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Cognition in the wild: understanding animal thought in its natural context

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Why study cognition in the wild? Comparative perspectives on cognition from nonhumans have long been an important avenue for answering questions about how the mind works, sometimes with animals standing in as models for different aspects of human thought, and sometimes with a focus on the diverse cognitive processes of different species. Yet, research in comparative cognition has to date overwhelmingly involved inquiry based in laboratories. While such captive contexts can allow for the control needed to tease apart the mechanisms underlying behavior, they are also limited in several crucial ways. In particular, understanding cognition requires examining how it works in the real world — which can be messy, complex, and confusing. While cognition may be challenging to study in natural contexts, such data are crucial to fully understand the breadth and depth of nonhuman thought and how it contributes to real-world behavior. Situating cognition in the wild — the context in which it evolved — is therefore necessary to understand the function of these traits.

Given the value of studying cognition in the wild for addressing fundamental questions about how cognition works in the real world as well as its evolved function, why has it historically been rare compared with captive studies? This is perhaps easy to answer: studies of cognition in the wild can be extremely challenging to carry out [1–3]! Experimental manipulations, generally seen as a crucial technique to infer underlying cognitive mechanisms, are challenging in wild populations and have generally taken the backseat to observations of animals' natural behavior. Some methods commonly used in captive studies of animal cognition — such as testing individuals without interference from their group, introducing novel apparatuses, or providing food treats — are difficult to implement with many wild populations. Collecting field experimental data may also be arduously slow in terms of waiting for the appropriate spatial constellation of free-ranging individuals or the necessary social or ecological context to occur. Relevant behavioral contexts, such as encounters with predators, may occur only rarely, and thus care must be taken not to artificially elevate encounter rates, such that long periods in-between experiments may be needed. Finally, experimental manipulations may have complex ethical implications that must be considered, as they can impact the animals' behavior in unexpected ways.

Yet, despite the challenges for studying cognition in the wild, one of the main messages of this issue is that the study of wild cognition has emerged

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as a robust and dynamic field where scientists around the globe are tackling how animals think in natural contexts. Our special issue brings together research using diverse approaches to gain new leverage on cognition in the wild. Papers throughout the special issue focus especially on varieties of field experiments [4–23], including vocal playbacks to study the mechanisms underpinning call production or to simulate social interactions, foraging tests to assess navigational prowess and decision-making preferences, and interactive methods introducing novel objects or apparatuses to test tool use or cooperation. In many cases, this work is advanced by the applications of new technologies that facilitate novel forms of data collection, such as camera traps to study unhabituated animals, radio-frequency identification tags to identify individuals, biologging to measure aspects of the individual or their environment, and GPS to track movements [16,17,20,24]. These new approaches have allowed scientists access to the minds of animal populations that are difficult to study and rare in captivity, and provided insight into complex phenomena such as group social dynamics, predator-prey interactions, and large-scale migrations that are essential aspects of animals' lives but not particularly tractable in laboratory contexts.

Yet, field experiments are not the only path into animal minds. Other reviews in our issue explore how captive experiments and wild observations can complement, supplement, or refine field-based cognitive experiments. For example, studies of captive or semi-free-ranging animals allow for greater control and can inform experiments conducted in the wild, as well as assess cognitive skills that may be difficult to parse in natural environments [13,22,23,25–29]. Similarly, wild observations can provide the critical context to inform our understanding of when and how these skills are actually used across different socioecological environments [6,9,11,12,14,19,25,29–33]. Finally, several papers highlight the translational value of cross-talk between the lab and the field [15,22,23,28,29] —including bringing wild-caught individuals into controlled laboratory contexts and then releasing them back to the wild [5]. This kind of trans-methodological dialog has the potential to address big questions in comparative cognition using all the tools currently available in a more holistic fashion.

Across these different approaches to studying cognition in the wild, our issue reveals a great breadth of current work. One of the most important aspects of this breadth is the diversity of different animal species under study. For example, our issue includes papers that focus on a wide variety of animals, including primates [6,7,9,10,13,14,20,22,23,27,28,30–33], elephants [25], carnivores [18,22,29], rodents [12], birds [11,15,16,19,21,22,26,34], reptiles [17], and fish [5]. While some of these species are extremely well-studied from a cognitive perspective, especially primates and corvids, this increasing breadth of species highlights the value of a broad comparative approach to understanding animals with variation in their social systems, foraging niches, and life histories. Along these lines, several papers further tackle conceptual problems that span wide taxonomic groups [4,8,11,16,17] to gain traction on a particular cognitive problem.

