EAORC BULLETIN 1,163 – 28 September 2025

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NOTICES

FORMATTED VERSION OF THIS BULLETIN

A pdf formatted version of this Bulletin is available for download at martinedwardes.me.uk/eaorc/eaorc_bulletins.htm.

PUBLICATION ALERTS

If you have had a paper or book published, or you see something which would be of interest to the group, please send me a publication alert so that I can include it in the newsletter. Many thanks to those who have already sent in alerts.
If there is a journal you feel I should be tracking on a regular basis, let me know.

And if you have any other ideas for extending the "EAORC experience", please contact me.

EDITORIAL INTERJECTIONS

Comments in curly brackets are editorial interjections. The Editor reserves the right to be wrong, and doesn't object to being called out on it.

NEWS

SCIENCEADVISER – What's in a name? Ask a Denisovan

Want to start a fistfight at an anthropology conference (or at least a polite verbal tussle)? Ask which species Neanderthals and their close cousins, the Denisovans, belong to.

The definition of a species in the study of evolution has always been a slippery and imprecise one. You may have learned in school that two animals belong to the same species if they can produce viable offspring, but that's an oversimplification. After all, coyotes and wolves can have babies that have babies, but few would argue that the two canids are the same species. In truth, the boundaries between species are often messy, contentious and, ultimately, arbitrary.

Regarding Neanderthals in the above question, there are a few different camps the answers might come from. Some might go with Homo neanderthalensis, first proposed in 1863, named after Germany's Neander Valley where the first identified Neanderthal was found. Others argue Neanderthals are a subspecies of our own species, Homo sapiens, making them Homo sapiens neanderthalensis.

No less contentious are the proposed designation for Denisovans. No formal species name has been given to this hominin, which was first identified in 2010 based on the analysis of mitochondrial DNA sequenced from a finger bone found in Siberia's Denisova Cave. But one proposed candidate is Homo longi, a species name proposed for a skull found in Harbin, China, that was described in 2021. Researchers argued its morphological characteristics were distinct enough from other known hominins to warrant a separate species name. Then, earlier this year, ancient proteins confirmed the Harbin skull was a Denisovan. Now, a paper out this week in Science argues, based on morphological analysis, that a 1-million-year-old Chinese skull known as Yunxian 2, previously classified as Homo erectus, belongs to H. longi, too. And based on physical similarities between known Denisovans, the Harbin skull, and Yunxian 2, the authors argue that Denisovans most likely belong to the H. longi clade.

So, does that mean Denisovans should now be called Homo longi? According to the rules set down by the International Code of Zoological Nomenclature, there's a good case to be made that they should. After all, according to the ICZN's so-called Principle of Priority, "the valid name of a taxon is the oldest available name applied to it, unless that name has been invalidated or another name is given precedence." So, assuming you buy the argument that modern humans, Neanderthals and Denisovans deserve to be classified as separate species in the first place, then there's a good argument that Denisovans should now be considered H. longi.

Still, there's room for dissent. Some have argued that the Harbin skull may not accurately represent the breadth of Denisovan diversity, and just because the Harbin Denisovan can be called H. longi doesn't mean that all Denisovans should be lumped under the same taxonomic category. In this view, there may yet be other hominins currently categorized under the broad term Denisovan that deserve entirely different species names.

Time and debate and flurries of papers will eventually settle this issue. Punches may or may not get thrown.

https://www.science.org/doi/10.1126/science.ado9202

THE CONVERSATION – Chimpanzees ingest more than the equivalent of one alcoholic drink a day

Alcohol consumption is common across human societies, but do animals other than humans regularly drink alcohol?

https://theconversation.com/chimpanzees-ingest-more-than-the-equivalent-of-one-alcoholic-drink-a-day-new-research-265644

THE CONVERSATION – Major theories of consciousness may have focussed on the wrong part of the brain

Do we need to change the way we think about consciousness?

https://theconversation.com/major-theories-of-consciousness-may-have-been-focusing-on-the-wrong-part-of-the-brain-264609

PUBLICATIONS

Animal Behaviour

PAPERS

KAY E. HOLEKAMP – The complex societies of spotted hyaenas

Spotted hyaenas, Crocuta crocuta, have well-defined membership in social groups called 'clans'. In most parts of the species' range, each spotted hyaena clan controls its own space, with its members actively advertising and defending the group's communal territory. Clanmates compete daily for food, but they also often join forces to defend both territory boundaries

from neighbouring clans and kills from neighbours and lions, Panthera leo. Although most clans contain multiple matrilines, these matrilineal family units are secondary in importance to clans as the enduring social units that defend key resources, especially the group's shared space, but also individual ungulate carcasses. Females are philopatric but most males disperse, and clan membership is permeable to males but not females. These hyaenas can clearly distinguish conspecifics that belong to their clan from those that do not, using various sensory modalities. Clan membership changes as new members are born or immigrate into the clan, and as others emigrate or die, yet clans typically persist for multiple generations, although they are not permanent.
https://www.sciencedirect.com/science/article/abs/pii/S0003347225002283

Current Biology

ARTICLES

CORY T. MILLER – Animal cognition: Adaptive cooperation strategies in marmoset monkeys
A recent study found that marmoset monkeys learned to coordinate their actions to successfully complete a cooperative pulling task. Notably, the marmosets flexibly adapted their cooperative behaviors based on social context, demonstrating that cognitively guided cooperation is more widespread and dynamic in nonhuman primates than previously recognized.
https://www.cell.com/current-biology/abstract/S0960-9822(25)01023-1

ANON – Manvir Singh Q&A
Manvir Singh is an Assistant Professor of Anthropology at the University of California, Davis, where he directs the Integrative Anthropology Lab. His team investigates the evolutionary and cognitive foundations of complex cultural behaviors that reliably develop in human societies, including music, story, supernatural belief, and justice. Methodologically, he combines long-term ethnographic fieldwork, especially among Mentawai communities in Indonesia, with the construction and analysis of cross-cultural databases, such as on music and witchcraft. He holds a bachelor's degree in human biology from Brown University and a PhD in human evolutionary biology from Harvard University. He is a contributing writer at The New Yorker and is the author of Shamanism: The Timeless Religion (2025).
https://www.cell.com/current-biology/fulltext/S0960-9822(25)01078-4

