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Editorial

Editorial introduction to *Hearing Research* special issue on communication sounds and the brain: New directions and perspectives

The mellifluous diversity of acoustic communication signals in the world is a testament to the power of evolutionary mechanisms to spawn complexity in nature. Selection pressures do not act on communication signals directly, however, but on the biological systems that produce and perceive them. As such, communication signals can provide a window into how these systems work, and in the right hands, become a powerful tool. At an early workshop on *Auditory Processing of Biologically Significant Sounds*, Worden and Galambos (1972) articulated the benefits of such tools, saying, "the full capacity of the auditory processor may not be revealed except through study of its responses to stimuli that pose analytical tasks of the kind that shaped its evolutionary development." The continuation of this neuroethological approach, from the study of natural behaviors to the study of natural signals in conjunction with those behaviors, has often been employed successfully to probe the neural mechanisms of audition in animals from diverse taxa including anurans, bats, fish, humans, invertebrates, non-human primates, rodents and songbirds (Hickok and Poeppel, 2007; Kanwal and Ehret, 2006; Platt and Ghazanfar, 2010; Wang, 2000; Worden and Galambos, 1972).

The benefits of using acoustic communication signals (or other natural signals) to study the neural mechanisms of auditory processing, while significant in theory, can be elusive in practice. Indeed, the same rich acoustic complexity that carries ethological meaning under certain behavioral contexts can be a hindrance to precise parameterization in the laboratory, tempting one to synthesize sounds that can be better controlled. After all, using complex natural vocalizations may be like throwing a bucket full of rocks into a pond and hoping to understand wave properties that might be more easily resolved by throwing a single, perfectly spherical, glass bead. Could one use simpler synthetic sounds and laboratory paradigms to gain equivalent knowledge about auditory neurobiological research topics of interest, including contemporary questions on circuitry, coding, plasticity, memory and attention? In fact, *non*-ethological stimuli and behaviors are readily adopted by many auditory researchers, often with great success. Do we really need to employ vocalizations to solve the mysteries of auditory neural processing? Is vocalization processing "special" in any way that necessitates their use for elucidating audition?

These were some of the questions we had in mind when we approached our invited contributors to this Special Issue on "Communication Sounds and the Brain: New Directions and Perspectives." Auditory research using vocalizations has progressed far from the days of simply describing responses to individual example communication sounds; more sophisticated controls, cross-species comparisons and functional analyses are being employed that will help elucidate any "specialness" of species-specific vocalization processing. Our goal here is to bring together researchers who are harnessing the benefits and working through the challenges of using natural vocalizations to probe brain mechanisms of audition across a diverse collection of animal models. The overall aims are (1) to summarize the background and current state of knowledge about using communication sounds in auditory neuroscience; (2) to articulate common issues in using these complex sounds to address outstanding questions; and (3) to suggest the next steps that will help advance our understanding of the auditory system.

Each of the papers in this Special Issue provides a different perspective on these aims. In the first four contributions, the authors consider perceptual and cognitive topics — like stimulus categorization (Bennur et al.), attention (Caporello and Gentner) and salience (Maney) — and discuss what we may learn from using species-specific vocalizations as stimuli in elucidating these general concepts. Poremba's article shifts the perspective by emphasizing how domain-general, rather than communication-signal specific, mechanisms of learning may contribute to the representation of species-specific vocalizations.

The next three contributions directly compare the auditory processing of vocalizations across species and throughout development. Woolley and Portfors focus on conserved mechanisms used by auditory midbrain neurons in mammals and songbirds to encode species-specific calls. Steinschneider and colleagues discuss their findings that responses to acoustic features in human speech are similar in the primary auditory cortex of macaques and humans, implying that the encoding of species-specific vocalizations at this level is *not* "special" in humans. Talkington and co-authors then consider the study of the evolutionarily conserved networks involving brain areas beyond the primary auditory cortex, such as regions sensitive to "voice" content. They advocate that future studies can gain considerable insights by comparing vocalization responses between human and non-human primate species and throughout development.

The last five articles use the neuroethological approach to study specific neural mechanisms at different processing stages involving early auditory representations, higher order multimodal interactions and vocal motor output. Pollak's article focuses on the important role that inhibitory mechanisms in the auditory brainstem play in shaping excitatory selectivity for acoustic features of communication sounds. Gaucher and co-authors discuss the hypothesis that temporally precise and sparse spiking in auditory cortex

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creates a high-level representation of vocalizations that correlates with perception. Edwards and Chang review psychophysical and neurophysiological data on the responses to amplitude modulated signals to make the argument that tuning to the natural rhythms found in communication signals, such as the syllable rate of human speech, arises at the level of the non-primary thalamocortical system. Plakke and colleagues look beyond the traditional auditory system to the macaque ventrolateral prefrontal cortex, where neurons' auditory-visual multimodal sensitivity might allow for improved classification of vocalization types and caller identities. Finally, Prather's contribution completes the loop from stimulus input to behavioral output in the context of vocal-motor learning. He reviews the literature on the interface between auditory perception and vocal production in the songbird model, which provides important parallels for investigating the neurobiology of speech learning.

The scientific community remains interested in embedding the neuroethological approach to address the neurobiological mechanisms of audition, even if the complexities in implementing this approach have meant that it has not always been fully embraced by the auditory community. In the end, however, we have the most to gain by advancing a plurality of approaches to understand auditory neurophysiology, using well-reasoned choices of acoustical signals from simple to complex, synthetic to natural. Towards this end, we hope this Special Issue provides a forward-looking collection of articles that serves as a benchmark of past and current progress, and a roadmap that can both excite established and young researchers as well as act as a primer for those entering the field. Together, the contributors make a strong case that for some neurobiological questions of deep interest to the auditory community, the continued use of natural stimuli and ethological paradigms remain essential not only for understanding normative function, but also for elucidating what may go awry in communication disorders.

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