The breadth of current research on cognition in the wild further extends to diversity in the cognitive phenomenon under investigation. Both traditional methods and technological advances in techniques have allowed for an explosion of work examining different domains of cognition, including vocal and gestural communication [6,9–11,14], theory of mind and social

knowledge [6,10,13,25,28,32], cooperation and prosociality [5,8,10,22,23,25,29,32], social and cultural learning [5,7–10,14,20,21,26,30,31,33], spatial memory and navigation [5,12,14–17,21,27], numerical cognition [17,25], tool use [7,19,30,33], foraging decisions [4,5,12,28,31,34], and flexible problem-solving [4,18,21,22,25,34]. This shows that the full span of research questions commonly addressed in laboratories has now been successfully tackled in more challenging field settings as well.

Work in our issue also reveals these new data have been harnessed to inform and expand our understanding of the evolution of complex cognitive and behavioral traits. This includes new theoretical frameworks for linking natural history, cognition, and behavior. For example, several papers highlight how important knowledge is, of not just an animal's cognition, but also of their socioecological niche and the behavioral consequences of cognition in natural contexts [6–9,11,12,14,17–19,26,27,30,32,33]. Work further explores the importance of cross-species comparisons assessing commonalities or differences across species to understand the functions of cognition [5,12,22,28,23]. Finally, within-species comparisons focused on ontogenetic experience and change [5,9,22,31], as well as individual variation and the processes of natural selection within a population [8,11,16,21], address the development and evolution of these cognitive traits.

Finally, our issue highlights the applications of cognitive data to pressing issues in conservation and human–animal conflict. This includes how studies of the cognition of endangered species may be harnessed to develop new conservation strategies [19,25,26] as well to inform interactions between humans and animals that may be viewed as a nuisance or even dangerous to human populations [4,18,25,34]. These scientific advances are allowing us access like never before to species that are rare or absent in captive contexts, including highly endangered species, and we hope this trend will continue. Once wild animal populations are lost, we will lose the ability to answer these important questions — and new insights into animal thought are often a key tool for motivating conservation of the natural world.

In conclusion, studying cognition in the wild is challenging, yet successfully tackling these challenges provides rich rewards for understanding the mechanisms supporting real-world behavior and the function of different cognitive skills. It is therefore vital that we continue to address these challenges and generate data that are crucial to a full understanding of animal thought processes. This issue highlights the remarkable progress in this field in recent years, spanning diverse taxa and domains of cognition. We look forward to the methodological and theoretical innovations that will grow from this progress, and will continue to offer new and exciting insights into animal cognition in the decades to come.

Conflict of interest

Nothing to declare.

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References

1. Morand-Ferron J, Cole EF, Quinn JL: **Studying the evolutionary ecology of cognition in the wild: a review of practical and conceptual challenges**. *Biol Rev* 2016, **91**:367-389.
2. Pritchard DJ, Hurly TA, Tello-Ramos MC, Healy SD: **Why study cognition in the wild (and how to test it)?** *J Exp Anal Behav* 2016, **105**:41-55.
3. Zuberbühler K: **Experimental field studies with non-human primates**. *Curr Opin Neurobiol* 2014, **28**:150-156.
4. Sarkar R, Bhadra A: **How do animals navigate the urban jungle? A review of cognition in urban-adapted animals**. *Curr Opin Behav Sci* 2022, **46**:101177.
5. Bshary R, Triki Z: **Fish ecology and cognition: insights from studies on wild and wild-caught teleost fishes**. *Curr Opin Behav Sci* 2022, **46**:101174.
6. Slocombe KE, Lahiff NJ, Wilke C, Townsend SW: **Chimpanzee vocal communication: what we know from the wild**. *Curr Opin Behav Sci* 2022, **46**:101171.
7. Falótico T: **Robust capuchin tool use cognition in the wild**. *Curr Opin Behav Sci* 2022, **46**:101170.
8. Thornton A, Truskanov N: **The role of natural history in animal cognition**. *Curr Opin Behav Sci* 2022, **46**:101154.
9. Zuberbühler K, León J, Deshpande A, Quintero F: **Socially scripted vocal learning in primates**. *Curr Opin Behav Sci* 2022, **46**:101153.
10. Benítez ME, Painter MC, Guisneuf N, Bergman TJ: **Answering big questions with small data: the use of field experiments in primate cognition**. *Curr Opin Behav Sci* 2022, **46**:101141.
11. Wyman MT, Walkenhorst B, Manser MB: **Selection levels on vocal individuality: strategic use or byproduct**. *Curr Opin Behav Sci* 2022, **46**:101140.
12. Robin AN, Jacobs LF: **The socioeconomics of food hoarding in wild squirrels**. *Curr Opin Behav Sci* 2022, **45**:101139.
13. Royka A, Santos LR: **Theory of mind in the wild**. *Curr Opin Behav Sci* 2022, **45**:101137.
14. Fichtel C: **Cognition in wild lemurs**. *Curr Opin Behav Sci* 2022, **45**:101135.
15. Healy SD, Sugasawa S, Tello-Ramos MC, Pritchard DJ: **Space, the original frontier**. *Curr Opin Behav Sci* 2022, **44**:101106.
16. Vámos TI, Shaw RC: **How does selection shape spatial memory in the wild?** *Curr Opin Behav Sci* 2022, **45**:101117.
17. Szabo B, Valencia-Aguilar A, Damas-Moreira I, Ringler E: **Wild cognition – linking form and function of cognitive abilities within a natural context**. *Curr Opin Behav Sci* 2022, **44**:101115.
18. Johnson-Ulrich L, Johnson-Ulrich Z, Holekamp KE: **Natural conditions and adaptive functions of problem-solving in the Carnivora**. *Curr Opin Behav Sci* 2022, **44**:101111.
19. Mioduszewska B, Auersperg AM, O'Hara M: **Treasure islands: foraging ecology and the emergence of tool use in wild Goffin's cockatoos**. *Curr Opin Behav Sci* 2022, **45**:101118.
20. Harrison RA, van de Waal E: **The unique potential of field research to understand primate social learning and cognition**. *Curr Opin Behav Sci* 2022, **45**:101132.