Evolutionary Anthropology

PAPERS

AXEL G. EKSTRÖM et al – Rethinking Hominin Air Sac Loss in Light of Phylogenetically Meaningful Evidence
The evolution of laryngeal air sacs in hominins has been a subject of considerable debate, with particular attention given to the inferred presence of air sacs in Australopithecus afarensis and inferred absence in Middle and Upper Pleistocene hominins. We challenge several assumptions prevalent in relevant discourse and assert that (1) while exhibiting morphological similarity, it cannot be ruled out that relationships between hyoid morphology and air sac morphology in extant African great apes may reflect convergence; (2) while the only known A. afarensis hyoid exhibits "ape-like" bulla, this feature may have persisted following the loss of air sacs, and not be indicative of their presence per se; (3) because there are currently only five known hominin hyoid bones represented in the fossil record (with a single specimen predating the Middle Pleistocene) the evidential basis for interpreting air sac presence or absence is minimal; and (4) inferences toward a role of sexual selection and communicative behavior in explicating the loss of air sacs in the hominin lineage are undermined by the atypical sexual dimorphism patterns in early hominins. We advocate for a cautious approach to interpreting hominin behavior and evolution which prioritizes data over speculation, and underscore the need for rigorous evidence when constructing evolutionary narratives about early hominin vocal anatomy and its evolution.
https://onlinelibrary.wiley.com/doi/full/10.1002/evan.70019

FRANCESCO RIGOLI & JACK LENNON – Cultural Incentive Learning: How Culture Shapes Acquisition of Values
Although research on human values is abundant, it has so far neglected a crucial question: what are the psychological mechanisms whereby culture shapes people's values? To address this, the manuscript introduces a framework examining how culture shapes the acquisition of values, a process referred to as cultural incentive learning. The proposal is that cultural incentive learning mediates the influence exerted by the structure of society upon people's values. According to the framework, when the social structure changes, certain forms of learning (i.e., conditioned reinforcement) are elicited which promote value change. Simultaneously, other forms of learning, which are based on imitating other people's behavior, pull toward the preservation of previous values, ensuring that value change is not too precipitous and that group cooperation is maintained. Applying these principles to cultural evolution, the paper develops a theory of how values evolve over history, a process we label Value Evolution.
https://onlinelibrary.wiley.com/doi/full/10.1002/evan.70005

SVEN M. KASSER et al with MARCUS W. FELDMAN – Not by Selection Alone: Expanding the Scope of Gene-Culture Coevolution

Gene-culture coevolution (GCC)—an ambitious synthesis of biological and social sciences is often used to explain the evolution of key human traits. Despite the framework's broad conceptual appeal however, empirical evidence is often perceived as limited to a few key examples like lactase persistence. We argue this apparent gap between theoretical appeal and empirical evidence stems from conceptual ambiguities regarding the scope of relevant gene-culture interactions. Drawing on recent work in animal gene-culture coevolution and human genomics, we propose a "broad" approach that formally incorporates drift and migration alongside natural selection. This builds upon and subsumes the existing "narrow" framework focused on selection. Through case studies of skin pigmentation evolution and gift-exchange network influences on genetic variation in Melanesia, we demonstrate how cultural factors shape both adaptive and neutral genetic variation and population structure. This integrative perspective accommodates diverse empirical findings while opening new avenues for research in human evolution.
https://onlinelibrary.wiley.com/doi/full/10.1002/evan.70007

MARCELO O. ORTELLS & STEPHON STEWART – The Multivariate Basis of Human Brain Evolution: The Prerequisites of Fire Control and Cooking

This study investigates the evolutionary origins of the human brain, focusing on the trend of increasing size in hominins, while also addressing exceptions such as Homo naledi, Homo floresiensis, and the recent reduction observed in Homo sapiens. It examines hypotheses related to brain enlargement, challenging the Social Brain and Ecological Hypotheses by suggesting that the increase in brain size was not an inevitable response to social complexity or ecological pressures. While the Cooking Hypothesis is considered, it is not identified as the primary driver of brain expansion. Instead, fire control and cooking are proposed as prerequisites for sustaining brain size increases by meeting the energetic demands of larger brains. Additionally, we examine mutations that influenced brain size and complexity and contributed to the genetic variability that was pivotal to brain evolution, particularly in Africa during its final phase.
https://onlinelibrary.wiley.com/doi/abs/10.1002/evan.70008

JAYASHREE MAZUMDER & PARTH RANDHIR CHAUHAN – Revisiting "Tool" for a More Unified and Holistic Definition in Animal Behavior

Understanding the concept of "tool" is vital for the study of animal behavior and cognition. The definition of what exactly constitutes a tool, its characteristics, and the corresponding behaviors is pivotal yet challenging due to its often arbitrary and anthropocentric nature. This ambiguity hinders our comprehension and necessitates further exploration into the essence of tools. A precise and widely accepted definition is critical for progress in fields such as anthropology, cognitive science, and evolutionary biology, enabling a more focused study on the evolution of tool use. It is important to identify why and how certain objects become tools among different species, including humans. This paper seeks to refine the definition of a "tool" by synthesizing prior research involving tools, tooling, or tool-using animals, aiming to offer a unified framework that can support and guide future research endeavors in understanding the intricacies and evolution of tool use across species.
https://onlinelibrary.wiley.com/doi/abs/10.1002/evan.70014

GERALD E. LOEB – Did Down-Regulated Instincts Enable Human Gene-Culture Coevolution?

The unique intellectual and cultural attributes of Homo sapiens that arose during the Middle Stone Age are often ascribed to positive evolutionary development of novel physical or personality traits, but attempts to correlate cultural with genetic evolution have been unsuccessful. Humans are also unique, however, in their ability to ignore or override hormonal and pheromonal instincts that define the social structures and behaviors of other animals. Humans can rapidly invade new environments because they invent rather than inherit such behaviors, which cumulatively we call a culture. Downregulation of instincts makes the invention and learning of cultures necessary, which imposes both an opportunity and a burden on individuals and societies. Cultural evolution enables human societies to invent, promulgate, compete and evolve their social structures in a generation or two rather than the hundreds of generations required for significant genetic evolution. Nevertheless, residual instincts may conflict with and delimit novel cultures and their social structures.
https://onlinelibrary.wiley.com/doi/full/10.1002/evan.70015

JUDITH M. BURKART et al with CAREL P. VAN SCHAIK – Cooperative Breeding as a Likely Early Catalyst of Human Evolution

