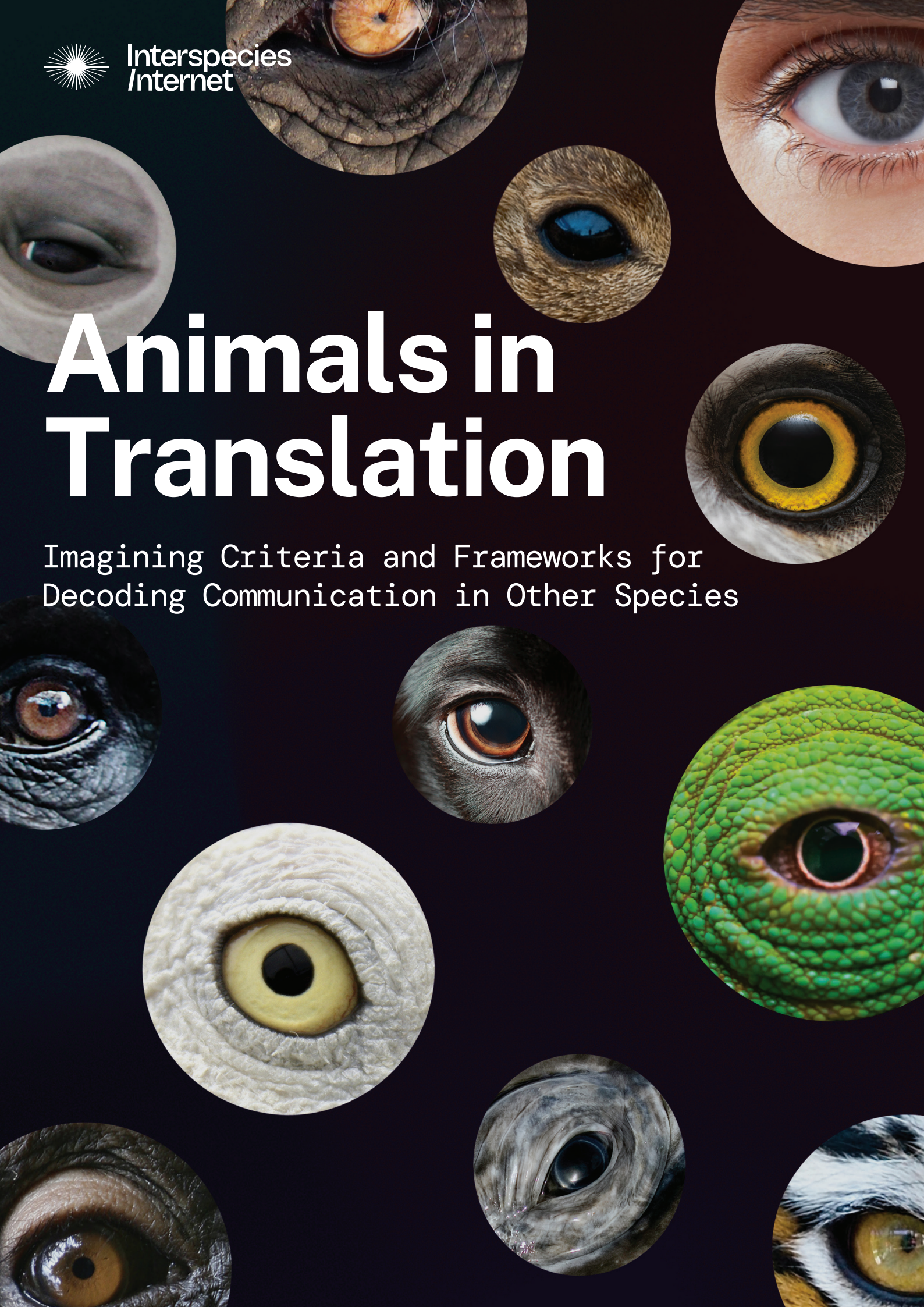
Interspecies Internet

Animals in Translation

Imagining Criteria and Frameworks for Decoding Communication in Other Species



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Interspecies Internet (IIO) is a 501(c)(3) charity and a multidisciplinary forum to advance interspecies communication towards conservation and understanding.

Biodiversity and Conservation Team is part of the XPRIZE Foundation's nonprofit work that is solving some of the world's greatest challenges for the last 25+ years.

Santa Fe Institute (SFI) is an independent, 501(c)(3) nonprofit research and education center that leads global research in complexity science.

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Deciphering the natural communication systems of non-human animals—how they work and how they function—continues to challenge the scientific community and was the focus of a two-day 'Animals in Translation Workshop' held by Interspecies Internet in late April 2024. Co-hosted by the Santa Fe Institute, and with interest from the XPRIZE Biodiversity and Conservation team, the workshop brought together 40 thought-leaders in the fields of animal communication, animal behavior and cognition, linguistics, mathematics, and technology.

The seed for this event was planted in September 2023, when Interspecies Internet trustee Diana Reiss was approached by the XPRIZE Foundation to consult on designing a contest to decode animal communication. When asked how a prize competition could be sure that animal communication had been achieved, Reiss replied "Don't ask me, ask the Interspecies Internet community." So we did, and these workshop proceedings are the outcome, marking an unprecedented advance for the study of intraspecies and interspecies communication - a collective effort to develop a set of criteria that would indicate the successful decoding of another animal's communication system. Reflecting a surge of interest in leveraging AI and other technologies towards this pursuit, the lively workshop touched upon both the rich history of animal communication studies and the current complexity of the field as it stands at the intersection of science, technology and ethics. This publication aims to collect the richness of these interdisciplinary discussions as well as the synthesis from the working groups that followed. It stands as a state-of-the-art for the field, highlighting a crucial insight that drives our curiosity towards decoding: *while a variety of nonhuman species have demonstrated the ability to learn elements of human languages, humans have yet to demonstrate the capacity to learn theirs.*

In this opening video, Interspecies Internet trustees Neil Gershenfeld, Vint Cerf, Peter Gabriel and Diana Reiss, along with Executive Director Kate Armstrong and President of the Santa Fe Institute David Krakauer, provide introductory remarks on the 2024 Workshop: Animals in Translation - Imagining Criteria and Frameworks for Decoding Communication in Other Species. Workshop participants are introduced to the purpose and expectations of the workshop, a 2-day event co-hosted by Interspecies Internet, the Santa Fe Institute, and XPRIZE Foundation geared towards establishing a framework for guiding future research in the field of interspecies communication.

(02) Introduction

Photo taken by Nick Brice

Introduction

Interspecies Communication: Bridging the Communication Gap

The field of interspecies communication emerged from our curiosity and interest in the mental and communicative capabilities of other species. A significant reason for teaching artificial codes to species like apes, African grey parrots, and dolphins stems from our inability to "crack" their natural communication systems. Non-human species have complex natural communication systems, and while we've made progress in deciphering some of them, many other species may encode highly complex, multi-layered information influenced by entirely different evolutionary and ecological pressures. Teaching other species artificial codes allows researchers to establish a shared "language" and provide a structured way to test hypotheses about cognition and communication, including the use of symbols to represent objects, actions, or ideas. For example, by teaching apes to use lexigrams or sign language, researchers can begin to evaluate their ability to understand syntax, abstract symbols, concepts like "past" and "future", and the use of symbols to represent objects, actions, or ideas. Early studies with chimpanzees and bonobos have shown us that some primates can learn to communicate with humans through sign language, keyboards, and symbolic lexigrams. Avian communication experiments suggested that some birds don't just mimic words or repeat sounds, but can actually reason, evidenced through the use of two-way communication codes and expansive vocabulary. Similar studies with bottlenose dolphins have revealed their capacity to learn to comprehend human produced gestural sentences and spontaneously imitate and produce facsimiles of novel synthesized whistles and use them in behaviorally appropriate contexts.

Standing on the shoulders of this ground-breaking, long-term interspecies research tradition, we are poised to consider whether we are ready and able to learn, or at best understand, the diverse communication systems of other species.

Origins of the Interspecies Internet

In 2013, a burgeoning collaboration between luminaries Peter Gabriel, Diana Reiss, Neil Gershenfeld and Vint Cerf culminated in the TED Talk "An Interspecies Internet? An Idea In Progress." With their presentation, this dynamic foursome ignited the interest of thousands with a simple provocation: could the internet be expanded to include non-human animal species? Is it possible to create technological interfaces into the minds of intelligent, sentient, nonhuman beings, and how might the development of existing technological infrastructure enable such a vision? With these questions in mind, the Interspecies Internet set out to foster a transdisciplinary forum to advance research into and understanding of both interspecies and intraspecies communication.

"Is it possible to create technological interfaces into the minds of intelligent, sentient, nonhuman beings?"

The proposition of an interspecies internet seems like one lifted from the pages of a science fiction novel. Yet it is rooted in a rich history of real world scientific inquiry spanning animal communication, bioacoustics, behavioral ecology, animal cognition, conservation, neurobiology, philosophy and more recently, artificial intelligence and machine learning. While the internet was initially designed as a system to connect computers together, its use for connecting humans was quickly discovered. This shift in framing unlocked profound and unforeseen potential and enabled its development and proliferation in recent decades. The vision of an interspecies internet augments and broadens this potential and envisions the evolution of a shared interactive and sensory environment for planetary connectivity—opening new windows into the minds of animals and encouraging our commitment to valuing and conserving life's biodiversity and its manifold domains of cognition.

Since this initial TedTalk, the organization Interspecies Internet has grown into an international think-tank, gathering a multidisciplinary forum of experts and enthusiasts from the sciences, arts and humanities to advance the understanding and appreciation of the intelligence and inner life of the diverse species with which we share our planet. In the years since its inception, the organization has worked to further this mission through a variety of ongoing events, workshops, collaborations, and other projects.

"The proposition of an interspecies internet seems like one lifted from the pages of a science fiction novel"

In July 2019, the proposal of an interspecies internet drove a productive workshop held at MIT, co-hosted by Google, the Jeremy Coller Foundation, and MIT's own Center for Bits and Atoms. The invitation-only event was the first formal workshop of its kind, focusing on interdisciplinary discussion for developing the Interspecies Internet initiative. With full capacity attendance, the workshop convened a wide range of leading professionals in ethology, machine learning, cognitive science, robotics and more, to discuss pursuing new forms of interspecies communication

using the internet and other forms of technologically-mediated interactivity. Central to this workshop was the notion that efforts to enrich and extend our interactions with conspecifics could also expand our awareness and understanding of the communicative and cognitive abilities of other animals and positively impact species conservation and welfare.

"Efforts to enrich and extend our interactions with conspecifics could expand our awareness and understanding of the communicative and cognitive abilities of other animals and positively impact species conservation and welfare"

In 2020, the COVID-19 pandemic prevented another in-person event. But with great success, the gathering pivoted to a virtual Interspecies Conversations Digital Workshop and Public Conference. Once more, attendance was high and interest was growing. A live broadcast on Saturday, July 18th reached audiences from multiple continents and brought together hundreds of participants from the fields of animal cognition and communication, neuroscience, anthropology, AI and computer sciences, philosophy, art, and music to engage in vibrant collaboration through a scientific workshop and public conference.

In 2021 a third event took place online with continued support from Google, the Jeremy Coller Foundation, and the MIT Center for Bits and Atoms. In keeping with prior events, contributors shared and debated research, ideas, and approaches to deciphering interspecies communication during both a private workshop and a public conference. This event featured representatives from other key organizations including Project CETI, Ocean Alliance, and the Internet Archive, as well as a special keynote address from renowned biologist, environmentalist, and pioneer in whale communication, Dr. Roger Payne.

