Musicae Scientiae
1–3

DOI: 10.1177/1029864914523548
msx.sagepub.com

Book Review

Jan Schnupp, Israel Nelken, & Andrew King. *Auditory neuroscience: Making sense of sound*. Cambridge, MA: MIT Press, 2011. 368 pp. ISBN: 9780262113182 (hbk); 9780262518024 (pbk).

Auditory Neuroscience: Making Sense of Sound is an excellent new book written by Jan Schnupp, Israel Nelken, and Andrew King that offers an engagingly comprehensive introduction to auditory neuroscience. For this book the authors have decided to drop the standard neuroscience textbook strategy of organizing their discussion around anatomical structures. Instead, the authors have adopted an alternative but uniquely effective organizational strategy, first using Chapters 1 and 2 to offer a preparatory background on the fundamentals of physical acoustics and the physiology of the ear, then subsequently using Chapters 3, 4, 5, and 6 to offer focused discussion on the neurobiology of pitch perception, speech processing, sound source localization, and the perceptual separation of sound mixtures, respectively, and finally, using Chapters 7 and 8 to conclude the book with discussion of neuroplasticity and recent technological advancements for the treatment of hearing loss. Each chapter is self-contained, offers approximately two lectures' worth of study material, and is written with remarkable lucidity and wit for a neuroscience text. This makes the book an equally excellent resource for either standard coursework or independent study. Though the book was written "with an advanced undergraduate readership in mind, aiming mostly at students in the biological or medical sciences, audiology, psychology, neuroscience, or speech science," the topical organization of the book along with the general ease with which it reads makes it an especially valuable resource for anyone that has a basic background in biology and psychology, is fascinated by hearing and sound, and is eager to learn more. For instance Chapter 6 of the book focuses on auditory scene analysis and considers issues surrounding the existence and nature of auditory objects, and such a chapter might be usefully integrated into a graduate seminar on the cognitive science of music, the philosophy of music, or even music theory, in addition to courses focused more directly on auditory neuroscience itself.

In Chapter 1 the book offers a useful introduction to auditory neuroscience by discussing the fundamentals of physical acoustics and how sound is generated by vibrating objects in the environment. It offers an exceptional review of basic mathematical concepts for those with little or no prior knowledge of mathematics and devotes individual sections to the discussion of simple harmonic motion (1.1), modes of vibration and damping (1.2), Fourier analysis and spectra (1.3), windowing and spectrograms (1.4), impulse responses and linear filters (1.5), voices (1.6), sound propagation (1.7), and sound intensity (1.8). Chapter 2 then proceeds to focus on the physiology of the ear and discusses how sound as a physical phenomenon becomes sound as a perceptual phenomenon. It reviews the basic anatomical structure of the outer, middle, and inner ear and devotes individual sections to the discussion of sound capture and transmission to the inner ear (2.1), transduction from vibration to voltage in hair cells (2.2), active amplification of outer hair cells (2.3), sound-encoding in neural firing patterns (2.4), and stations of the central auditory pathway (2.5). Those drawn to the book for the purpose of enriching their understanding of music more specifically will be glad to find several musical examples in the first two chapters, with, for instance, a guitar string being used to illustrate modes of vibration in Figure 1.3, a piano and bell being used to illustrate differences in frequency spectra in Figure 1.4, and a wooden castanet and metal glockenspiel being used to illustrate differences in sound decay in Figure 1.5.

After providing important background information on the fundamentals of physical acoustics and the physiology of the ear, Chapter 3 next turns to focus on the neurobiology of pitch perception and discusses the physical attributes of sounds that are likely to evoke particular types of pitch percepts in humans. It devotes individual sections to the discussion of periodicity as the major cue for pitch (3.1), the relationship between periodicity, frequency content, and pitch (3.2), the psychophysics of pitch perception (3.3), pitch and scales in Western music (3.4), pitch perception by non-human listeners (3.5), algorithms for pitch estimation (3.6), periodicity encoding in subcortical auditory pathways (3.7), periodicity coding in auditory cortex (3.8), and paradoxes of pitch perception (3.9). Next, in Chapter 4, the neurobiology of speech processing is considered and individual sections of this chapter are devoted to the discussion of speech as a dynamic stimulus (4.1), the categorical perception of speech sounds (4.2), the subcortical representations of speech sounds and vocalizations (4.3), the cortical areas involved in speech processing (4.4), the role of auditory cortex in speech processing (4.5), the representation of speech and vocalizations in primary auditory cortex (4.6), the processing of speech vocalizations in higher-order cortical fields (4.7), and visual influences on speech processing (4.8), along with a chapter summary (4.9). Section 3.9 on "The Paradoxes of Pitch Perception" may be of particular interest and serve as a fruitful topic of discussion for cognitive scientists and philosophers of mind drawn to topics concerning sound representation, abstraction and generalization, and the processing hierarchy for auditory perception.