21. Pravosudov VV: **Cognitive ecology in the wild — advances and challenges in avian cognition research**. *Curr Opin Behav Sci* 2022, **45**:101138.

22. Horn L, Cimarelli G, Boucherie PH, Šlipogor V, Bugnyar T: **Beyond the dichotomy between field and lab — the importance of studying cognition in context**. *Curr Opin Behav Sci* 2022, **46**:101172.

23. Brooks J, Yamamoto S: **The evolution of group-mindedness: comparative research on top-down and bottom-up group cooperation in bonobos and chimpanzees**. *Curr Opin Behav Sci* 2022,.

24. Griebling HJ, Sluka CM, Stanton LA, Barrett LP, Bastos JB, Benson-Amram S: **How technology can advance the study of animal cognition in the wild**. *Curr Opin Behav Sci* 2022, **45**:101120.

25. Plotnik JM, Jacobson SL: **A "thinking animal" in conflict: studying wild elephant cognition in the shadow of anthropogenic change**. *Curr Opin Behav Sci* 2022, **46**:101148.

26. Bastos APM, Nelson XJ, Taylor AH: **From the lab to the wild: how can captive studies aid the conservation of kea (Nestor notabilis)?** *Curr Opin Behav Sci* 2022, **45**:101131.

27. Poindexter SA: **Strepsirrhine movement and navigation: sense and sociality**. *Curr Opin Behav Sci* 2022, **45**:101133.

28. De Petrillo F, Bettle R, Rosati AG: **Insights from matched species comparisons for understanding cognition in the wild**. *Curr Opin Behav Sci* 2022, **45**:101134.

29. Berghänel A, Lazzaroni M, Cimarelli G, Marshall-Pescini S, Range F: **Cooperation and cognition in wild canids**. *Curr Opin Behav Sci* 2022, **46**:101173.

30. Lonsdorf EV, Sanz CM: **Behavioral and cognitive perspectives on the evolution of tool use from wild chimpanzees**. *Curr Opin Behav Sci* 2022, **46**:101144.

31. Carvajal L, Schuppli C: **Learning and skill development in wild primates: toward a better understanding of cognitive evolution**. *Curr Opin Behav Sci* 2022, **46**:101155.

32. Gilby IC, Machanda ZP: **Advanced cognition in wild chimpanzees: lessons from observational studies**. *Curr Opin Behav Sci* 2022, **46**:101183.

33. Pal A, Sinha A: **Beyond food for thought: tool use and manufacture by wild nonhuman primates in non-foraging contexts**. *Curr Opin Behav Sci* 2022,.

34. Griffin AS, Peneaux C, Machovsky-Capuska GE, Guez D: **How alien species use cognition to discover, handle, taste, and adopt novel foods**. *Curr Opin Behav Sci* 2022, **45**:101136.