The collective audiences for these annual meetings, convened under the banner of Interspecies Internet, now comprise a network of hundreds of researchers, technologists, innovators, and philanthropists affiliated with the mission of accelerating the study of nonhuman animal communication, cognition, behavior, and welfare. To further expand its impact, Interspecies Internet now runs a series of ongoing initiatives including a monthly lectures series featuring leading researchers, a regular newsletter to 2393 recipients and an open Slack channel currently hosting over 600 members contributing to discourse surrounding animal communication and cognition, ethics, AI, and more.

Intraspecies and Interspecies Communication

Communication is ubiquitous in the living world. It was once thought that animal communication was nothing more than mere emotive signaling. An abundance of well-documented scientific evidence now shows that animals engage in complex forms of communication in a variety of dynamic social contexts. Such studies form a rich and varied history of research in the field and form the backdrop of current efforts to translate and communicate with nonhuman animals.

"Communication is ubiquitous in the living world"

Beginning in the early 1900s, Austrian ethologist Karl von Frisch shared his groundbreaking discovery of the first evidence of symbolic communication in a non-human animal, the waggle dance of bees—a series of movements used to communicate information about the direction and distance of nectar sources. [1] His studies resulted in a Nobel Prize and opened Western science to the sophisticated communication system of these insects, providing valuable insights into animal navigation, sensory perception, and social organization. [2]

Von Frisch's work represented a milestone in humanity's understanding of nonhuman animal communication: he had effectively documented a symbolic communication system in another species, translating patterns of spatial movement to gain insight into how meaning is conveyed in a biological context wholly alien from our own. Interpreting the dances of bees captured the attention of many other curious minds who could now see a commonality between the behavior of insects and humans, opening the potential to pursue a greater understanding of animal communication and the possibility of interspecies communication.

"Scientists argued for an evolutionary continuity of consciousness"

Along with von Frisch, scientists such as Donald Griffin, considered the father of cognitive ethology, argued, much like Charles Darwin had done previously, for an evolutionary continuity of consciousness in the living world [3] and scientists began to make inroads in our understanding of the cognitive capacities of animals, gradually building legitimacy around this inquiry within the scientific community.

Over the last 50 years, a variety of approaches have been employed to explore and understand the communication systems and cognitive communicative abilities of other species. The vast majority of these have focused on intraspecific communication, the ways individuals within a species communicate with each other. Through years of living among chimpanzees in Tanzania, Jane Goodall explored their personalities and behaviours, profoundly altering our conception of primates. [4] Roger Payne and his colleagues brought to light the hauntingly beautiful songs

and complex sonic arrangements sung by male humpback whales during breeding season, and Ian Douglas-Hamilton pioneered the first in-depth scientific studies of elephant social behaviour. [5] Joyce Poole and Katy Payne discovered the use of infrasonic calls by elephants to communicate over long-range distances, and Frans De Waal revolutionized research on primate social behaviour, cognition and emotion. [6] Notably, many of the scientists conducting this research have also been engaged in environmental protection and animal welfare and conservation. This area of the field is vast and diverse and unfortunately a comprehensive review of its full breadth, and the multitude of scientists working within it, lies beyond the scope of this document.

It's been a challenge to understand and decode natural forms of animal communication, that is, how conspecifics use signals among themselves. Scientists have learned about the functions of many individual signals but have failed to grasp the nature of a species' entire communication system. To gain further insights, a more current approach to this challenge has included studies focused on interspecies communication—communication between species which includes approaches that use human designed artificial codes to study the communicative and cognitive capacities of other species. Early interspecies research employed human-devised artificial codes, such as forms of sign language and lexigrams with ape species, human speech with African grey parrots, and gestural sentences and underwater keyboards with dolphins. These studies produced compelling evidence that nonhuman species possess the cognitive underpinnings to support abstract, referential or symbolic forms of communication. Among these, groundbreaking work conducted by Allen and Beatrix Gardner, Roger and Deborah Fouts, David Premack, Duane and Sue Savage-Rumbaugh, Penny Patterson, Sarah (Sally) Boysen, Lyn Miles, and Lou Herman made significant contributions to the field of interspecies communication and comparative psychology.

"Nonhuman species possess the cognitive underpinnings to support abstract, referential or symbolic forms of communication"

The Gardners and the Fouts conducted seminal research demonstrating the capacity for chimpanzees to learn and use a form of sign language referentially, while Premack's work established this species' ability to parse complex sentences. [7] Patterson pushed the boundaries of animal-human communication by teaching Koko the gorilla to communicate through a modified American Sign Language. [8] Miles undertook longitudinal research teaching orangutans sign language, investigating the cognitive aspects of learning and the evolution of human symbol systems. [9] Boysen advanced the understanding of animal cognitive development and numerical competence by investigating chimpanzees' abilities for symbolic representation and counting, reading, naming objects, and forming abstract concepts. [10] Herman's vast contributions to the field of animal cognition included work on language comprehension, [11] providing evidence that dolphins could comprehend human-generated gestural sentences in a manner similar to the capabilities of bonobos shown in work by Savage-Rumbaugh et al. [12]


Photo taken by Denure Storyteller

Some of these scientists, including Duane and Sue Savage-Rumbaugh, Irene Pepperberg, and Diana Reiss, employed technological interfaces to enhance their studies. Rumbaugh pioneered the use of computerized tests to train chimpanzees to communicate using keyboards and lexigrams, demonstrating language learning and their ability to sequence words grammatically and make novel utterances. [13] Savage-Rumbaugh used technology extensively in her research on language acquisition and cognition in non-human primates—developing an artificial communication system using lexigrams and working with bonobos to build referential associations between symbols and specific shared meanings. [14] Pepperberg showed the communicative and cognitive prowess of African Grey parrots and their impressive ability for referential learning, including labelling and requesting objects, identifying features (e.g. color, size, material) and exhibiting numerical competence—challenging the belief that only humans possess advanced cognitive skills. [15] Through the development of an interactive audiovisual keyboard that gave dolphins choice and control over objects and activities, Reiss conducted innovative research showing that cetaceans possessed a proclivity for vocal learning and associating visual forms, novel whistles, and specific objects and activities. [16]

"Developments in artificial intelligence and machine learning during the last decade seem poised to yield radical new findings in the field"

Developments in artificial intelligence and machine learning during the last decade seem poised to yield radical new findings in the field and researchers have begun integrating these tools into their work. [17] These technologies hold the promise of innovating animal communication studies with their ability to collect and process massive volumes of bioacoustics data and extract nuanced variation in a range of complex, often multimodal signaling that human researchers are sometimes unable to detect or synthesize on their own. These technologies may also possess the potential to detect the basic units and higher-level structures of animal vocal communication systems and avoid the anthropocentric bias that can shape data collection and interpretation.

Defining Research Standards

Advances in the field could unlock new perspectives of the rich inner lives of animals, shedding light on their social, cognitive, and communicational complexity. And groundbreaking insights into the full spectrum of animal life may also inspire a shift in the way we perceive, empathize, and treat other species and embolden a broader cultural commitment to valuing and conserving the biodiversity of life. Yet in spite of these advances, challenges remain. One of the most pressing obstacles is a lack of consensus within the field about what might constitute the successful decoding of another animal's communication system. Despite a rich legacy of the study of animal signaling and behavior, a recent surge of interest in applying machine learning techniques to the study of animal communication, and growing amounts of data and findings in the field, researchers still lack a rigorous and shared framework for determining whether one has conclusively translated nonhuman communication. [18] Furthermore, as more attention and resources are directed into this area and developments continue to accelerate, other deeper ethical questions arise related to how this research might shape our perception of and interactions with nonhuman species, their behaviors, and the ecosystems they inhabit. [19] With the field seemingly on the brink of unparalleled breakthroughs in decoding animal communication, it is a critical time for these important discussions.

"Groundbreaking insights into the full spectrum of animal life may also inspire a shift in the way we perceive, empathize, and treat other species and embolden a broader cultural commitment to valuing and conserving the biodiversity of life"

The Santa Fe Institute and the Animals in Translation Workshop

This brings us to the present moment and the most recent point in Interspecies Internet's trajectory: a pioneering workshop, in partnership with the Santa Fe Institute [SFI] and with interest from the XPRIZE Foundation, to establish criteria that would indicate the successful decoding of another animal's communication system.

In light of questions surrounding the identification of criteria for defining the translation of animal communication systems, as well as related inquiries into research goals, methodology, ethical guidelines and frameworks, a collaborative workshop was held in April 2024 at the Santa Fe Institute. The workshop, titled Animals in Translation: Imagining Frameworks for Decoding Communication in Other Species, was jointly organized by Interspecies Internet and the Santa Fe Institute, with interest from the XPRIZE's Biodiversity and Conservation team. The Santa Fe Institute is renowned globally for its innovative approach to studying complex systems, including in the field of animal communication. Their recent efforts to explore the mechanisms of how complex systems extract meaning from the world, with a focus on the relevance of human-like understanding for AI systems, set the tone for our discussions, adding valuable insights and new perspectives.

The event convened experts from a wide array of disciplines, including animal communication, AI, ethology, comparative psychology, linguistics, philosophy, exobiology, and mathematics to deliver talks, discuss findings, exchange views on the future of animal communication research, and co-create robust yet flexible criteria that would constitute evidence for the successful decoding of communication systems of another species. In the following chapters, we outline the structure, proceedings, and outcomes of this workshop.

Photo taken by Ambitious Studio* | Rick Barrett

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(03) Animals in Translation Workshop

(April 28-30, 2024)

Photo taken by Hari Nandakumar

Methodology and Framing

Over the course of two days in late April, 40 researchers, scientists and other innovative thinkers gathered at SFI in an environment conducive to the open exchange of collaborative, dynamic discussion aimed at developing criteria for translating animal communication. It is our hope that bringing together brilliant minds from diverse fields to guide the focus of future research will pave the way for a new era of interspecies communication.

Through a series of breakout sessions and curated prompts, the workshop framework utilized a modified Delphi method to document and synthesize outcomes from small group discussions, and then anonymously rank outcomes through a post-workshop online survey based on their relevance to the goal of the workshop: to identify criteria that would serve as evidence of having decoded or translated another species' natural communication system. This framework facilitated the development of preliminary criteria or benchmarks that could be used for evaluating whether a nonhuman animal species' natural communication system has been decoded.

Photo taken by Katie Mast, SFI

Day One: Sharing Knowledge

Objective

Inspire and spark conversations through presentations and open discussions.

Structures

- Nine researchers presented their latest findings.
- 15-minute presentations + 5-minute Q&A.
- The content focused on intraspecies communication in apes, wolves, bats, humans (whistle languages), prairie dogs, and whales.
- A general discussion led by Diana Reiss set the tone for the next day's activities.

Photo taken by Katie Mast, SFI

Day Two: Deconstructing Assumptions and Imagining Criteria to Decode

Objective

Develop priority statements for the "Criteria to Decode" by fostering a highly collaborative and open environment.

Structures

- Three sessions, each addressing different topics, culminating in "Criteria to Decode."
- Four groups per session, with rotating members, including an online group.
- Groups presented their conclusions at the end of each session (Share-outs).
- Each session was 75 minutes long.
- Plenary discussions prioritized and summarized the group's focal statements.
- A post-workshop survey was emailed to participants to anonymously rank synthesis statements relative to the workshop goal.