Unlike any other great ape, humans give birth to large, secondarily altricial babies, show precocial social development, have bigger brains that require a long maturation period, and engage in cooperative breeding (CB). These traits, which characterize the human adaptive complex, are intricately linked and must have mutually reinforced each other over evolutionary time. Here, we use recent evidence from paleontology, developmental psychology, and pediatrics, complemented with comparative analyses, to ask what may have triggered this coevolutionary feedback loop: bipedality, direct selection on altriciality, a higher-quality diet, or cooperative breeding. An early adoption of extensive allomaternal care during human evolution, that is, the CB-first model, best accommodates the available data. In particular, CB was a catalyst

enabling further increases in brain size, because even though larger brains slow down life history and neurodevelopment and thus lead to a demographic dilemma, CB enabled the necessary increase in birth rates.
https://onlinelibrary.wiley.com/doi/full/10.1002/evan.70016

MARCO BOGGIONI et al – Neanderthal Cranio-Cervical Features: Morphological Integration and Functional Evaluation of Their Early Appearance

Neanderthals (Homo neanderthalensis) and their direct ancestors are characterized by a number of derived cranial and postcranial morphological features. Many of these traits first appear in European Middle Pleistocene populations, likely as a result of adaptation and/or genetic drift. According to the "accretion model," this accumulation of traits was shaped by repeated extreme glacial conditions and associated demographic bottlenecks. However, the functional significance of many of these features—particularly those related to the cervical spine, basal cranium, mandible, and face—remains controversial, in part because they have often been studied in isolation. This paper reviews a set of traits that emerged early in the Neanderthal lineage and attempts to interpret them as part of an integrated morpho-functional system. To our knowledge, this is one of the first studies to examine multiple cranio-cervical traits of Homo neanderthalensis within a coherent, functionally integrated analytical framework.
https://onlinelibrary.wiley.com/doi/abs/10.1002/evan.70013

BEGUN ERBABA et al with WILLIAM D. HOPKINS & CHET C. SHERWOOD – Insights From Language-Trained Apes: Brain Network Plasticity and Communication

Language is central to the cognitive and sociocultural traits that distinguish humans, yet the evolutionary emergence of this capacity is far from fully understood. This review explores how the study of the brains of language-trained apes (LTAs) offers a unique and valuable opportunity to tease apart the relative contribution of evolved species differences, behavior, and environment in the emergence of complex communication abilities. For example, when raised in sociolinguistically rich and interactive environments, LTAs show communicative competencies that parallel aspects of early human language acquisition and exhibit altered neuroanatomy, including increased connectivity and laterization in regions associated with language. Sustained and enriched early exposure to symbolic experience may also alter molecular pathways, including modifications in the expression of genes involved in synaptic plasticity, neural connectivity, and cognitive function, thus critically underpinning speech and language processing. This theoretical synthesis highlights how research on language-trained apes can inform our understanding of experience-dependent plasticity in distributed neural networks, providing insights into the evolutionary origins of human communication.
https://onlinelibrary.wiley.com/doi/full/10.1002/evan.70018

NICOLE M. HERZOG & KATHRYN DEMPS – Adaptive Responses to Adversity Drive Innovation in Human Evolutionary History

Thinking is costly. Nonetheless, humans develop novel solutions to problems and share that knowledge prosocially. We propose that adversity, not prosperity, created a dependence on innovation in our ancestors who were forced through fitness valleys to develop new behaviors, which shaped our life history characteristics and a new evolutionary trajectory. Driven by competitive exclusion into novel habitats, and unable to reduce costs associated with finding appropriate food sources once there, our Pliocene ancestors adopted a diet different from our forest-dwelling great ape cousins. In a reimagining of classic foraging models we outline how those individuals, pushed into an ecotone with lower fitness, climbed out of the fitness valley by shifting to a diet dependent on extractive foraging. By reducing handling costs through gregarious foraging and emergent technology, our ancestors would have been able to find new optima on the fitness landscape, decreasing mortality by reducing risk and increasing returns, leading to extended life cycles and social reliance.
https://onlinelibrary.wiley.com/doi/abs/10.1002/evan.70006

EMMA VITALE, TATIANA R. FEUERBORN & MATTHEW WALLS – Human-Dog Symbiosis and Ecological Dynamics in the Arctic

Since the Late Pleistocene, humans and dogs have coevolved in the Arctic, forming a symbiotic relationship essential to survival, mobility, and adaptation. Archeological evidence shows dogs were used as traction animals by the Early Holocene, ultimately facilitating Inuit expansion and shaping Arctic settlement patterns. Despite recent declines in sled dog populations due to colonial factors, climate change, and cultural shifts, dogs remain central to Inuit identity. This paper frames the human-dog cooperation as a dynamic system of mutual learning, or enskilment, where both species acquire shared skills through collaboration. Tools like harnesses and whips serve as communicative devices within this system. Drawing on archeological and contemporary Inuit practices, the study highlights how embodied knowledge and animal agency contribute to ecological resilience. By viewing the Arctic as a co-managed landscape shaped by human-dog cooperation, the paper challenges static views of adaptation and underscores the enduring significance of this interspecies relationship.
https://onlinelibrary.wiley.com/doi/full/10.1002/evan.70009

TOLGA YILDIZ – The Cognitive Foundations of Ritual Monumentality: Multicausal Pathways to the Neolithic in Southwest Asia

This article reconceptualizes the Neolithic transformation in Southwest Asia as a cumulative and recursive process shaped by the interplay of symbolic cognition, ecological thresholds, ritual innovation, and demographic intensification. Departing from linear or monocausal models, it proposes that the emergence of agriculture, sedentism, and monumentality resulted not from discrete breakthroughs but from feedback loops between communication, cooperation, and cosmology. Drawing on recent archeological evidence from sites such as Göbekli Tepe, Körtik Tepe, WF16, and Jericho, as well as theoretical insights from cognitive evolution and ritual theory, the paper argues that symbolic institutions—ritual, architecture, and myth—were not consequences of surplus, but preconditions for its development. It distinguishes between ancient symbolic potential and the formalization of shared meaning into durable, transmittable cultural systems. Rather than treating Göbekli Tepe as an anomaly, the study situates it within a broader regional network of symbolic convergence and architectural innovation, tracing how ritual ecologies stabilized early social complexity. The article concludes by offering a multicausal, testable framework for understanding the Neolithic as a transformation in relations—between humans, environments, and shared representations.
https://onlinelibrary.wiley.com/doi/abs/10.1002/evan.70017

