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Editorial: An Ecological Perspective on Decision-Making: Empirical and Theoretical Studies in Natural and Natural-Like Environments

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Editorial on the Research Topic

An Ecological Perspective on Decision-Making: Empirical and Theoretical Studies in Natural and Natural-Like Environments

The processes that neuroscientists study, including sensory systems, cognitive capabilities, and decision-making, depend on ecological and evolutionary forces that shape how animals adapt to environmental change. This raises fundamental questions both in neuroscience and in evolutionary biology. In systems neuroscience, decision-making has usually been studied by training animals to perform stereotyped behavior in laboratory conditions (Gold and Shadlen, 2007; Shadlen and Kiani, 2013; Hanks and Summerfield, 2017). This has helped to elucidate the neurobiological mechanisms of decision-making, but does not describe how such decisions are performed in a natural environment, and what are the ecological and evolutionary forces that shaped these processes (Krakauer et al., 2017; Mobbs et al., 2018). It remains an open question whether the neural mechanisms for trained behavior are recruited for decisions made in natural settings. On the other hand, behavioral ecology examines the evolutionary pressures that lead to decisions that function in natural environments (Krebs and Davies, 1997). This approach generally does not examine the cognitive machinery that processes information, leaving open the question how neural processing systems constrain decision-making.

Recent advances in data acquisition technology, computer vision, behavioral modeling, and machine learning facilitate the collection and efficient processing of data on behavior and environmental details (Berman, 2018; Brown and Bivort, 2018), and also enable neural recordings from freely moving animals (Kerr and Nimmerjahn, 2012; Jun et al., 2017). The perspectives of both systems neuroscience and behavioral ecology are needed in order to use such data to form a deeper mechanistic understanding of decision-making (Bateson and Laland, 2013; Nesse, 2013). The articles in this special issue provide theoretical frameworks and case studies that highlight the crucial importance of connecting ecological context to the study of decision making. Two review articles discuss challenges, open questions, and theoretical frameworks related to incorporating ecological context and cognitive processes into studies on decision-making (DeAngelis and Diaz), Budaev et al.. Three research articles provide examples across a range of species—ants, caterpillars, and primates—for how both lab and field experiments can be used to study natural decisions (Despland), how environmental context affects evolution of sensory processing systems (Ogawa et al.), and how environment conditions can affect the information used to make decisions (Janson).

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A challenge in designing laboratory experiments is to capture the key elements of the decisions that animals make in their natural environment. Despland combined field observations with lab experiments to study aggregation behavior of caterpillars and their decisions when to initiate feeding on leaves. The results show that when a caterpillar decides to feed, a behavior which influences its survival, depends both on social context and environmental factors including the trichome defenses of the plant.

Natural environments present many sensory stimuli that can combine to influence decision-making. Budaev et al. discuss the influence of state-dependence and the need to filter relevant sensory information, such as hunger or fear, on decisions made in a complex environment. In the framework they present, an animal's state sets the priority for each decision system, such as nutrition or survival, and top-down attention mechanisms regulate and limit which sensory information is processed.

Filtering of information can also be selected for, leading to animals with sensory systems that are adapted to their environment, as demonstrated in the case of ants in the article by Ogawa et al. This study examines two closely related ant species and show that they have optimized their visual system differently in order to adapt to their respective visual ecology.

Janson demonstrates that environmental conditions and individual capabilities influence the relative benefit of additional information and cognitive processes, such as memory, in decision-making (e.g., memory). Inspired by the results of field experiments on wild capuchin monkeys, they simulate foraging decisions and ask how including memory of elapsed time since prior foraging visits improves foraging efficiency in different resource environments.

DeAngelis and Diaz highlight the importance of including individuals' decision making strategies into population level ecological models, and discuss how agent-based models can be used to examine the fitness consequences of specific individual decision rules. For example, agent based modeling can represent differences between individuals in a population or co-dependent strategies such as predator-prey interactions, and opens up the opportunity to provide mechanistic interpretations for long standing population level ecological phenomena.

We hope these articles inspire further work that combines systems neuroscience and behavioral ecology.

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