Workshop Participants

Brenda McCowan

Professor of Ethology and the Director of the McCowan-Vandeleest Laboratory of Biobehavioral Complexity at the University of California

McCowan's research centers on animal behavior and communication, aiming to enhance human and animal well-being. Her work focuses on complex systems at the human-animal interface, including cognitive systems, wildlife disruption, social networks, and epidemiology and she is passionate about applying machine learning to decode animal communication, particularly in dolphins and whales.

C. Brandon Ogbunu

Assistant Professor in the Department of Ecology and Evolutionary Biology at Yale University

Ogbunu is a computational biologist whose research investigates complex problems in epidemiology, evolutionary and population genetics, and evolution. His work utilizes a range of methods, from experimental evolution, to biochemistry, applied mathematics, and evolutionary computation.

Carrie Figdor

Professor in the Departments of Philosophy and Psychological and Brain Sciences at the University of Iowa & visiting academic at the University of Edinburgh

Figdor works on theoretical and philosophical issues in comparative psychology and cognitive science, focusing on the phylogeny of cognition. She is the author of Pieces of Mind (Oxford University Press, 2018), has published extensively in leading journals, and is the principal investigator on a Templeton World Charity Foundation grant studying referential signals in bonobos and dolphins.

Catherine Hobaiter

Wild Minds Lab & Reader at the University of St Andrews

Hobaiter has spent the past 20-years living with and studying primates across Africa. Her work on gestural communication in wild apes aims to understand the evolutionary origins of language. Hobaiter explores what the communication of wild apes living in their natural environment tells us about how they think and the origins of our own behavior. She leads ape field sites in Uganda and Guinea and serves on expert groups for the UN and IUCN.

Chris Kempes

Professor & Science Steering Committee at SFI

Kempes is a scientist using mathematical and computational techniques to explore phenomena ranging from major evolutionary life-history transitions to the biogeography of plant traits and the organization of bacterial communities, with a particular focus on biological architecture as an intermediate between physiology and the environment.

Con Slobodchikoff

Professor Emeritus, Biology Department, Northern Arizona University

Slobodchikoff is the founder of Zoolingua, a company that is using artificial intelligence technology to decode animal communication. His research involves the study of animal languages and communication. His book on animal languages, Chasing Doctor Dolittle: Learning the Language of Animals (St. Martin's Press, 2012) explores the issues of animal languages.

Cris Moore

Professor & Science Board at SFI

Moore is a professor at the Santa Fe Institute with expertise in physics, mathematics, and computer science. He has authored 160 interdisciplinary papers, co-authored the book The Nature of Computation (Oxford University Press, 2011), and is a Fellow of the American Physical Society, the American Mathematical Society, and the AAAS.

David Gruber

Founder and Project Lead at CETI

Gruber is an interdisciplinary researcher bridging animal communication, climate science, marine biology, microbiology, and molecular biology. He is the founder and president of CETI, a nonprofit, interdisciplinary scientific and conservation initiative on a mission to listen to and translate the communication of sperm whales. His inventions include technology to perceive the underwater world ("shark-eye camera") from the perspective of marine animals.

David Krakauer

President + William H. Miller Professor of Complex Systems at SFI

Krakauer's research explores the evolution of intelligence and stupidity on Earth by studying the evolution of genetic, neural, linguistic, social, and cultural mechanisms supporting memory and information processing, and exploring their shared properties. He is a graduate of the University of London, where he went on to earn degrees in biology and computer science, receiving his D.Phil. in evolutionary theory from Oxford University in 1995.

David Wolpert

Professor at SFI

Wolpert holds positions at SFI, Complexity Science Hub Vienna, ASU, and ICTP in Trieste. An IEEE Fellow, he has authored three books, over 200 papers, and holds three patents. His research combines nonequilibrium statistical physics with computer science, and he developed the stacking technique in machine learning.

Diana Reiss

Professor of Cognitive Psychology in the Department of Psychology at Hunter College (CUNY) and IIO Trustee

Reiss is a marine mammal scientist and cognitive psychologist who studies the cognitive and communicative capacities of dolphins in zoological and wild environments. She pioneered the use of an interactive underwater keyboard system with dolphins and she and her colleagues demonstrated the capacity for mirror self-recognition in bottlenose dolphins and Asian elephants.

Fred Sharpe

Co-investigator with the Whale-SETI Study Team

Sharpe has been studying the social ecology of humpback whales in SE Alaska since 1987. He is a co-investigator with the Whale-SETI Study Team, using an astrobiological framework to explore whale communication as an analog for extraterrestrial intelligence, involving call classification, dynamic playbacks, and responses to whales' volitional signals.

Gašper Beguš

Assistant Professor at UC Berkeley; Linguistics Lead at Project CETI; Member of Berkeley's Institute of Cognitive and Brain Sciences

Beguš' research focuses on understanding biological and artificial intelligence by developing realistic deep learning models of human language. He combines machine learning and statistical models with neuroimaging and behavioral experiments to better understand how deep neural networks learn internal representations and how humans learn to speak.

George Vengrovski

Computational Neuroscience PhD student under the guidance of Dr. Tim Gardner

Vengrovski is a computational neuroscience PhD student at the University of Oregon whose work has culminated in the development of TweetyBERT, a neural network enabling unsupervised classification of birdsong units. He aims to expand AI models to diverse animal species and integrate multi-modal communication analysis for research and conservation.

Gerry Ohrstrom

SFI Trustee; Chairman of Vistan Corporation; Director at Nanotronics Imaging

Ohrstrom, a private investor in New York City, has an extensive background in finance, private equity, and corporate governance. He has been involved in various family-owned companies and foundations, as well as nonprofit organizations focusing on scientific research, education, and public policy.

Grace McNally

Documentary Filmmaker

Grace McNally is a New York City based freelance documentary filmmaker. She has contributed to content that has appeared on National Geographic, PBS, Discovery Channel, History Channel, Comedy Central, HBO and Netflix in addition to producing her own independent projects.

Irene Pepperberg

Adjunct Research Professor at Boston University in Boston, Massachusetts

Pepperberg investigates avian cognition, focusing on the cognitive and communicative abilities of gray parrots. She was the first to establish two-way referential communication with parrots and has published over 170 works, including the books The Alex Studies (Harvard University Press, 2002) and Alex & Me (Harper Perennial, 2009).

Isabel Behncke

Primatologist at Oxford University

Behncke is a field ethologist who studies animal behavior to understand other animals, as well as to understand humans and our place in nature. Originally from Chile, she is a primatologist, a pioneer adventurer-scientist and the first South American to follow great apes in the wild.

Jeff Reed

Lead engineer of Yellowstone's Cry Wolf bioacoustics project

Reed is the lead engineer of Yellowstone National Park's Cry Wolf bioacoustics project, a long-term study of wolf communication. With a PhD in computational linguistics and a 30-year career in industrial software, he develops sensor technology to understand animal behavior, particularly carnivores.

Judith Donath

Faculty fellow at Harvard's Berkman Klein Center | Harvard University

Writer, designer, and artist focused on the co-evolution of technology and society. Author of "The Social Machine" (MIT Press, 2014) Donath has published extensively on social media, AI, ethics, and anonymity. As the former director of MIT Media Lab's Sociable Media Group, she designed innovative online community interfaces.

Julien Meyer

Researcher at the French National Center of Scientific Research (CNRS/Gipsa-Lab/Université Grenoble Alpes)

Meyer specializes in ancient telecommunication systems transforming speech and musical surrogacy of human languages. His inquiries into whistled, drummed and other instrumental forms of languages are based on first hand fieldwork documentation and experimental study in 15 different populations around the world.

Kevin Marriott

Technical Lead, Rainforest XPRIZE

Marriott, a military veteran, wildlife biologist and telecommunications engineer, co-founded the Forgotten Parks Foundation before joining XPRIZE. He has extensive experience in wildlife conservation, technical capabilities development, and working with leading-edge technologies.

Laurance Doyle

Lead at the Whale-SETI Group

Since 1987, Doyle has been a Principal Investigator with the SETI Institute in Mountain View, California where his main projects have been the photometric detection of extrasolar planets, and the application of information theory to animal communication. His current work with the Whale-SETI Group involves developing "intelligence" filters based upon information theory applied to quantify the complexity of humpback whale vocalizations, which may be applied to broadening the search for extraterrestrial intelligence.

Leo Trottier

Founder & CEO of FluentPet

Trottier is a blend of cognitive scientist and entrepreneur. His company combines community and scientific collaboration with carefully designed communication tools to help humanity realize the potential of the animals with whom we share this planet. He started CleverPet as a PhD candidate at UC San Diego.

Mark Graham

Director of the Wayback Machine at Internet Archive

An internet pioneer with extensive experience in technology and business leadership, currently leading initiatives to archive the public web and global TV news. Graham also directs projects in AI and various endeavors related to Wikipedia.

Mirjam Knörnschild

Professor of Evolutionary Ethology at the Humboldt University Berlin

Knörnschild studies vocal communication, social behavior and cognition in free-living bats using an integrative approach that combines classic field observations with acoustic, genomic and neurogenetic analyses. She is passionately curious about animal culture, vocal learning, and complex social interactions in the wild.

Neil Gershenfeld

Director, The Center for Bits + Atoms at MIT and IIO Trustee

Gershenfeld's lab breaks down boundaries between the digital and physical worlds, from pioneering quantum computing to digital fabrication to the Internet of Things. A pioneer and founder of the global Fab Labs network, he is the recipient of several awards including membership in the National Academy of Engineering and the Irwin Sizer Award.

Pedro Marquez-Zacarias

Complexity Postdoctoral Fellow at SFI

Marquez-Zacarias is a Purépecha biologist from Mexico whose research focuses on biological complexity, the evolution of language, science communication, and the inclusion of marginalized people in science.

Peter Gabriel

Musician, Humanitarian Activist and IIO Trustee

A visionary musician who transcends boundaries through music, activism, and innovation. Gabriel has won six Grammy Awards, thirteen MTV Video Music Awards, and the prestigious Polar Music Prize. Co-Founder of the WOMAD Festival. Since 1982, has entertained over one million people by celebrating the world's many forms of music, arts and dance. As a musician one of his most transformative experiences was playing music with apes.

Peter Houlihan

EVP, Biodiversity & Conservation XPRIZE

Houlihan is a tropical ecologist and conservation scientist leading over 50 expeditions in rainforests globally. His work has established protected areas and discovered new species. He combines conservation science with media, featuring on platforms like BBC and National Geographic.

Ramon Ferrer-i-Cancho

Professor and researcher at Universitat Politècnica de Catalunya

Ferrer-i-Cancho studies human language, animal communication, and other biological systems, focusing on statistical patterns, particularly "linguistic laws." His research aims to develop a parsimonious yet predictive mathematical theory of language and communication. He pioneered the statistical study of syntactic dependencies, introducing baselines and the principle of dependency distance minimization.

Sara Keen

Senior Research Scientist at Earth Species Project (ESP)

With a background in behavioral ecology and electrical engineering, Keen specializes in acoustics, machine learning, animal communication, and soundscape ecology. Her work advances research and conservation, often collaborating with artists to create biologically inspired works and interactive sound installations.

Stuart Firestien

Chair of the Department of Biological Sciences at Columbia University

Firestien investigates the olfactory system to understand signaling and perception in the brain. He is dedicated to making science accessible to the public and has received prestigious awards for his work. Firestein has authored books on the workings of science and its successes, which have been translated into multiple languages.

Sue Savage-Rumbaugh

Formerly based at Georgia State University's Language Research Center in Atlanta, and the Iowa Primate Learning Sanctuary in Des Moines

Savage- Rumbaugh is a psychologist and primatologist most known for her work with two bonobos, Kanzi and Panbanisha, investigating their linguistic and cognitive abilities using lexigrams and computer-based keyboards.