Frontiers in Human Dynamics

PAPERS

LYNN H. GAMBLE – Navigating cooperative marketplaces: the Chumash Indians and the dynamics of hunting/gathering/fishing economies

The Chumash Indians from Southern California produced, used, and traded shell beads for approximately 8,000–10,000 years. Their exchange network included an extensive portion of Western North America. Many scholars recognize that some shell beads from the region were used as currency starting at least 1,500 years ago. Substantial evidence for the production and use of these beads exists in the Santa Barbara Channel region, allowing researchers to investigate a hunting/gathering/fishing group's use of money in marketplaces. The Chumash Indians used money for purchasing food, ceremonial paraphernalia, and other items at open marketplaces during ritual gatherings with groups of southern California Indians from diverse cultural and linguistic backgrounds. The focus of the paper is to assess a non-state society to determine if its marketplace strategies are based on self-serving actors who do not promote cooperation, or if the participants create and maintain institutions to inhibit overexploitation and depletion of resources, therefore fostering cooperation. On the basis of ethnohistoric, ethnographic, and archeological data, I propose that among the Chumash, participants in their marketplaces organized and maintained institutions that furthered cooperation. The Chumash created hybrid spaces at their ritual gatherings where strategies such as altruistic punishment, market management, regular marketplace periodicity, and established marketplace locales served to promote cooperation. Understanding non-state societies that had an emphasis on trade networks and economic structures such as the Chumash is one means in revisiting past interpretations of premodern societies that traditionally were viewed as lacking marketplace exchange.
https://www.frontiersin.org/journals/human-dynamics/articles/10.3389/fhumd.2025.1606256/full

Human Nature

PAPERS

CLAUDIO TENNIE, WILLIAM D. SNYDER & RONALD J. PLANER – Costs of Early Stone Toolmaking cannot Establish the Presence of Know-how Copying

Compared to other apes, humans show a distinctive capacity for the cultural learning and transmission of know-how: we extract know-how from other individuals and artifacts in ways that regularly give rise to forms of know-how that no single individual could realistically invent on their own. Such a capacity is plausibly foundational to humans' striking cultural prowess and hence all that goes with it (e.g., symbolic language, religion). In this article, we critically examine attempts to date the transformation of know-how copying in the hominin lineage through an estimation of the costs of stone toolmaking. More specifically, we take as our target the idea that the costs inherent in making early stone tools, that is, Oldowan and Early Acheulean tools, already likely reflect a meaingful upgrade in hominin know-how copying abilities. Our survey of potentially relevant costs of stone toolmaking is generous, covering: (i) the risks and dangers of toolmaking; (ii) the time, energy, and opportunity costs of toolmaking; and finally (iii) the material costs of toolmaking. Ultimately, we find that, based on current evidence pertaining to these costs, the case for inferring know-how copying abilities in Oldowan or even Early Acheulean stone toolmakers is weak. This skeptical conclusion, combined with independent evidence that the design of stone tools during this period likely remained within the range of what the relevant hominins could invent without know-how copying, points to a later date for the establishment of this crucial human skill.
https://link.springer.com/article/10.1007/s12110-025-09494-w

GRANT S. MCCALL – Hominin Population Structure, Mating Systems, and Intrasexual Competition

The self-domestication hypothesis has made significant contributions to our thinking about hominin evolution and ecology. It has struggled, however, to find compelling and testable causes of reductions in hominin aggression and violent behavior. This paper examines variability among hominin mating systems and imbalances in operation sex ratios (OSRs) as a potential factor

influencing levels of aggression resulting from male intrasexual competition, i.e., male-male competitive aggression. This paper uses multivariate generalized linear modeling (GLM) to examine data from modern hunter-gatherer societies having to do with the causes and consequences of OSR imbalances (as reflected by levels of polygamy) and male intrasexual competition. This paper focuses especially on the role of population density as a potential source of OSR variability. This paper shows that population density correlates strongly with hunter-gatherer OSRs and that this relationship remains strong when controlling for the effects of other potentially intercorrelated variables. This paper shows that, among modern hunter-gatherers, lower population densities lead to greater imbalances in terms of OSRs and therefore higher levels of male-male aggression. This implies high levels of male intrasexual competition among early hominins given likely conditions of very low population densities. The paper closes by proposing some strategies for investigating hominin demographic patterning prehistorically and predicting OSR imbalances, as well as intrasexual competition, based on that information.
https://link.springer.com/article/10.1007/s12110-025-09498-6

Humanities and Social Sciences Communications

PAPERS

FANGZHE LU et al – The principle of anticipation in language use

Anticipation is a psychological phenomenon that refers to the beliefs or desires of cognitive agents with respect to the world surrounding them, and that can influence the behaviour and decisions of such agents. This paper addresses the status and the role of anticipation in the shaping of language structures. We sketch a preliminary theoretical framework for anticipation in language and linguistic research. Anticipation is presented as a neural mechanism that projects as a principle shaping cognitive processes. Anticipation is then shown to permeate a three-level architecture also shaping language use: the underlying cognitive structure, the middle-level information structure, and the surface discourse structure. It is suggested that anticipation in language may explicitly emerge as a relation between the informational (i.e. propositional and presuppositional) content of clauses and sentences. It is then suggested that anticipation plays a role across different language structures (e.g. subject–predicate and topic-comment structures; sentence types and multi-clausal discourses) and via different categories (e.g. Discourse Markers such as sentential adverbs, discourse connectives). It is proposed that this framework can capture several well-studied but recalcitrant linguistic phenomena in a unified manner by offering a model of how anticipations shape language use. The paper introduces preliminary evidence in support of these claims. First, clauses can minimally introduce anticipations as agents' expectations about sentences and their content. Second, discourse structures can modulate anticipations without the explicit presence of categories expressing these anticipations (e.g. Discourse Markers). When present, however, these categories must match the anticipation types that relations between sentences express. It is thus suggested that anticipation patterns can emerge in language as conceptual/rhetorical relations in discourse. The paper concludes by discussing the consequences of our proposal for linguistic theories that address the topic of anticipation in language and cognition.
https://www.nature.com/articles/s41599-025-05776-x

