Sensory Ecology, Evolution, and Behavior

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1 Introduction

Sensory ecology deals with how animals capture information from their environment, and the sensory systems involved in doing so (Hailman, 1977; Lythgoe, 1979; Dusenbery, 1992; Mappes and Stevens, 2010). Although the term sensory ecology itself is comparatively recent, its basis has a long history, in part due to numerous links with subjects such as neurobiology, physiology, ethology, and evolutionary behavioral ecology. Studies of sensory ecology have also more recently incorporated other new techniques, such as those of molecular biology and phylogenetics. Sensory ecology deals with both mechanistic questions (for example, how receptors capture information from the environment) and functional questions (for example, the adaptive significance of the information gathered). It covers the full range of sensory systems and modalities. This special issue of Current Zoology presents a range of papers, both original research and reviews, covering sensory ecology, evolution, and behavior. A full coverage of the discipline is clearly well beyond the scope of one journal issue, but the aim is to present representative examples of work conducted by current researchers.

2 Key Questions in Sensory Ecology

There are many key questions researchers of sensory ecology currently investigate. A fundamental principle is what information is available to animals from the biotic and abiotic environment, and how this information is captured and processed (Mappes and Stevens, 2010). Clearly then, understanding how sensory organs work in capturing this information is crucial. Sensory ecologists utilize this knowledge to understand how animals perform various tasks during their lives, such as finding food, navigating, choosing a mate, and so on. In addition, a central area of sensory ecology is the study of signaling. A signal can be thought of as a change in the environment caused by an individual (the emitter) that conveys information to a receiver (Endler, 1992; Endler, 1993). Signals can be thought of as having two main components: content (the actual ‘message’ provided) and efficacy (the structure or form of the signal to convey the message). Sensory ecology frequently deals with efficacy, for example, how signals are most detectable, distinguishable, and recognizable from other cues or signals in the environment (Guilford and Dawkins, 1991).

However, sensory ecology is more than simply studying how sensory systems and signals work. For example, key questions include how energetic/metabolic costs influence signal efficacy (i.e. physically generating a signal; Kotiaho et al. 1998), and constrain sensory systems themselves (Niven and Laughlin, 2008), and also how animals cope with conflicting selection pressures and trade-offs on signal efficacy, such as eavesdropping from unwanted receivers (e.g. predators). In addition, other key areas investigate what role the environment and sensory systems play in sexual selection and diversification. This includes sensory biases/exploitation (Endler and Basolo, 1998), and sensory drive (Boughman, 2002), and whether signals or the sensory systems themselves adapt to the environment. Furthermore, research tests how animals integrate multiple senses in behavioral tasks, and how multimodal signals convey information through more than one sensory channel.

Whilst Dusenbery’s 1992 book, Sensory Ecology, set the scene for the subject, a great deal has changed since, and in the last few years there have been many exciting studies. For example, research has illustrated how animals may avoid unwanted receivers and use private communication channels, such as visual signals in some fish (Partridge and Douglas, 1995; Douglas et al., 2000; Siebeck et al., 2010). Furthermore, whilst predation pressure is thought to usually constrain the form of communication signals (e.g. Endler, 1978; Endler, 1980), recent findings in electric fish suggest it can cause diversification, for instance in electric signal form (Stoddard, 1999). A growing body of research on animal camouflage has illustrated how understanding anti-predator coloration can help researchers to understand features of visual processing (e.g. Zylinski et al., 2009) that have potential relevance to computer vision and image analysis software, and also how prey animals
exploit features of the predator’s vision to remain hidden (Stevens and Cuthill, 2006). Conversely, other work has shown how markings on the predators, such as on some spiders, can exploit features of prey (e.g. bee) spatial and color vision (e.g. Chiao et al., 2009). Studies of predator-prey arms races have also recently verified the idea that some moths may prevent predation from bats by using ‘sonar jamming’ of bat echolocation calls (Corcoran et al., 2009). Studies of communication have illustrated how there can be close links between the properties of a specific signal and the sensitivity of the sensory system itself, such as fireflies, where spectral sensitivity can match bioluminescent emission spectra closely (Cronin et al., 2000). Studies in a range of animal groups have also shown how information can be conveyed in multiple modalities, and the relative importance of different components to the success of the signal (e.g. Partan and Marler, 1999; Hebets, 2008). Such communication systems, including signal structure and transmission, can be influenced by the properties of the environment (e.g. Elias et al., 2004; Hebets et al., 2008), including, for example, effects of anthropogenic noise on the calls of birds (Slabbeikoorn and Peet, 2003). The environment may not just influence signal form, but also drive animals to switch from one predominant sense and improve performance in a different modality, for example guppies becoming more sensitive to chemical and less sensitive to visual cues when reared under low light levels (Chapman et al., 2010). Other recent work has shown how the environment and sensory systems can drive diversification and speciation (Boughman, 2001; Seehausen et al., 2008). These examples represent a small sample of recent work. This issue of Current Zoology, covers a range of the above subjects.

3 Contributions to the Special Issue

This issue begins with three reviews. First, Wiltschko and Wiltschko (2010) review the avian magnetic compass across three orders of birds, and discuss the function of the magnetic compass, and the physical mechanisms underlying it. Montgomery and Bodznick (2010) discuss the functional origins of the vertebrate cerebellum and cerebellum-like structures, and their role in sensory processing and other tasks. Maan and Seehausen (2010) review work that has investigated species divergence in cichlid fish, and the role of sensory adaptation and drive, and sexual selection in this. In the first of the research papers Melin et al. (2010) investigate differences in foraging in free-ranging white-faced capuchins, based on sex and color vision phenotype. Partan et al. (2010) use mechanical robots to investigate multimodal alarm behavior in grey squirrels, and the differences between squirrels in urban and rural areas. New and Peters (2010) produce a framework using cameras to quantify movement-based signals in three-dimensions, based on tail flicks in Jacky lizards. Webb et al. (2010) study the generalization of different types of anti-predator behavior of velvet geckos to the chemical cues of different snakes. Following this, Ryan et al. (2010) investigate female preference in túngara frogs to a range of natural and synthetic calls, to examine latent female preferences for acoustic ornaments. Corcoran et al. (2010) conduct a cross-species analysis of tiger moth sounds aimed at bats, to investigate the diversity of sounds used by moths in acoustic aposematism and mimicry, and sonar jamming. Elias et al. (2010) studied how the efficacy of vibration-based mating signals in spiders is affected by the transmission properties of different natural substrates, and the influence of this on mating success. Finally, Gan et al. (2010) investigate the role of web decorations (plant debris, eggsacs, prey remains, and moults) in visually camouflaging orb-web spiders from avian and hymenopteran predators. Together, these give a flavor of the diversities of questions and approaches that make sensory ecology such an exciting field of research.

Acknowledgements I thank all the authors that contributed to the theme, the Executive Editor of Current Zoology, Zhiyun Jia for a range of help, and Graeme Ruxton and Johanna Mappes for comments on the manuscript. I was supported by a Biotechnology and Biological Sciences Research Council David Phillips Fellowship (BB/G022887/1)

References