Ted Chiang

American fiction writer; Miller Scholar in the Santa Fe Institute

Award-winning science fiction writer has written numerous acclaimed works such as "Story of Your Life", which was the basis for the film Arrival. Chiang's unique storytelling style and exploration of philosophical questions have garnered him worldwide recognition.

Terry Mulligan

Ex-Director, Advancement XPRIZE

Mulligan is dedicated to ending global poverty, with initiatives in education, global health, and social enterprise in Africa and South America. His achievements include scaling a top-rated hotel, co-founding a school in Tanzania, and managing international development organizations.

Vinton G. Cerf

Vice President and Chief Internet Evangelist at Google and IIO Trustee

Cerf is the co-creator of the Transmission Control Protocol and Internet Protocol (TCP/IP), playing a pivotal role in developing the technology that established the foundations of the Internet as we know it today. Widely regarded as one of the "fathers of the Internet," Cerf's numerous prestigious honors include the U.S. Presidential Medal of Freedom, the U.S. National Medal of Technology, and the ACM Turing Award.

Yossi Yovel

Member of the School of Zoology; Head of the Sagol School of Neuroscience at Tel Aviv University

Yovel studies animal behavior, focusing on navigation, sensing, and communication, blending biology with technology such as GPS sensors for tracking small animals. His pioneering work on bats' bio-sonar navigation in the field, coupled with MRI studies of bats' brains in the lab, has led to the establishment of Neuro-Ecology, integrating Neuroscience and Ecology.

Presenter Abstracts and Talks

Universal Language Games

David Krakauer

President and William H. Miller Professor of Complex Systems at SFI

In order to understand a language we need to know its rules -- either tacitly or explicitly. Wittgenstein's *Philosophical Investigations* asks how we might learn a new language's rules without fully understanding the different "Form of Life" in which it exists and that it supports. The problem consists in knowing how to map an objective signal onto a subjective concept, and what function this paired signal-concept enables or encodes. John Nash invented non-cooperative game theory to explore how coordination in communication might come about, and how this coordination seems to depend on shared strategic categories and imperatives. I consider the possibility of a Universal Language Game (ULG), that combines the Wittgenstein and Nash frameworks with an evolutionary logic to explore how meaning between divergent agents might come to be shared. The objective of inter-specific mutual comprehension is a search for rules of translation that transcend the *umwelt* of distinct species.

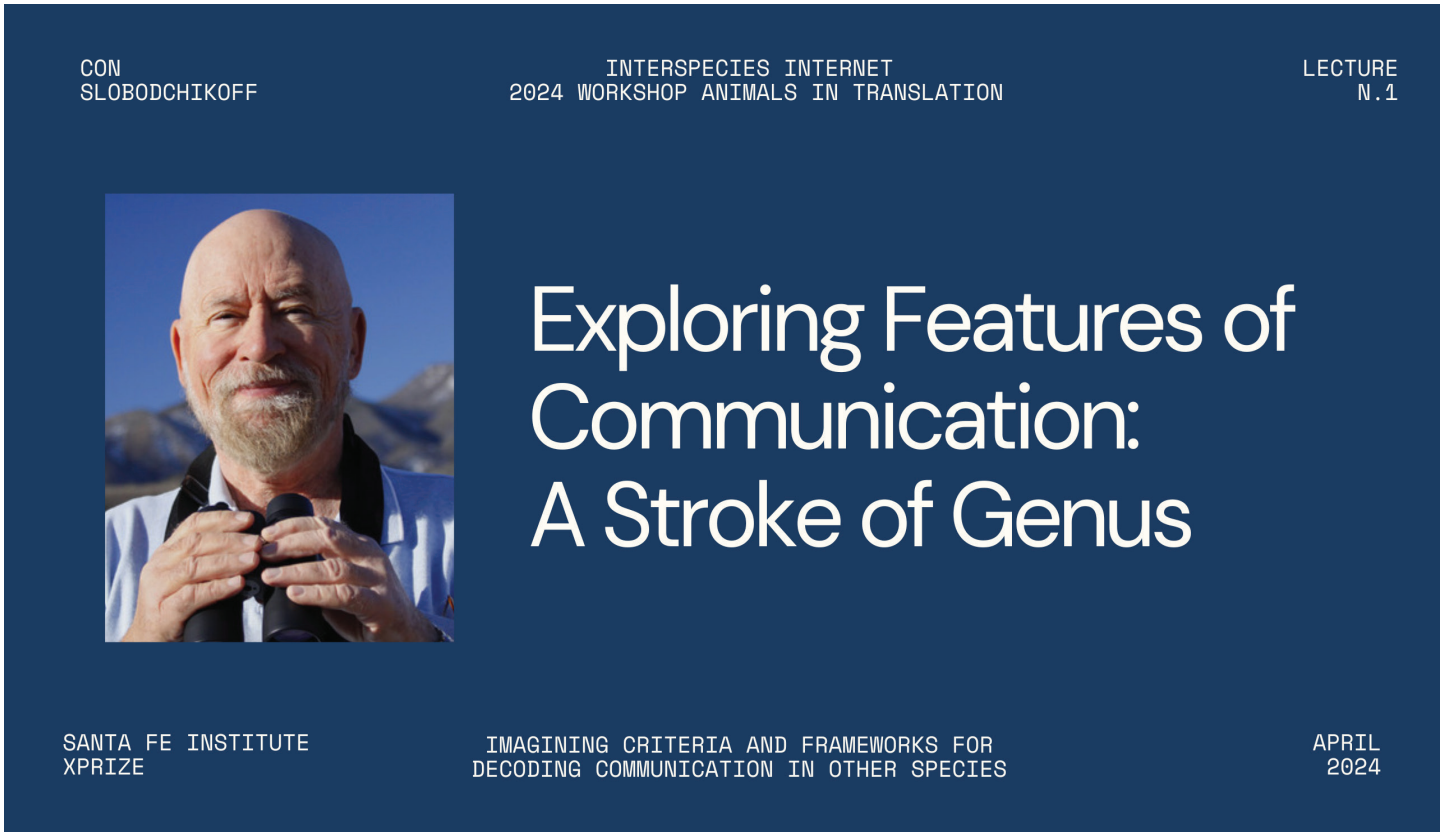
Exploring Features of Communication: A Stroke of Genus

Con Slobodchikoff

Zoolingua and Animal Language Institute
Professor Emeritus, Biology Department,
Northern Arizona University

This talk has three parts. The first focuses on the Discourse System proposed in Slobodchikoff's 2012 book, Chasing Doctor Dolittle: Learning the Language of Animals. The second part shows how the Discourse System predicts that phylogeny is essential in studying the communication systems of related animals. The third part gives an example of how the Discourse System meshes with linguistic analysis to understand the importance of communication's complexity.

The Discourse System suggests that there is a system used in communication that controls elements of other systems, such as neural, hormonal, sensory, and morphological systems, in the production and reception of messages. This system has been overlooked by animal behaviorists, but is vital to generating and processing signals and messages.



Because closely related animals have very similar physiological and morphological systems, they are expected to have very similar communication processes. Prairie dog alarm calls are an example of this. A cluster analysis of the alarm calls of all five species of prairie dogs exactly matches a phylogenetic analysis of the five species based on serological and DNA relatedness.

Within a species of prairie dogs, *Cynomys gunnisoni,* linguistic analysis shows that the alarm calls for a human can be modified to include additional information when a dog is walking along with the human. This is another prediction of the Discourse System: that it is flexible enough to include different linguistic elements.

Photo taken by Joshua J. Cotten

From Cacophony to Order in Animal Communication

Yossi Yovel

YOVEL YOSSI 1 1 Tel Aviv University, Faculty of Life sciences, Department of Zoology, Ramat Aviv, 6997801, Tel Aviv, Israel

Many bat species are extremely social roosting in crowded roosts and using social vocalizations to interact. I will present results on: (1) The information content of bat vocalizations and (2) Its acquisition by new-born pups. To study the information content, we continuously monitored Egyptian fruit bats for months, recording audio and video around-the-clock. We found that bat vocalizations carry ample information about the identity of the emitter, the context of the call, the behavioral response to the call, and even the call's addressee. To study vocal acquisition, we raised three groups of pups in conditions mimicking their natural roosts. Namely, pups could hear their mothers' vocalizations but were also exposed to a manipulation playback. The vocalizations in the three playbacks mainly differed in their fundamental frequency. From the age of approximately six months and onwards, the pups demonstrated distinct dialects, where each group was biased towards its playback.

We demonstrate the emergence of dialects through social learning in a mammalian model in a tightly controlled environment. Unlike in the extensively studied case of songbirds where specific tutors are imitated, we demonstrate that bats do not only learn their vocalizations directly from their mothers, but that they are actually influenced by the sounds of the entire crowd. This process, which we term "crowd vocal learning," might be relevant to many other social animals such as cetaceans and pinnipeds.

YOSSI
YOVEL

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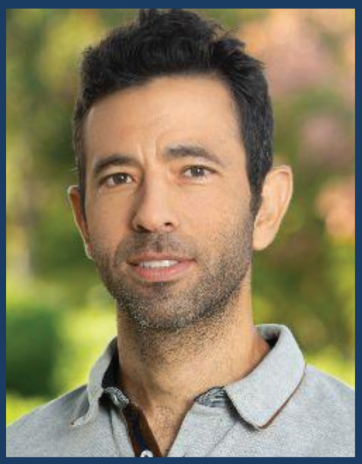
LECTURE
N.2



From Cacophony to Order in Animal Communication

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DECODING COMMUNICATION IN OTHER SPECIES

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2024

"When we think of bats as humans, or of our animals as humans, we have to be careful with this. So, I think in a lot of cases the interactions are local and they are actually paying attention to a specific individual. Sometimes it's referred to as the cocktail party. But I think in other cases, definitely, you see these fruit-bats in the cave, they do not have an alarm call and I think they don't need it. Because once I enter the cave—I'm a predator of course—then there'll be a wave of interactions moving through the colony, and at some point, we haven't measured this, but I'm quite sure that at some point there's just so much commotion, so much going on, that for them it's clear that a predator has entered the colony. There's no need for an alarm call. We've also shown in another study—we call it crowd vocal learning—we show that the pups will actually learn [their vocalization] from the crowd and not from specific individuals."

Note: The text above is an excerpt from the speaker in the linked video.

Cry Wolf Project at Yellowstone Park

Jeff Reed

Lead engineer of Yellowstone's Cry Wolf bioacoustics project

The Cry Wolf project, located in Yellowstone National Park, represents the largest ongoing bioacoustics initiative within the world's most intact temperate ecosystem. Utilizing next-generation, modular systems that integrate both cameras and audio recorders, we have amassed the world's most extensive collection of wild wolf vocalizations. This unprecedented dataset lays the groundwork for researchers to decode wolf communication, develop innovative strategies to mitigate livestock-wildlife conflicts, and create more accurate models for estimating wolf populations. We believe that bioacoustics is a powerful tool for both science and conservation. Wolves are known to produce over 25 distinct call types. By combining our recordings with field observations from 10 different packs and leveraging AI to analyze tens of thousands of hours of audio, we can cluster large datasets of wolf vocalizations to explore potential semantic structures. This brief presentation outlines our model for decoding wolf communication and showcases some of our current findings. Our expanding dataset is also available to researchers studying other species within the unique biophony of Yellowstone National Park, including grizzly bears, bison, wolverines, and more.