JINGJING WU & LE CHENG – Beyond binary opposition: philosophical reflections on a multi-level Language cognitive model from an embodied constructional perspective

Through the analysis of the bio-linguistic approach represented by Chomsky and the social cognitive approach represented by Tomasello, the paper finds neither theory is sufficient to fully explain current linguistic phenomena. This paper explores philosophical questions about the nature of language, especially new thoughts against the backdrop of AI language model development, and then establishes the Embodied Constructional-Cognitive Model (ECCM). The ECCM transcends this binary opposition, constructing three interconnected levels: the Cognitive-Constructional Level (CCL) processes language information based on general cognitive abilities; the Representational Integration Level (RIL) explains how language constructions are formed through embodied experience and integrated into the cognitive system; the Social-Interactive Level (SIL) focuses on the process by which language acquires complete meaning in the social dimension. The model proposes that language is essentially a multi-level cognitive tool formed through bodily experience and ecological construction, functioning to reduce environmental uncertainty and maintain the stability of self-symbols. This integrative theoretical framework has important implications for understanding the uniqueness of human language ability and the limitations of AIGC systems.
https://www.nature.com/articles/s41599-025-05690-2

YING WANG et al – The effect of childhood experience on consumers' willingness to donate: an imprinting perspective

Plenty of research has been done to examine the influence of corporate marketing activities on consumer behavior; however, less attention is paid to exploring the childhood experience that shapes consumers' donation intention. Most charitable organizations always view donations as a one-off effect, but charitable donation is a sustainable event resulting from childhood influence. Drawing on imprinting theory, this article deeply explores how perceived social support in childhood affects consumers' willingness to donate, and further, is empirically tested utilizing a survey method. Prosocial motivation and perspective taking are first introduced to construct a chain mediating model to explain the relationship between consumers' perceived social support in childhood and donation intention in adulthood. This paper concludes with discussions on the implications of theory, research, and practice.
https://www.nature.com/articles/s41599-025-05807-7

JINSEO PARK & AH JEONG HONG – Development and validation of civic engagement scale
This study identifies areas of civic engagement measurement that contribute to sustainable social revitalization. Applying the theory of motivation and behavior, we developed and validated a civic engagement scale through a comprehensive literature review and analysis to explore its concept and components. Interviews with five academics and nine field personnel, alongside two Delphi surveys, were conducted to verify the content validity of the civic engagement concepts, components, and preliminary questions. A civic engagement model was then developed to capture cognitive, affective, agentic, and relational behaviors. To ensure contemporary relevance, the scale development process incorporated evolving civic values such as environmental sustainability, cultural participation, and digital engagement. Using results from a preliminary survey (N = 206), we established a hypothesized model and validated it through a main survey (N = 842). We ensured scientific rigor by assessing the validity and reliability across dimensions. The study yielded a multidimensional framework for interpreting civic engagement, capturing highly engaged agentic and relational behaviors that existing tools may not measure. Additionally, shifts in citizens values were analyzed to propose new areas of civic engagement activity. Lastly, the validation process confirmed the scale's scientific rigor and demonstrated its reliability for interpretation.
https://www.nature.com/articles/s41599-025-05837-1

iScience

PAPERS

CLAIRE MARCOUT et al – Statistical Olfactory Learning in Honey Bees
Statistical learning is a cognitive process for detecting regularities in sensory inputs typically presented as strings of sounds, shapes or objects, enabling species to predict future events thereby guiding decision-making and behavior. Such an adaptive trait has been demonstrated in vertebrates, including human and non-human primates, birds, and dogs. It remains unclear whether invertebrates, which possess smaller and simpler neural systems than vertebrates, can extract statistical information from sensory inputs. Here, we show for the first time that honey bees are able to learn and recall the temporal (statistical) structure of an olfactory stimulus. These results suggest that statistical learning is a fundamental component of a conserved cognitive toolkit present even in invertebrates.
https://www.cell.com/iscience/fulltext/S2589-0042(25)01923-6

Journal of Linguistic Anthropology

PAPERS

STEPHANIE V. LOVE – Languaging as time travel
"So do you hear me? And how do you hear me?" Miyako Inoue (2003) ends her seminal article with this jarring, even uncanny interpellation. A "me" addressing a "you"—such a mundane occurrence. Yet here it pops out of an academic text at the most unexpected moment. I look around. Is she talking to me? Inoue momentarily ripped open spacetime to tap me on the shoulder, ensuring the phatic connection remained intact. Indeed, this warping of spacetime is precisely what Inoue's work illuminates: how absent people act on present social worlds. I heard Inoue's voice more than two decades after her words were first written, allowing myself to be interpellated as the subject of her utterance; this is precisely the type of subjectivity that many early career scholars, like me, desire—that is, to be recognized, addressed, even cited. More importantly, Inoue reminds me that this is what it means to do language—languaging is time travel. Past, present, and future people are engaging in a mysterious conversation with no certainty that anyone is listening (Irvine, 1996).
https://anthrosource.onlinelibrary.wiley.com/doi/full/10.1111/jola.70024

ANNA-MARIE SPRENGER – Listening at different scales: Sociolinguistic perception and the listening subject
This commentary argues that sociophonetic perception studies and linguistic anthropological analyses of the listening subject examine the same underlying process—ideologically structured listening—though at different observational scales. Drawing on Inoue's foundational work and subsequent research on enregisterment, mediatization, and indexical inversion, I show how experimental and ethnographic approaches each illuminate complementary dimensions of listening as both cognitive and sociohistorical. I advocate for a multiscalar model of listening that brings these traditions into closer dialogue, emphasizing how collaboration across methods can reveal the ideological conditions under which voices become audible, meaningful, and contested.
https://anthrosource.onlinelibrary.wiley.com/doi/full/10.1111/jola.70023

