA
San Francisco, CA

Jeffery A. Winer
Christoph E. Schreiner

References

Aitkin L (1990) *The Auditory Cortex: Structural and Functional Bases of Auditory Perception*. Chapman and Hall, London.

Atencio CA and Schreiner CE (2008) Spectrotemporal processing differences between auditory cortical fast-spiking and regular-spiking neurons. *Journal of Neuroscience* **28**: 3897–3910.

Atencio CA, Sharpee TO, and Schreiner CE (2009) Hierarchical computation in the canonical auditory cortical circuit. *Proceedings of the National Academy of Sciences of the United States of America* **106**:21894–21899.

de La Mothe L, Blumell S, Kajikawa Y, and Hackett TA (2006) Thalamic connections of the auditory cortex in marmoset monkeys: core and medial belt regions. *Journal of Comparative Neurology* **496**:72–96.

Huang CL and Winer JA (2000) Auditory thalamocortical projections in the cat: laminar and areal patterns of input. *Journal of Comparative Neurology* **427**:302–331.

Kilgard MP and Merzenich MM (1998) Cortical map reorganization enabled by nucleus basalis activity. *Science* **279**:1714–1718.

König R, Heil P, Budinger E, and Scheich H (eds.) (2005) *The Auditory Cortex. A Synthesis of Human and Animal Research*, Lawrence Erlbaum Associates, Mahwah.

Metherate R and Hsieh CY (2004) Synaptic mechanisms and cholinergic regulation in auditory cortex. *Progress in Brain Research* **145**:143–156.

Miller LM, Escabí MA, and Schreiner CE (2001) Feature selectivity and interneuronal cooperation in the thalamocortical system. *Journal of Neuroscience* **21**:8136–8144.

Poremba A, Saunders RC, Crane AM, Cook M, Sokoloff L, and Mishkin M (2003) Functional mapping of the primate auditory system. *Science* **299**:568–572.

Rauschecker JP and Tian B (2000) Mechanisms and streams for processing of "what" and "where" in auditory cortex. *Proceedings of the National Academy of Sciences of the United States of America* **97**:11800–11806.

Verbny YL, Erdélyi F, Szabó G, and Banks MI (2006) Properties of a population of GABAergic cells in murine auditory cortex weakly excited by thalamic stimulation. *Journal of Neurophysiology* **96**:3194–3208.

Weinberger NM (1998) Tuning the brain by learning and by stimulation of the nucleus basalis. *Trends in Cognitive Sciences* **2**:271–273.

Winer JA, Diehl JJ, and Larue DT (2001) Projections of auditory cortex to the medial geniculate body of the cat. *Journal of Comparative Neurology* **430**:27–55.

Winer JA and Lee CC (2007) The distributed auditory cortex. *Hearing Research* **229**:3–13.

Winer JA, Miller LM, Lee CC, and Schreiner CE (2005) Auditory thalamocortical transformation: structure and function. *Trends in Neurosciences* **28**:255–263.

Zhang Y, Hakes JJ, Bonfield SP, and Yan J (2005) Corticofugal feedback for auditory midbrain plasticity elicited by tones and electrical stimulation of basal forebrain in mice. *European Journal of Neuroscience* **22**:871–879.

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