Humpback Whales in Translation: Toward Decoding Communication and its Complexity

Brenda McCowan

Professor of Ethology and the Director of the McCowan-Vandeleest Laboratory of Biobehavioral Complexity at the University of California

Humpback whales exhibit some of the most complex and varied vocal repertoires among nonhuman animals, making them a prime candidate for studying nonhuman communication complexity, the focus of our Whale-SETI Research Group. Humpback whales have a long divergent evolutionary history, global distribution, complex social behavior, and cultural transmission of vocal patterns, which make them excellent subjects for understanding communication complexity in nonhuman species. Along with passive acoustic recordings, a key method we use are interactive playback experiments, where we attempt to engage with humpback whales using recorded vocalizations. During an experiment conducted in Southeast Alaska, a female whale, identified as "Twain," exhibited a strong and sustained response to the playback of a humpback social sound known as "whup" (contact call), during a prolonged 20-minute exchange that suggested a rudimentary form of communication or turn-taking. Analysis of Twain's responses revealed that the intervals between her calls and our playback exemplar were matched in latency, with greater matching during the engagement phase than during the agitation or disengagement phases. This finding supports the idea that humpback whales modulate their vocalizations in response to interactants, a behavior that parallels communication strategies observed in human interactions.

Future directions for this research include the development of more advanced, real-time adaptive playback systems and the expansion of studies to include a broader range of social sounds and behavioral contexts. The ultimate goal is to integrate engagement-based methods with other analytical tools, such as AI and information theory, to decode the communication systems of humpback whales and other nonhuman species.

BRENDA MCCOWAN

INTERSPECIES INTERNET
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LECTURE N.4

Humpback Whales in Translation

Toward Decoding Communication and its Complexity in Non-Humans

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"Why are humpback whales an important model for decoding complexity and interspecies communication? And I'll first say that I think a really important point is that whales in general are evolutionarily divergent from humans. In fact, they have a last common ancestor from over 65 million years ago, which means that there's been independent convergent evolution of both social and vocal complexity. And this has occurred in vastly different environments. Whales in general also have a long history of brain evolution that outspans our own. Second, humpback whales have an enormously diverse and complex vocal repertoire that is composed of song and social sounds."

Note: The text above is an excerpt from the speaker in the linked video.

How Traditional Extreme Transformations of Speech May Help Decoding Animal Communications

Julien Meyer

Researcher at the French National Center of Scientific Research (CNRS/Gipsa-Lab/Université Grenoble Alpes)

In situations of telecommunication and proximal artistic performance, human groups have engineered diverse, ingenious formats of non-voiced auxiliary speech: (i) modulating the vocal tract to enhance selected acoustic features of a sound source alternative to the vocal cords; or (ii) adapting musical instruments to simulate aspects of the spoken phonetic signal (Meyer and Manfredi 2024). One of the most striking aspects of these whistled, drummed or other instrumental transformations of spoken words – also called speech/language surrogates (Nketia 1971) - is that they remain intelligible to trained speakers, despite a reduced acoustic channel to convey meaning. Several studies proposed that some of the characteristics found in human whistled or drummed communications, for which we have a translation or a musical explanation, may be worth considering in the analysis of clicks of sperm whales (Kamminga and Andre 2000) or of whistled signals of dolphins (Busnel 1966 ; Meyer, Magnasco and Reiss 2021). Indeed, they are characterized by similar acoustic parameters and serve a common purpose of long distance communication in natural surroundings in large brained social species.

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JULIEN
MEYER

INTERSPECIES INTERNET
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LECTURE
N.5

How traditional extreme transformations of speech may help decoding animal communications

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DECODING COMMUNICATION IN OTHER SPECIES

APRIL
2024

"Here I distinguished these two aspects, for tele-communication ... and for verbal art: while you have less pressure ... you can use the vocabulary of the songs but still imitation is more or less the same. The process of phonological or phonetic imitation of phonological categories in the language are the same for the two branches, it's just that when the pressure is different you use a little bit different organization of the sentence to add help for the listener. And you see that the drum can do both and it's an interesting aspect also to explore differences between music and language, for example, with the same kind of sounds, and simple ones."

Note: The text above is an excerpt from the speaker in the linked video.

Intelligence for Discovery: Project CETI

Gašper Beguš

Assistant Professor at UC Berkeley; Linguistics Lead at Project CETI Member of Berkeley's Institute of Cognitive and Brain Sciences

AI can help us uncover patterns previously unobserved by human researchers. Gašper Beguš presents a case where AI facilitated the discovery of vocal patterns in sperm whales that are akin to human vowels. The key to this finding was the observation that timing likely functions differently in whales compared to humans.

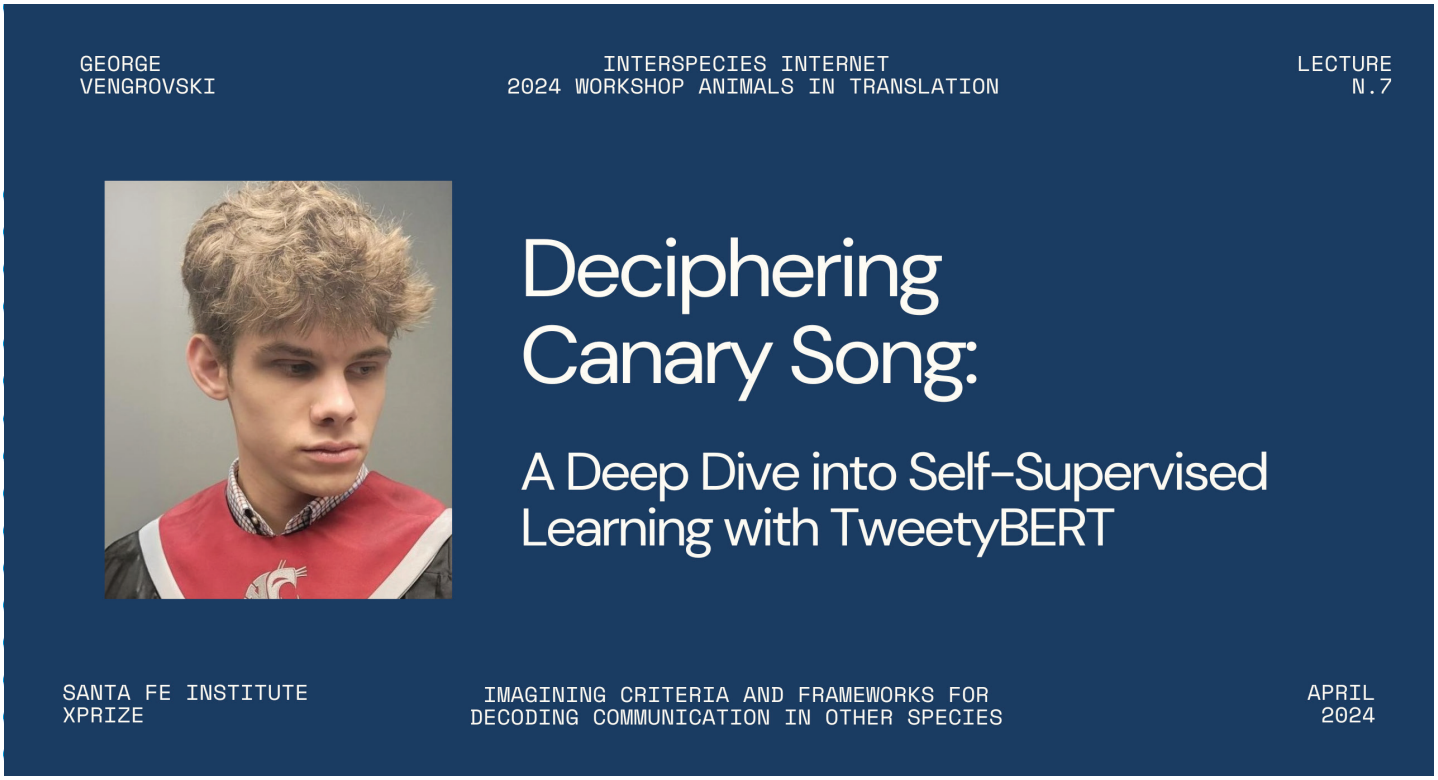
What can this newly discovered dimension in sperm whale vocalizations teach us about their complex communication system?

Deciphering Canary Song: A Deep Dive into Self-Supervised Learning with TweetyBERT

George Vengrovski *Computational neuroscience PhD student, University of Oregon*

Canaries serve as an excellent model for studying sensory-motor learning due to their rich auditory behavior, offering insights into speech acquisition. However, manual and supervised annotation of birdsong is time-consuming and costly, necessitating automated methods for classifying song elements such as syllables, phrases, and motifs. While existing unsupervised approaches like Uniform Manifold Approximation and Projection (UMAP) work well for stereotyped songs, they require complex preprocessing steps. We introduce TweetyBERT, a self-supervised convolutional network combined with a transformer encoder, designed to learn compressed and informative representations of canary song through masked spectrogram prediction. Our model incorporates modifications to the encoding transformer and operates on pre-generated spectrograms, enabling it to learn effective song representations while achieving an order of magnitude reduction in computational cost compared to existing audio transformer models. By applying dimensional reduction to the transformer's attention layer activations via UMAP, we extract a lower-dimensional representation of the canary song. This representation enables effective visualization and clustering using the Hierarchical Density-Based Spatial

Clustering of Applications with Noise (HDBSCAN) clustering algorithm. Our results demonstrate that the discovered clusters correspond with high accuracy to phrase-level ground truth labels in the canary song dataset. Furthermore, visualizations of the transformer attention layer reveal a highly structured embedding of the canary song. TweetyBERT eliminates the need for manual annotation and complex preprocessing steps associated with previous techniques. This approach represents a significant advancement in automated birdsong analysis, facilitating large-scale studies and contributing to our understanding of animal speech acquisition.



"Canary Song is obviously a form of birdsong, and birdsong is a highly sophisticated form of social interaction. It's used for birds to identify themselves to other birds, to demarcate their territory, and primarily to attract mates. It's not studied by birdsong researchers just because it's beautiful and sophisticated, but because it could serve as a model of speech acquisition. Because the neural circuits that underlie the genesis of birdsong, as well as its production, are analogous to the neural circuits in other animals, including humans, that acquire speech. And because that insight that you learn from birdsong can be transferred to other animals. And we're developing these deep learning models in order to accelerate this research. And while we hope that we will accelerate birdsong research, we hope that our models generalize to other animals and help researchers studying other vocal behaviors."

Note: The text above is an excerpt from the speaker in the linked video.

Using Animal Communication Systems To Develop Information-Theoretic "Intelligence" Filters for Quantifying Complexity and Assisting Detection in SETI

Laurance Doyle *Lead at the Whale-SETI Group*

We present ongoing research in the application of information theory to animal communication systems with the goal of developing additional detectors and estimators for possible extraterrestrial intelligent signals. Regardless of the species, for intelligence (i.e., complex knowledge) to be transmitted certain rules of information theory must still be obeyed. We demonstrate some preliminary results of applying information theory to socially complex marine mammal species (bottlenose dolphins and humpback whales) as well as arboreal squirrel monkeys, because they almost exclusively rely on vocal signals for their communications, producing signals which can be readily characterized by signal analysis. Metrics such as Zipf's Law and higher-order information-entropic structure are emerging as indicators of the communicative complexity characteristic of an "intelligent message" content within these animals' signals, perhaps not surprising given these species' social complexity. In addition to human languages, for comparison we also apply these metrics to pulsar signals—perhaps (arguably) the most "organized" of stellar systems—as an example of astrophysical systems that would have to be distinguished from an extraterrestrial intelligence message by such information theoretic filters. We also look at a message transmitted from Earth (Arecibo Observatory) that contains a lot of meaning but little information in the mathematical sense we define it here. We conclude that the study of non-human communication systems on our own planet can make a valuable contribution to the detection of extraterrestrial intelligence by providing quantitative general measures of communicative complexity. Studying the complex communication systems of other intelligent species on our own planet may also be one of the best ways to deprovincialize our thinking about extraterrestrial communication systems in general.