Nature Communications Biology

PAPERS

CHRISTOPHER KENDALL et al – Archaic adaptive introgression in modern human reproductive genes
Modern humans and archaic hominins, namely Denisovans and Neanderthals, have a long history of admixture. Some of these admixture events have allowed modern humans to adapt to new environments outside of Africa. Little research has been done on the impact of archaic introgression on genes associated with reproduction. In this study we report evidence of adaptive introgression of 118 genes within modern humans that have been previously associated with reproduction in mice

or modern humans. We identified 11 archaic core haplotypes, three that have been positively selected, with 327 archaic alleles being genome-wide significant for a variety of traits. Over 300 of these variants were discovered to be eQTLs regulating 176 genes with 81% of the archaic eQTLs overlapping a core haplotype region regulating genes expressed in reproductive tissues. Several of the adaptively introgressed genes in our results are enriched in developmental and cancer pathways, while some have been associated with embryo development and reproductive-inhibiting phenotypes like endometriosis and preeclampsia. Lastly, we find that archaic alleles overlapping an introgressed segment on chromosome 2 are protective against prostate cancer. Our results highlight that archaic alleles show connections with important developmental pathways throughout the lifespan and may help regulate these critical processes.
https://www.nature.com/articles/s42003-025-08682-9

Nature Human Behaviour

PAPERS

ERIN M. BUCHANAN et mul with CHRISTOPHER KOCH – Measuring the semantic priming effect across many languages
Semantic priming has been studied for nearly 50 years across various experimental manipulations and theoretical frameworks. Although previous studies provide insight into the cognitive underpinnings of semantic representations, they have suffered from small sample sizes and a lack of linguistic and cultural diversity. In this Registered Report, we measured the size and the variability of the semantic priming effect across 19 languages (n = 25,163 participants analysed) by creating the largest available database of semantic priming values using an adaptive sampling procedure. We found evidence for semantic priming in terms of differences in response latencies between related word-pair conditions and unrelated word-pair conditions. Model comparisons showed that the inclusion of a random intercept for language improved model fit, providing support for variability in semantic priming across languages. This study highlights the robustness and variability of semantic priming across languages and provides a rich, linguistically diverse dataset for further analysis. The Stage 1 protocol for this Registered Report was accepted in principle on 15 July 2022. The protocol, as accepted by the journal, can be found at https://osf.io/u5bp6 (registration) or https://osf.io/q4fjy (preprint version 6, 31 May 2022).
https://www.nature.com/articles/s41562-025-02254-x

Nature Scientific Reports

PAPERS

CRISTINA CARA et al – Prenatal brain connectivity and postnatal language: how familial risk and prenatal speech exposure shape early language skills
The maturation of the auditory-language brain network begins before birth, driven by gene-environment interactions. We investigated the association between familial and environmental factors and the foetal development of this network, as well as the predictive value of this association for postnatal language outcomes. Using prenatal resting-state fMRI, we examined 25 foetuses to identify functional connectivity within the auditory-language network. Postnatal language was assessed longitudinally between 1 and 3 years using the Bayley-III scale. Familial risk for language disorders and prenatal speech exposure were quantified using a newly developed questionnaire. First, hierarchical clustering on foetal functional connectivity confirmed that an auditory-language network can be identified in the foetal brain. In this network, foetuses with higher speech exposure exhibited increased connectivity between left-hemisphere regions and decreased connectivity between homologous right-hemisphere regions. Higher familial risk was linked to reduced connectivity within the left language network. Regression analyses revealed that prenatal functional connectivity between insula, caudate nucleus, and rolandic operculum significantly predicted postnatal language. These findings underscore the critical role of genetic and environmental influences in functionally shaping the foetal auditory-language network, with lasting impacts on early language development. By integrating prenatal brain connectivity, familial risk, and speech exposure, this study provides new insights into prenatal language neurodevelopment, highlighting its importance for future language capabilities.
https://www.nature.com/articles/s41598-025-17531-y

New Scientist

NEWS

Wild chimpanzees may get mildly intoxicated from alcoholic fruit
Chimpanzees are consuming significant levels of alcohol from their diet of ripe fruit and the finding may help explain the origins of humans' taste for alcohol.
https://www.newscientist.com/article/2496701-wild-chimpanzees-may-get-mildly-intoxicated-from-alcoholic-fruit/

REVIEWS

ALISON GEORGE – A compelling book about the end of the Neanderthals is a rare treat
Forget the tropes about how violence or maybe volcanic eruptions killed off our ancient cousins, The Last Neanderthal by Ludovic Slimak offers a very different take on how they died out.
Review of 'The Last Neanderthal' by Ludovic Slimak (translated by Andrew Brown), Polity Press (2025).

https://www.newscientist.com/article/mg26735620-500-a-compelling-book-about-the-end-of-the-neanderthals-is-a-rare-treat/

Physics of Life Reviews

PAPERS

MICHAEL J. WALKER – "Homo informatio"

A phylogenetic split ~7.5 Ma (million years ago) separated paninan ancestors that were unlike today's chimpanzees, from homininan ancestors that were unlike Homo sapiens today; neither had evolved into their modern physical and behavioural forms. Those paninans gave rise to the mainly frugivorous woodland-dwelling chimpanzees (Pan troglodytes), whose multifemale-multimale troops have social hierarchies where prominent parts are played by promiscuous males whose female offspring have little choice after menarche but to seek sexual partners in other troops, hostility between troops notwithstanding, whilst male promiscuity is incompatible with paternal interest in their offspring, interest being provided mainly by mothers or female alloparents. Contrary to widespread conjecture that the social arrangements of Pan were those of primaeval homininans, it is proposed here that ~4 Ma the nature of the mosaic landscapes (of grasslands and stands of trees) that were the habitat of australopithecine homininans, had 4 consequences that impinged on homininan evolution, differentiating it from that of woodland-dwelling paninans: (1) The diversity of whatever was available to eat was not the same in adjoining habitats of homininan social units, each of which may have been constrained by whatever mostly could be foraged, scavenged, eaten, or carried away, within perhaps a 2-hour walk; (2) Whatever was forageable, scavengeable, and edible within that distance likely was limited at any period of the year, so social units were increasingly omnivorous and necessarily small; (3) Smallness demanded cognitive ingenuity and transmissibility of existential information acquired by active inference generated by self-evidencing through enacted neuroethological behavioural responses, in line with the free energy principle, thanks to the cognitive broadening of homininan "zones of bounded surprisal" (ZBS) with respect to paninans' ZBS, both within each homininan "small-world" social unit and between nearby homininan units spreading out, in space and time, as budding very small-world information networks; (4) The existential continuity of small homininan social units depended on cooperation and sporadic collaboration between social units with mixed-sex philopatry (perhaps present ~4 Ma among Australopithecus anamensis), behaviour which, together with (a) the generation of information within each unit that is enhanced by the intimate proximity to toddlers and children of older females and males in small mixed-sex social units, and (b) mixed-sex dispersal of sexually-active partners establishing mixed-sex social units at newly-formed localities nearby, was behaviour that maintained not only heterozygosity, but also, crucial cognitive awareness of kinship links favouring transmissibility of information and cooperation and collaboration (rather than hostility) between neighbouring social units, and was behaviour that represented evolutionary cognitive and social divergence from paninans. The vulnerability of small fragile social units implies there were hundreds of false dawns between ~4 Ma and ~40,000 BCE when even Homo neanderthalensis had vanished, leaving only our prehistoric Homo sapiens ancestors bearing "Homo informatio's" highly-evolved hierarchically mechanistic mind with its unequalled wide cognitive "zone of bounded surprisal" (ZBS) grounded in active inference in accord with the free energy principle.
https://www.sciencedirect.com/science/article/pii/S1571064525001502