Chapter 5 then turns to cover the neurobiology of sound localization, devoting individual sections to the discussion of how the direction (5.1) and distance of sound sources are determined (5.2), the processing of spatial cues in the brainstem (5.3), maps of space and the midbrain (5.4), what the auditory cortex contributes to sound localization (5.5), and sound localization in more complex environments (5.6). After considering the neurobiology of sound localization, Chapter 6 then proceeds to consider the neurobiology of perceptual separation of sound mixtures. It devotes individual sections to the discussion of auditory scene analysis (6.1), the low-level and high-level representations of the auditory scene (6.2), simultaneous segregation and grouping (6.3), streaming (6.4), change detection (6.5), and concludes with an overview of the auditory analyses of scenes and objects (6.6). Those drawn to the book for the purpose of enriching their understanding of music more specifically will once again be pleased to find several musical examples considered in these four chapters (3–6), with, for instance, Figures 3.4 and 3.6 using a piano keyboard to illustrate the chromatic scale and intervals of Western music, Figure 6.12 using the melodic line from Franz Liszt's *La Campanella* to illustrate streaming, and Figure 3.5 outlining a partial theory of consonance. These are surely unique features for an auditory neuroscience textbook, and most readers will find that this contributes to the book being a uniquely entertaining read.

Moving past the focus of Chapters 3 through 6 on perceptual tasks, Chapter 7 subsequently turns the focus of the discussion towards the development and plasticity of the auditory system, devoting individual sections to the discussion of when hearing starts (7.1), how hearing capabilities improve after birth (7.2), the importance of early experience on speech and music (7.3), the maturation of auditory circuits in the brain (7.4), the plasticity of the adult brain (7.5), and the pros and cons of plasticity (7.6). Finally, the book comes to a close with Chapter 8, which discusses contemporary technologies aimed at treating hearing loss.

In this concluding chapter individual sections are devoted to discussing the historical context of hearing aid devices (8.1), the basic layout of cochlear implants (8.2), place-coding with cochlear implants (8.3), speech processing strategies used in cochlear implants (8.4), pitch and music perception through cochlear implants (8.5), spatial hearing with cochlear implants (8.6), as well as considerations of brain plasticity for cochlear implantation (8.9). The book includes 117 figures throughout to support the main text, with the reference section economically drawing upon 348 relevant publications from 1947 through 2010.

The book is officially accompanied by a website – www.auditoryneuroscience.com – that provides useful supplementary materials including sound samples, movie clips, discussion forums, relevant links, and more. Of particular interest to instructors and self-directed students is the fact that the accompanying website includes a link to lecture handouts and video recordings appropriate for a second year course in auditory neuroscience (the available handouts focus on the nature of sound, the ear and brain, periodicity and pitch, spatial hearing, auditory scene analysis, hearing speech, hearing aids and cochlear implants, and development, learning, and plasticity; the available video recordings focus on hearing speech, and hearing aids and cochlear implants): http://auditoryneuroscience.com/Lectures.

Auditory Neuroscience: Making Sense of Sound is surely an excellent book accompanied by a resourceful website that will prove immensely valuable to students and experts alike. I highly recommended this book for anyone eager to learn more about the science of hearing, sound, and music.

A copy of Chapter 1 of the book can be freely downloaded from the accompanying website: http://auditoryneuroscience.com/sites/default/files/Schnupp_FM_Ch1.pdf

Adam M. Croom
University of Pennsylvania, USA