LAURANCE DOYLE

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LECTURE N.8

Animal Communication, Information Theory, and SETI

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APRIL 2024

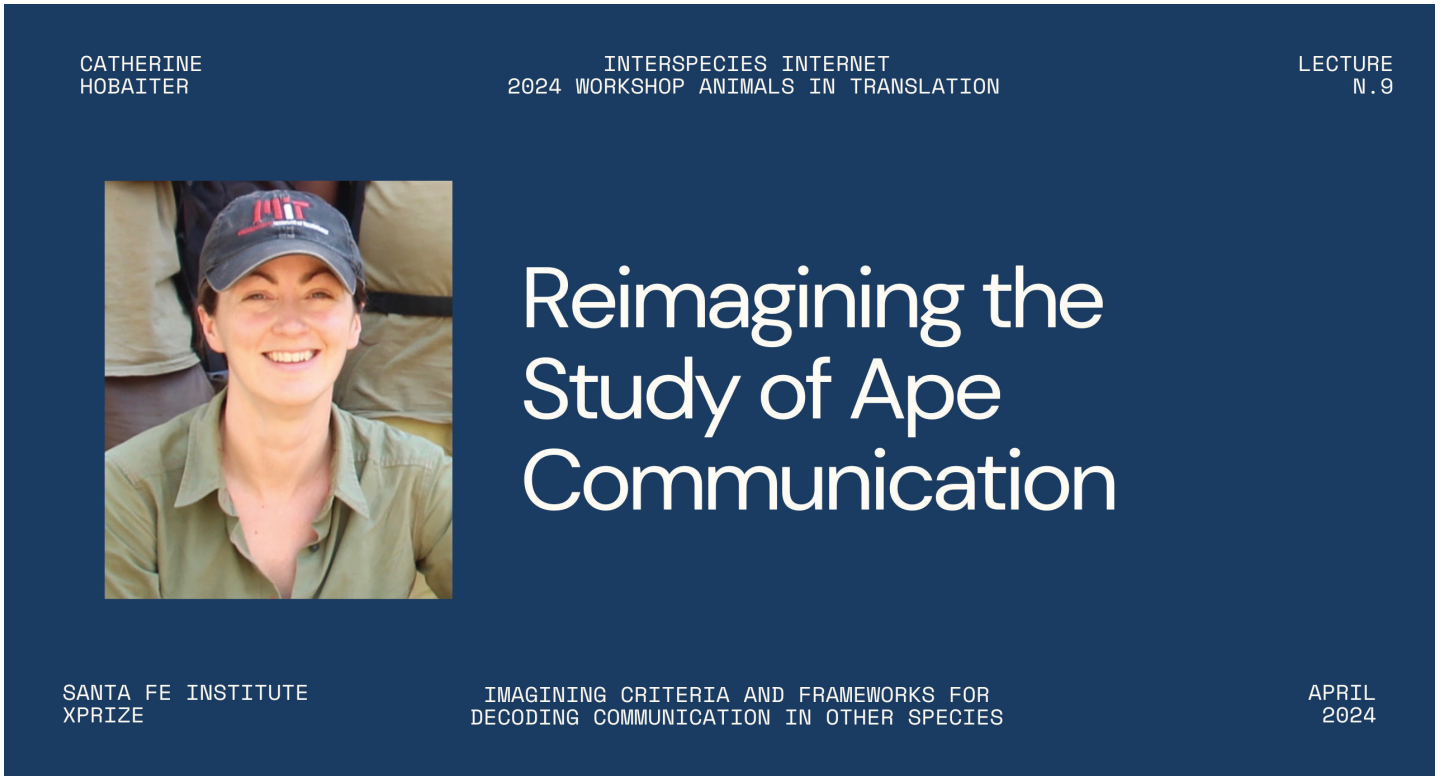
"We discovered syntax in the humpback whales by actually measuring the channel capacity using information theory and then using the channel capacity, we calculated that the humpback whales were not drawing out their signals enough to overcome the noise that they were encountering. And we thought about this for a while, and we finally realized, you know, we had a Xerox machine that was low on toner, but we filled in the missing words, and we figured out the humpbacks are filling in the missing signals."

Note: The text above is an excerpt from the speaker in the linked video.

Reimagining the Study of Great Ape Communication

Catherine Hobaiter *Wild Minds Lab & Reader at the University of St Andrews*

In the Wild Minds Lab we explore the communication and cognition of wild apes and other species. Like most researchers interested in communication of other primates, I have spent much of my career exploring the different signals great apes use, asking questions such as, how do they combine them? And, what do they mean? At the end of the day, I do this because I'm interested in what it means to be a chimpanzee, or a gorilla, or a human. And systems of communication give us a framework through which we can investigate what individuals of other species, and our own, are thinking and feeling. But I worry that the ways we have studied communication, asking what each species has in their communication tool kit, might not be well suited to understanding how communication is used by individuals, groups, and cultures. I will describe how we are reimagining the study of non-human communication, and how I hope this will help us to better understand other species, and the evolutionary origins of our own.



Workshop Breakout Sessions

Session 1

The Complexity of Communication: Assumptions and Barriers to Decoding

Key Themes and Topics

Defining Communication and Complexity

Context and Multimodality

Communication in animals involves various channels, such as visual, acoustic, gestural, and chemical signals.

The complexity of these signals and their combination poses a challenge to defining and decoding them.

It is important to assess the basic signal types and understand their multimodal nature, which can be used simultaneously or sequentially.

Researchers need to catalog the signals and types of transactions using these signals, and acknowledge the difficulty of perceiving them all.

Units of Communication

The concept of "units" in communication is not clearly defined and needs careful consideration.

There is no consensus on what specific number of units would facilitate decoding; instead, one should focus on the quality and functionality of units.

Ethical and Practical Barriers

Context and Multimodality

Current technologies, such as playback systems, are limited to certain modalities (e.g., acoustic) and may not be applicable to more complex or multimodal signals.

Practical issues like the difficulty of playback for gestural or olfactory signals were noted.

Ethical Considerations

The use of advanced technologies like fMRI on animals poses ethical dilemmas.

Some technologies could enhance research but are limited in their application due to ethical concerns.

Interpreting Meaning and Function

Behaviorist Approach

Significant emphasis on a behaviorist approach, focusing on observable inputs and outputs. The absence of behavior is also data.

This method involves looking at the predictability of responses using signals across multiple contexts, which, while practical, may overlook deeper aspects of meaning and intentionality.

Function over Meaning

Understanding the function of signals within communication systems is prioritized over decoding intrinsic meanings.

Observing and measuring predictable responses and behaviors can provide insights into communication.

Human Bias and Cultural Noise

Bias in Research

Human perspectives and language heavily influence research approaches and interpretations.

There is a need to minimize human biases to better understand non-human communication.

Cultural Noise

The concept of cultural noise, which refers to interference in communication due to cultural differences, is underexplored but crucial for accurate communication decoding.

Misunderstandings can arise due to cultural differences within and across species.

Criteria for Successful Decoding

Predictability and Reproducibility

Successful decoding should involve reliably predicting behaviors and responses using the identified communication units.

This predictability must be demonstrated across various contexts to validate the findings.

Peer Review and Expert Validation

Any conclusions drawn from the research must undergo a rigorous verification process, including peer review by experts in the field.

This step ensures credibility and prevents ridicule from the scientific community.

Species-Specific Considerations

Natural Context

The communication systems studied should be relevant to the species' natural behaviors and lifestyles.

This includes considering their social structures, ecological contexts, and what is relevant to them in their world.

Universal Principles

Universal approach allows for cross-species comparisons and understanding of the organization of communication units.

While searching for universal principles underlying communication, it is important to recognize the unique aspects of each species' communication system.

Multimodal and Context-Dependent Communication

Integration of Signals

Communication often involves the integration of multiple signals that can change meaning based on the context.

Understanding how these signals work together in different contexts is crucial for decoding.

Temporal Aspects

Communication can span different time frames, from immediate interactions to signals that extend over days.

Considering temporality is important, as some signals may not have immediate responses but still play a role in communication.

Information Theory

Neutral Framework

Information theory offers a neutral framework to study communication by focusing on signal patterns rather than meanings.

This approach can help reduce human bias and provide a more objective analysis.

Function and Intent

Determining the function and intent behind signals is essential for understanding the effectiveness and purpose of communication systems.

The use of information theory can help in assessing the function of signals and their role in communication.

Future Directions

Exploration of universal communication principles.	Investigating non-traditional and non-explicit forms of communication.
Adapting traditional tests (like the Turing test) to non-human species.	Ethical frameworks to guide the research community.

Session 2

The Coupling of AI, The Human Eye and Other Tools to Decode

Key Themes and Topics

Ground Truthing with Humans

Role of Humans

Humans can provide objective observations for AI models, but biases can affect accuracy.

Pattern Recognition

AI can uncover complex communication patterns that humans might neglect.

Ethical Advantages of AI

AI can create non-anthropocentric benchmarks, offering fresh perspectives and reducing human biases.

AI as a Tool for Animal Communication

Types and Limitations

AI models range from problem-solving to social intelligence, but current models often fail to capture the full scope of animal communication.

Data Availability

Humans generate vast data aiding AI prediction, but data for other species is limited and potentially biased.

Need for Specialized Models

AI needs to be tailored to interpret the social intelligence and communication of non-human species.

Challenges in Capturing Species-Specific Data

Comprehensive Datasets

Comprehensive datasets akin to human "symphonies" are required to enable accurate pattern recognition.

Technological Limitations

Practical challenges include the invasive nature of data collection and existing technological constraints.

Using VR to Simulate Animal Sensory Perception

Intuitive Development

Virtual reality technologies may assist researchers in understanding the sensory modalities of animals and aid the creation of deep learning models.

Ground Truthing Signal Recordings

Methods

Observing animal responses using a variety of methods behavioral observations, sound playback) to validate signal recordings.

Building AI Foundation Models for Communication

Predictive Models

Using predictive models to identify behavioral modalities that best predict responses in the animals that researchers are building a deep learning model of.

AI for Self-Discovery of Discrete Units in Speech

Collaborative Annotation

AI may assist in discovering speech units, limiting human bias while working alongside human annotation.

Human Influence and Bias in AI Models

Human Decisions

Humans decide hyperparameters and data curation, which can introduce biases into AI models.

Efficiency and Multimodal Analysis

Data Processing

AI can process and label large datasets faster than humans, facilitating extensive data analysis.

Multimodal Communication

AI excels at analyzing simultaneous and sequential communication signals.

Hypothesis Testing and Validation

Predictive Validation

AI helps in making predictions which can be validated through subsequent observation of animal behavior.

Innovative Data Collection Methods

Animal Perspectives	Using cameras and tracking devices on animals may help capture interactions and communication modalities.

Ethical Considerations and Collaboration

Proactive Collaboration	Emphasizing the importance of ethical considerations and ensuring mutual benefits and proper credit in AI and scientific collaborations.

Two-Phase Approach for Ground Truth

Discovery	Testing
AI maps the patterns of signals to actions.	Formulate prediction of the identified actions then use playbacks to confirm those actions.