PLoS Biology

PAPERS

STEPHEN CURRY et mul – Ending publication bias: A values-based approach to surface null and negative results

Sharing knowledge is a basic tenet of the scientific community, yet publication bias arising from the reluctance or inability to publish negative or null results remains a long-standing and deep-seated problem, albeit one that varies in severity between disciplines and study types. Recognizing that previous endeavors to address the issue have been fragmentary and largely unsuccessful, this Consensus View proposes concrete and concerted measures that major stakeholders can take to create and incentivize new pathways for publishing negative results. Funders, research institutions, publishers, learned societies, and the research community all have a role in making this an achievable norm that will buttress public trust in science.
https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.3003368

PLoS One

PAPERS

BONNIE K. LAU et al – The relationship between intellectual ability and auditory multitalker speech perception in neurodivergent individuals

The ability to selectively attend to one talker in the presence of competing talkers is crucial to communication in noisy, real-world environments. In this study, we investigated the relationship between intellectual ability and speech perception under multitalker conditions. Since neurodivergent individuals show a wide range of intellectual ability, from above average IQ to intellectual disability, intellectual ability may be an important individual characteristic that impacts multitalker speech perception, but this is not currently well understood. We tested individuals with autism, fetal alcohol spectrum disorder, and an age- and sex-matched comparison group, all with typical hearing. We found a strong positive correlation between IQ and multitalker speech perception thresholds. This demonstrates that deficits in intellectual ability, despite intact peripheral

encoding of sound, are associated with difficulty listening under complex conditions for individuals with autism and fetal alcohol spectrum disorder. Future research is needed to investigate specific cognitive control mechanisms that contribute to difficulty listening under complex conditions. These findings suggest that audiological services to improve communication in real-world environments for neurodivergent individuals should be considered during clinical evaluations.
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0329581

ANITA RESTREPO et al – Loneliness is not associated with attention interference of negative social information: Evidence from four studies

Extended experiences of loneliness, defined as perceived social isolation, are associated with lasting impacts on health outcomes. One proposed mechanism through which loneliness contributes to health risk is heightened vigilance to cues of social threat resulting in extended activation of stress responses systems. This heightened vigilance is thought to be driven by loneliness-related shifts in a variety of cognitive and affective processes, though the differential effects of loneliness on specific stages of processing remain unclear. The present study examined four datasets using individual participant data meta-analytical techniques to test the link between loneliness and attention interference to social threat cues in an Emotional Stroop task. Despite existing theoretical frameworks predicting heightened attentional interference for negative social information in lonely individuals, we found no support for this effect across the four samples. These findings highlight the need for further work delving into the complex interplay between distinct perceptual processes associated with loneliness and how they contribute to the maintenance of loneliness states over time.
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0333167

JACOPO GENNAI et al – Tracking the emergence of the Upper Palaeolithic in western Asia and Europe: A Multiple Correspondence Analysis of Protoaurignacian and Southern Ahmarian lithics

Reconstructing changes in human behaviour during the Pleistocene, particularly when based on lithic or other artefact types, is often hindered by the traditional categorisation of these materials into discrete entities. The Early Upper Palaeolithic of Mediterranean Eurasia – comprising the Protoaurignacian, Early Aurignacian, Northern Ahmarian, and Southern Ahmarian technocomplexes – represents the first emergence of a pan-European cultural unit. However, this conventional categorisation into discrete entities obscures a deeper understanding of the dynamics of Homo sapiens' dispersal across Eurasia during this period. In this study, we apply Multiple Correspondence Analysis (MCA) to assess patterns of reduction processes, technological variability, and inter-assemblage homogeneity across technocomplexes. Using the comprehensive dataset provided in this paper, we analyse variability by grouping it into three domains: platform preparation, convexity management, and retouch. Solutrean Upper Palaeolithic assemblages from the Iberian Peninsula are used as an outgroup. We selected blanks, retouched and unmodified ones, and we focused on blades and bladelets, which are the typical end-product of the Upper Palaeolithic knapping. We excluded cores to avoid pitfalls of late or early reduction patterns, as our blanks cover most of the knapping sequence. We applied MCA to Early Upper Palaeolithic blanks for the first time, providing a geographically widespread comparison. Our results show that the MCA of blank attributes, particularly those describing the preparation of convexities, is sufficiently robust to reveal the distinctiveness of Early Upper Palaeolithic technologies relative to Solutrean ones. Our analysis also confirms technological similarities between the Southern Ahmarian and the Protoaurignacian, particularly in bladelet production, reinforcing the interpretation of bladelets as a primary production target in Early Upper Palaeolithic lithic technology. This study contributes laying the foundation for open-access databases, standardised analytical protocols, and MCA to support efforts in understanding hominin dispersal and interaction during this pivotal phase of prehistory.
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0331393

HANS VANDENDRIESSCHE & COLAS GUÉRET – Pressure knapping west of the Rhine during the Mesolithic? New evidence from Kerkhove (Belgium)