Limitations and Future Potential of AI

Computational Limits	Acknowledging current computational limits to multimodal signals analysis, with quantum computing suggested as a potential solution.

Role of Human Observers

Verification	Human validation is critical to ensuring AI accuracy and reliability, particularly in recognizing stress or harm during testing.

Public Engagement

Public Science Communication	Documentaries and visual evidence are crucial for public engagement and demonstrating significant discoveries.

Simplicity vs. AI

Simpler Solutions	Researchers should be mindful of the fact that simpler, non-AI methods may be more effective at times.

Questioning the Role of AI

AI as a Supplementary Tool

AI should complement, not replace, other research tools, given its current limitations in causality and data interpretation.

Data Quality

It is important to build high-quality, comprehensive datasets before utilizing AI.

Emotions and Human Observer

Emotional Understanding Debate over AI's role in understanding and communicating emotions, and the significance of ensuring AI aligns with human intents in research.

Caution with AI

Prudent Application Emphasizing caution in applying AI to avoid drawing false conclusions from insufficient or noisy data.

Session 3

Criteria for Decoding

Key Themes and Topics

The XPRIZE Process

Role of Communication

Emphasizing the significance of broader communication efforts recognizing animal intelligence and driving meaningful conservation outcomes.

Suggestions that the prize could reward not only direct scientific achievements but also effective communication strategies that raise public awareness and engagement, and policy outcomes.

Types and Limitations

Stories about interspecies communication already capture public interest, suggesting that the XPRIZE could build on this.

Framing the competition narrative around meaningful applications, such as conservation and connection with nature, to ensure broader public interest and engagement.

General Public Benefit

XPRIZE should strive for outcomes that resonate with the general public, making scientific advancements accessible and relevant to broader audiences.

Challenges and Support for Teams

Funding and Early Stage Challenges

Addressing the lack of funding for early-stage research, suggesting that milestone funding could help teams overcome initial challenges.

Discussing the importance of including conservation outcomes and demonstrating high levels of intelligence as part of the competition goals to attract more interest and funding.

Team Dynamics and Skill Sets

Recognizing that teams participating in the XPRIZE competitions are often small and may lack the complete skill set needed to scale their solutions or translate research into policy action.

Suggesting a focus on specific, impactful parameters to help teams succeed without overwhelming them with requirements beyond their core competencies.

Evaluation Criteria and Competition Structure

Qualifying vs. Scoring Criteria

Explaining the distinction between qualifying criteria (minimum standards that must be met) and scoring criteria (used to evaluate the quality and impact of the work).

Discussing the possibility of including qualitative judging criteria to assess the positive impact of the insights gained, while balancing the need to minimize ambiguity in evaluations.

Broader Outcomes and Policy Interface

Considering the interface with policymakers and how XPRIZE could facilitate broader policy impact, whether through competition parameters or through associated summits and events.

Highlighting a potential for creating opportunities for policy engagement and investor interest through structured events as part of the competition's operational plan.

Process and Engagement

Iterative and Inclusive Process

Emphasizing the ongoing and iterative nature of the discussion, with plans to continue gathering input and refining ideas even after the session.

Encouraging participants to take home ballots and continue the conversation within their networks, ensuring a wide range of perspectives are considered.

Future Gatherings and Documentation

Plans for future gatherings to continue the dialogue about the prize and the broader collaboration among participants.

Highlighting that all discussions and notes will be documented and published, providing a comprehensive resource for the community and supporting future development.

Summits and Events

Discussing plans for hosting summits and events as part of the competition, such as investor summits for carbon removal or policy summits for biodiversity.

Recognizing the importance of involving partner organizations that may not compete directly but can amplify the work and spread the message.

Final Collective Debate

Phylogenetics and Clades

Understanding communication at different biological levels, from large evolutionary groups (clades) to individual species and their interactions.

This approach might help identify general patterns and unique aspects of communication in various animal groups.

Predictive Communication

Aim to predict the behavior of animals based on their communication signals.

Focus on multi-step, transactional, and dynamic interactions.

Includes understanding complete sequences of signals during interactions.

Generalization and Validation

Validating findings could involve generalizing across different species.

Ensure that studies are concordant and can be replicated.

Simulated Bayesian approach to study communicative evolution.

Cultural Transmission

Study how cultural elements (memes) move through populations.

Use tools like simulated injections, playbacks, and presentations to introduce novel ideas and analyze resultant behaviors.

Identify hosts or donors who transmit these ideas and observe how naive populations adopt them.

AI and Technological Tools

AI Utilization

Employ AI to detect patterns in communication that might be missed by human observers.

AI can provide less biased alternatives to traditional observational methods.

Use AI to analyze large datasets, identify subtle patterns, and reduce observer bias.

Human Ground-Truthing

Combine AI findings with human observations to validate results and ground-truth data, balancing the former's computational power with latter's experiential insight.

Use human perceptions and testing to ensure the accuracy and relevance of AI-detected patterns.

Demonstrating Decoding

Novel Behaviors and Predictive Communication

Show that decoding has been successful by inducing behaviors in animals that they wouldn't normally exhibit.

E.g., If Chimp A communicates something novel to Chimp B, and B then behaves in a new way.

Includes predicting not just individual behaviors but also how animals communicate these behaviors to conspecifics.

Social Complexity Tests

Use specific tests to assess communication complexity.

Breakfast Room Test: Inform animals about a change in food location and observe if they alter their habitual behaviors to find the new location.

Gossip Test: Test if animals can understand and act on information about conspecifics (e.g., avoiding a food-stealing individual).

Criteria for Decoding Success

Reproducibility

Ensure that decoded communication can be reliably reproduced by other researchers.

Aim for consistent results across different studies and methodologies.

Natural Communication

Focus on the natural modes of communication rather than artificial setups.

Demonstrate understanding by observing and interpreting communication in natural contexts.

Behavioral Evidence

Show that communication leads to observable behavioral changes.

Provide clear examples where communication directly influences behavior in predictable ways.

Capacity Estimation

Use information theory to estimate the expressive capacity of the species' communication signals.

Determine the range and complexity of signals that the species can produce and understand.

Ethical Considerations

Ethical Engagement

Consider the ethical implications of research interventions.

Ensure that studies are conducted responsibly and with respect for animal welfare.

Conservation and Coexistence

Include conservation outcomes as part of the criteria for success.

Examples include keeping whales out of shipping lanes or wolves away from livestock.

Use decoded communication to enhance human-animal coexistence and reduce conflicts.

Experimental Approaches

Experimental Probes

Use synthetic or playback experiments to test hypotheses about communication.

Design experiments that predict specific behavioral responses based on the analysis.

Play back recorded signals to animals and observe their responses to validate the meaning of the signals.

Natural Communication

Focus on the natural modes of communication rather than artificial setups.

Demonstrate understanding by observing and interpreting communication in natural contexts.

Behavioral Contexts

Recognize that not all communication leads to immediate behavioral changes.

Study instances where signaling occurs without an observable behavioral context and consider these in the analysis.

Human Behavior and Presentation

Impact on Human Behavior

Explore how decoding animal communication can influence human behavior and attitudes towards animals.

Aim to increase empathy and understanding, potentially leading to greater conservation efforts.

Consider how scientific presentations can change public perceptions and behaviors for the benefit of animals.

Interdisciplinary Approaches

Complexity and Interrelatedness

Emphasize mutual benefits and shared interests between humans and animals.

Use complexity science to understand and illustrate the interrelationships within ecosystems.

Highlight how understanding animal communication can reveal broader ecological dynamics and cooperation.

Blueprints for Future Research

Provide clear methodologies and blueprints for other researchers to replicate and build upon successful decoding efforts.

Ensure that research findings are accessible and actionable for future studies.

(04) Virtual Focus Group

(September 24, 2024)

Photo taken by Hans Veth

Methodology and Framing

Following the Animals in Translation workshop held at SFI, a subset of nine researchers gathered to further refine the workshop criteria and synthesize statements during a separate three-hour virtual workshop. This online focus group also provided additional written feedback to continue the elaboration of workshop outcomes. All nine researchers were also attendees of the original SFI workshop.

This virtual focus group and criteria development team consisted of:

- Brenda McCowan
- Catherine Hobaiter
- Con Slobodchikoff
- Diana Reiss
- Irene Pepperberg
- Jeff Reed
- Julien Meyer
- Kevin Marriott
- Sue Savage-Rumbaugh

Objective

Analyze and incorporate the post-workshop survey results, further discuss ambiguous topics, and co-create the final statements.

Methods & Structure

- A three hour session with a 15 minute break.
- Presentation of the survey analysis and key outcomes of the SFI workshop.
- A deep dive into the current criteria statements and related questions needing further clarification.
- Collectively review the corrections and concerns shared during the deep dive.
- Refocus and synthesis of the criteria statements.
- Wrap-up and next steps.

(05) Criteria for Decoding

(05) Criteria for Decoding

In this chapter, we present a collection of succinct statements resulting from both the SFI workshop and the virtual focus group, encapsulating the combined efforts of this research team working collaboratively to explore the creation of criteria, benchmarks, and frameworks for decoding communication in other species.

We hope that these criteria can catalyze meaningful advancements in the field, inspire innovative initiatives like an XPRIZE for decoding animal communication, encourage empathy for the diverse forms of life with which we share this planet, and prompt global initiatives in animal welfare and conservation.

[1] AI and other technologies may be powerful tools for revealing new or unimagined patterns in communication, but verification is needed and will always involve ground-truthing by humans

It is well understood that research in the field requires both technological systems to detect patterns in data, as well as human participants to verify these emergent patterns with confirmation of corresponding behavioral responses. Depending on the architecture, training data and methods, and context of application, machine learning technologies in particular exhibit various types of common errors, such as hallucination or fabrications, over and underfitting, systemic bias, extrapolation errors, and so on. The use of AI and other technologies should require a verification step in the research pipeline, where patterns from machine learning systems or other tools are assessed through ethical testing approaches to ensure the efficacy of decoding. That is to say, researchers should first ensure that a species is sensitive to a pattern revealed by technology, followed by a demonstration of how a signal or pattern functions via prediction, probability models, and other forms of experimental confirmation.

Photo taken by Benjamin Grull

[2a] Researchers must verify that a communication system has been described through replicability and predictability of outcomes of signal use

Researchers must include verification in their submission. That is to say, they should provide evidence of both predictability and replicability of outcomes of signal use. It will be the responsibility of a panel of expert XPRIZE judges to adjudicate these claims and their efficacy according to the guidelines provided in the following two sections.

Replicability refers broadly to achieving consistent results across various studies using separate data sets but aimed at addressing the same scientific question. In the context of the XPRIZE, replicability means that the outcome or function of signal use must be shown to occur:

(1) Across at least three different subgroups within a population or in groups of animals from different geographies. This criterion reflects the requirement that results across studies using different data sets—in this case different animal groups or population subgroups—must show consistent results.

Some possible problematic irregularities should be noted:

a. With respect to dialects: Variations of the same signal may differ in form and function across different populations and may not be consistent across populations.
b. Signal use may differ or may be the same across groups.

(2) Between two or more individual animals, and in more than one pair of animals. Our research team prioritizes studying functional vocal or non-vocal behavioral exchanges among animal groups, rather than just individual animal behaviors, to capture the full complexity and dynamics of information exchange and dialogic communication.

If researchers are working with a model species for which the aforementioned quantitative thresholds do not hold they should include a justification for why their species does not meet these benchmarks. Relatedly, the more populations studied—and the more individuals included in a study—the better, as this would strengthen evidence of convergent results using different data. However, it would also suffice to focus on a specific population or one social group with multiple individuals and report on their repertoire of signals and signal use and verify their function.