Until now, evidence for the use of pressure knapping in NW Europe during the Mesolithic has remained very scarce. In this paper, we present the technological (and functional) analysis of a new pressure knapped microbladelet assemblage from the Belgian site of Kerkhove. Attributed to the Middle Mesolithic (between 9525 and 8224 cal. BP), it marks an unexpected early appearance of this technique in the region, that strongly suggests knowledge transmission and contacts with the Maglemosian cultural area from Northern Germany and Southern Scandinavia where this technique was already present at that time. Nevertheless, based on the absolute scarcity of the evidence so far in NW Europe and based on the lack of genetic evidence, we argue that the spread of the pressure knapping technique to NW Europe did not involve large-scale demic diffusion as it was the case with its dispersal into Scandinavia. In Kerkhove, in addition, the limited size of the assemblage and the lack of other tools, cores and knapping waste related to pressure knapping and the lack of refits among the pressure knapped bladelets, indicates that it could have fulfilled a complementary role to the other lithic productions at the site, perhaps related to the (re)tooling of a very specific tool type akin to the slotted bone points/daggers known from the Maglemosian/Kongemosian area and the Baltic region.
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0330662

CHAOQUN WANG et al – Construction and application of a novel urban knowledge model with extended historical and cultural semantics

Historical urban spaces, imbued with profound historical and cultural significance, have evolved from 'spaces' into meaningful 'places'. But they now face the risk of being eroded by rapid urbanisation and forgotten by today's society, making it challenging to integrate them into modern life. UNESCO's Historic Urban Landscapes (HUL) Recommendation highlights the importance of understanding the holistic, layered, and dynamic nature of urban heritage. Therefore, focusing on the ancient city district of Guangzhou as a case study, this research explores innovative approaches to integrating holistic semantics of urban places by merging contemporary semantics from geo-big data with historical and cultural semantics from documents and archives to create an urban knowledge model that bridges the gap between the present and the past. Furthermore, using knowledge graph embedding technology, we develop a model capable of entity prediction, similarity calculation, and query retrieval. We propose four key application scenarios for the implementation of the model. First, our research identifies potential cultural spatial connections that contribute to the joint preservation and promotion of historic urban places. Second, we develop a recommendation system that caters to users' various requests, increasing the visibility of historical places. Third, we predict optimal locations for Time-Honored Brands. Finally, we identify visitor profiles to assist managers in meeting cultural promotion needs. To summarize, the integrated framework proposed in this study demonstrates both methodological efficacy and reusability. It not only helps to deeply explore the historical and cultural connotations, providing a scientific basis for urban planning and cultural inheritance, but also has the potential for enhancing the public's awareness and participation in historical culture, promoting the sustainable development and prosperity of urban culture.

https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0331170

Proceedings of the Royal Society B

PAPERS

NING TANG et al – Joint commitment in human cooperative hunting through an 'imagined we'

Cooperation involves the challenge of jointly selecting one from multiple goals while maintaining the team's joint commitment to it. We test joint commitment in a multi-player hunting game, combining psychophysics and computational modelling. Joint commitment is modelled through an 'imagined we' (IW) approach, where each agent infers the intention of 'we', an imagined supraindividual agent controlling all agents as its body parts. This is compared against a reward sharing model, which frames cooperation through the positive reinforcement of sharing in the rewards of a successful hunt. Both humans and IW, but not reward sharing, maintained high performance by jointly committing to a single prey, regardless of prey quantity or speed. Human observers rated all hunters in both human and IW teams as making high contributions to the catch, regardless of their proximity to the prey, suggesting that high-quality hunting stemmed from sophisticated cooperation rather than individual strategies. Unlike reward sharing hunters, IW hunters are capable of cooperating not only with one another but also with human participants actively engaged in the same hunting game. In conclusion, these results strongly suggest that humans achieve cooperation through joint commitment that enforces a single goal, rather than simply motivating members through reward sharing.

https://royalsocietypublishing.org/doi/10.1098/rspb.2024.3070

Science

PAPERS

XIAOBO FENG et al with CHRIS STRINGER – The phylogenetic position of the Yunxian cranium elucidates the origin of Homo longi and the Denisovans

Diverse forms of Homo coexisted during the Middle Pleistocene. Whether these fossil humans represent different species or clades is debated. The ~1-million-year-old Yunxian 2 fossil from China is important for understanding the cladogenesis of Homo and the origin of Homo sapiens. In this study, we restored and reconstructed the distorted Yunxian 2 cranium using recently introduced technology. The results show that this cranium displays mosaic primitive and derived features. Morphometric and phylogenetic analyses suggest that it is an early member of the Asian H. longi clade, which includes the Denisovans and is the main part of the sister group to the H. sapiens clade. Both the H. sapiens and H. longi clades have deep roots extending beyond the Middle Pleistocene and probably experienced rapid early diversification. Yunxian 2 may preserve transitional features close to the origins of the two clades.

https://www.science.org/doi/10.1126/science.ado9202

Science Advances

PAPERS

CHARLOTTE HELFRICH-FÖRSTER et al – Synchronization of women's menstruation with the Moon has decreased but remains detectable when gravitational pull is strong

To increase reproductive success, many species synchronize reproductive behavior with a particular phase of the lunar cycle. The human menstrual cycle has also a period close to that of the lunar cycle, and recent studies suggest a temporary synchrony between menstrual and lunar cycles. Nevertheless, lunar influence on human reproductive behavior remains

controversial. Here, we analyzed long-term menstrual records of individual women from the past 24 years and compared them with records from the past century. We show that women's menstrual cycles recorded before the introduction of light-emitting diodes in 2010 and the extensive use of smart phones significantly synchronized with the Moon, while those after 2010 coupled to the Moon mostly in January. We hypothesize that the high gravimetric forces between the Moon, Sun, and Earth every January are sufficient for this coupling, while the increasing exposure to artificial light at night impinges on synchrony at other times.
https://www.science.org/doi/10.1126/sciadv.adw4096

Trends in Cognitive Sciences

PAPERS

FELIPE PARODI, KONRAD P. KORDING & MICHAEL L. PLATT – Primate neuroethology: a new synthesis
Neuroscience has probed only a sliver of the rich cognitive, emotional, and social behaviors that enable primates to thrive in the real world. Technological breakthroughs allow us to quantify these behaviors alongside wireless neural recordings. New studies reveal that neural activity is intricately bound to movement and is profoundly modulated by behavioral context, emotional states, and social dynamics. We frame our review of primate neuroethology around Niko Tinbergen's four foundational questions – function, mechanism, development, and evolution – to unify classic ethological insights with modern neuroscience tools. We demonstrate that investigating natural behavior promises deep insights into primate cognition, which are relevant for advanced brain–machine interfaces, improved therapies for neurological disorders, and deeper understanding of natural and artificial intelligence.
https://www.cell.com/trends/cognitive-sciences/abstract/S1364-6613(25)00241-4

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