The aforementioned criteria are preferable but not exhaustive. For example, researchers could be permitted to provide a sufficient explanation for why a signal-function changes across geographically isolated social groups. We suggest that XPRIZE require a species-specific expert panel to be included in the judging team for each of the chosen focal species to: adjudicate whether these criteria are met and assess explanations when they are not; provide guidance on the team's advancement based on the current state of knowledge; and confirm their adherence to best practices and ethical frameworks. This panel could also be interdisciplinary, including researchers in associated fields such as developmental and comparative psychology, linguistics, and ethology. However, it should be noted that even specialists may disagree on the meaning of communication signals, so some complications may persist in this area.

Finally, we stress that replication does not require another outside research group to reproduce a study; rather, sufficient documentation of methodologies employed and testing by the team itself will suffice. In fact, most published studies do not require reproducibility by another team, and it is often prohibitively difficult to reproduce the details of subtle and dynamic variation occurring in the context of one study or natural system. Therefore, it is too demanding to require reproducibility of evidence for decoding by multiple research groups.

Photo taken by Max Christian

[2b] Researchers must verify that a communication system has been described through replicability and predictability of outcomes of signal use

Researchers should integrate predictive modeling into their methodology. There are many ways to verify results with prediction. Possible scientific approaches to test for prediction that are traditionally used in the field, include:

- Bayesian methods
- P-values
- Randomization and modeling
- Information theory approaches
- Artificial intelligence or machine learning algorithms
- Non-specific combinations of various statistical analyses
- Predicting subsequent signals in a sequence

Certain methods may need to be species-specific and a combination of approaches might be required depending on the research context and species being studied. It should also be noted that there is currently a feeling among our advisory team that LLMs per-se may not work for animal communication decoding because such systems require more data on a given animal communication system than is currently available.

Our research group also recommends obligatory testing of predictions after the third or fourth year, by conducting research on a group outside of the original testing group or subgroup. In other words, part of the experimental paradigm must be the ability to verify predictions within a system of observations through repeatable or replicable testing.

[3] Researchers must demonstrate functional use of signals across individuals

Researchers should show that their species uses communication (not excluding multi-modal) demonstrating signal function within that species, and when applicable, with other species with whom they interact in their environment. Researchers should explain what methodologies they will use to demonstrate signal function and provide a clear and detailed description of the methods and frameworks employed, and a statement and evidence of the ethical use of the methodologies.

Suggested examples of evidence might include, but are not limited to:

- Context-Specific Usage: Demonstrating signal use in specific contexts (e.g. mating, warning, foraging) and a demonstration of non-random signal use. In cases in which signals may be used across different contexts, specific details on contextual use of such signals should be included.

- Predictable Outcomes: Signal production reliably leads to a specific behavioral response in receivers (e.g., flight in response to bark-howls).

- Adaptive Value: Evidence that a signal provides some survival or reproductive benefit (e.g., reducing predation or increasing mating success).

- Consistency Across Individuals Within a Social Group, Social Groups or Populations: Specific communication signals used consistently between and across different individuals from the same group, in multiple groups (possibly from different populations or different areas) within a species.

- Experimental Validation: Playback experiments should confirm that different signals influence behavior in a predictable way (e.g., response to playback of different types of alarm calls).

- Neurological or Physiological Response: If ethically achievable, evidence that the signal triggers a measurable response in the nervous or endocrine systems of the sender and/or the receiver.

- Information Theory: Examples include Zipf's Law of Word Frequency and Zipf's Law of Abbreviation.

Owing to differences between species, providing a fixed number of instances of specific signal production and specific types of responses may be a problematic criterion to demonstrate functional use. Another issue is that many species could become rapidly accustomed to human playback signals and begin ignoring them. Instead, it may be sufficient to show functional use of a specific signal or signal sequence between numerous different individuals within one social group. Researchers could also be encouraged to demonstrate signal use between different pairs or ensembles of individuals of the same group when these pairs or subgroups are not proximal. Showing signal use between groups with different dialects in different geographical populations would be an added benefit as this would demonstrate either common functional aspects in communication across dialects that lead to the same behavioral changes, or differences in functional use which lead to different behaviors.

It should also be noted that the concept of a "unit" of communication is not clearly defined in the field and therefore requires careful consideration when it comes to its potential inclusion in any benchmark for decoding. In this document, we refer instead to "specific signals" or "signal sequences." Additionally, owing to a lack of consensus on what specific number of units would facilitate decoding, our research team instead endorses a focus on the quality and verifiable and predictable functionality of communication signals or signal sequences.

[4] Research on wild animals is preferable to animals in captive environments

Natural environments are likely necessary to see a richer scope of signal use and behavior and should therefore be the focus of this prize. For instance, animal behavior and experience is strongly limited by captive environments as there is no predation or natural foraging, and some calls observed in wild species are not present among captive animals. However, research efforts are permitted to include, and often benefit from, insights obtained from research done in an environment in which animals are in the care of humans (e.g. sanctuaries, rescue centers, zoological institutions).

Some members of our research team underscore the fact that a great deal of knowledge about the intrinsic cognitive and communicative abilities of animals has been derived from research involving animals in managed care environments. In particular, pioneering studies conducted in non-natural environments involving the use of human-devised artificial codes—such as ASL and lexigrams—have shown that animals like chimps, dolphins, and parrots have the cognitive underpinnings to understand and use complex referential-like communication. That being said, research for XPRIZE should include and prioritize wild populations in order to generate the fullest insight into animal communication possible. However, focusing on researching wild populations necessitates great care and consideration in anticipating and preventing research impacts to individuals and groups within the study population.

Photo taken by Irina Blok

[5] All research must be conducted under requisite permitting and IACUC (United States) or equivalent animal welfare review systems for animals in human care (e.g., UACC (Canada) or AWERB (UK))

These standards are routine and compulsory within institutional research contexts. As research on wild animals in natural environments is preferable, researchers should seek all necessary and relevant permits as well as approval from animal welfare review and permitting systems when conducting field work involving free-living wildlife if studies require activities beyond unobtrusive observation. The inclusion of this recommendation is warranted to limit unethical and nonstandard practice among non-academic research teams which may participate in XPRIZE contests.

Generally speaking, it is of utmost importance that research be conducted in an ethical manner, and must not compromise the welfare of the subjects of study or their environment(s). Ethical oversight could also include a dedicated committee to review research practices and hold research accountable to best possible standards. Additionally, it is of critical importance to involve Indigenous perspectives on ethical concerns, when applicable. Members of our research team have noted that many Indigenous communities have longstanding cultural relationships with local species and hold views on animal welfare that may exceed those of established institutional entities. For instance, Indigenous views on ecological and animal wellbeing may bring alternative insights to the harmful effects of practices still permitted under IACUC for the sake of research benefits.

[6] Interdisciplinary collaboration across different research groups—including Indigenous communities, where applicable—is encouraged to optimize capacity and insight

Our research team has a preference for a collaborative approach to this XPRIZE initiative, one which involves the efforts of multiple teams and promotes co-constructive research outcomes. Broadly speaking, interdisciplinary collaboration among research teams is desirable for enhancing capacity and integrating diverse methodological approaches, varying theoretical assumptions, and specialized knowledge from multiple domains. As noted earlier, interdisciplinarity is also encouraged for XPRIZE expert panels, and the inclusion of indigenous and global perspectives, knowledge, and concerns will critically enhance prize outcomes and impact. For instance, we wish to highlight the role that Traditional Ecological Knowledge (aka Indigenous Local Knowledge or Indigenous Traditional Knowledge) could play in heightening behavioral knowledge of animals with centuries old, intergenerational experience and awareness. Moreover, Indigenous knowledge and practices emphasize kinship with nature, biodiversity, ecological resilience and sustainability–further complementing welfare concerns mentioned earlier.

[7] Results should translate into increased public awareness and empathy to inform public policy and positively impact conservation and animal welfare

In keeping with our ethics recommendations, as well as an interest in the fruits of interdisciplinarity, our research team advocates for developing means of channeling XPRIZE outcomes towards public awareness and policy discussions related to conservation and animal welfare. We anticipate growing discourse around the ethical and legal implications of research in this field, especially as it pertains to the use of novel AI and machine learning technologies in studying animal communication, cognition, and behavior. Our organization, and many in the affiliated research community, are involved in various efforts to engage with these topics and the development and implementation of this XPRIZE initiative represents an opportunity to contribute further to this undertaking.

To reiterate what was stated in our introduction: Advances in the field, along with initiatives like an XPRIZE for decoding animal communication, could unlock new perspectives of the rich inner lives of animals, shedding light on their social, cognitive, and communicational complexity. Groundbreaking insights into the full spectrum of animal life may also inspire a shift in the way we perceive, empathize, and treat other species and embolden a broader cultural commitment to valuing and conserving the biodiversity of life.

Photo taken by Hu Chen

(06) Concluding Remarks

The workshop sparked rich and extensive discussions on criteria to evaluate evidence for decoding the communication system of another species. Participants touched on an expansive list of possibilities, ranging from the difficulties of defining communication and complexity, to strategies for interpreting meaning and function, ground truthing and machine learning models, ethical guardrails and practices, and future directions for research. During subsequent focal follow-up sessions, the team honed in on key ideas and methods, collaboratively formulating the set of seven core statements published in this document.

It is likely, perhaps inevitable, that criteria and frameworks such as those presented here will be fine-tuned, enhanced and supplemented with additional considerations as the study of animal communication continues to develop. After all, the pursuit of decoding, translating, or comprehending animal communication remains a complex and formidable challenge, inspiring decades of research and debate that resists oversimplification and straightforward consensus. As such, the process of developing benchmarks and frameworks for the field is an undoubtedly open-ended task, liable to ongoing iterations and improvement. Additionally, decoding may never conform to a "one size fits all" framework, as different species may require varied, specialized, and/or nuanced approaches, with attention to these qualitative differences proving equally as valuable as demonstrating quantitative rigor.

As of now, the workshop participants and criteria development team offer the following recommendations for evaluating the work of researchers decoding animal communication:

[1] AI and other technologies may be powerful tools for revealing new or unimagined patterns in communication, but verification is needed and will always involve ground-truthing by humans.

[2] Researchers must verify that a communication system has been described through replicability and predictability of outcomes of signal use.

[3] Researchers must demonstrate functional use of signals across individuals.

[4] Research on wild animals is preferable to animals in captive environments.

[5] All research must be conducted under requisite permitting and IACUC or equivalent animal welfare review systems for animals in human care.

[6] Interdisciplinary collaboration across different research groups—including indigenous communities, where applicable—is encouraged to optimize capacity and insight.

[7] Results should translate into increased public awareness and empathy to inform public policy and positively impact conservation and animal welfare.

Importantly, all participants in this research endeavor expressed a strong common interest in the importance of ethical approaches and protocols for continuous accountability. Efforts by various practitioners and organizations are currently underway to address ethical questions arising at the intersection of AI tools and animal communication research, and further work in this area is critical. Interspecies Internet emphasizes animal welfare science and pathways towards increased public empathy for animals and positive conservation policy impacts. It is imperative that advances in the field, and opportunities to accelerate scientific knowledge through various parainstitutional endeavors to decode, are oriented towards the benefit of all the species with which we share this planet.

Expanding our grasp of how other species communicate strengthens our efforts to protect, conserve, and value their existence. We hope the outcomes of this project will play an important role in ushering a sea change in our awareness and appreciation for the diversity of life and the intrinsic value of every species that shares our planetary home.

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