

## EAORC BULLETIN 1,020 – 1 January 2023

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## NOTICES

### 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.

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### ACADEMIA.EDU – The Early Prehistory of Western and Central Asia

*In Colin Renfrew & Paul Bahn (eds.), The Cambridge World Prehistory, Vol VII, Western and Central Asia. Cambridge University Press, 1357-1378 (2014).*

#### GONEN SHARON – The Early Prehistory of Western and Central Asia

The region that is the focus of this chapter is but a small stretch of land enjoying Mediterranean climate, located between the Mediterranean Sea to the west and one of the harshest deserts on earth to the east. The Levantine Corridor (Goren-Inbar & Speth 2004), despite its small size, has been subject to one of the most intensive archaeological efforts anywhere. Here some of the world’s most important prehistoric sites have been discovered during almost one hundred years of excavation.

Together with new sites, they remain the source for many of the cutting-edge questions and debates in palaeoanthropology today. The story of the Levant in early prehistory is first of all the story of a corridor, the main pathway leading out of Africa

taken by continuous waves of human groups reaching out for new territory in Eurasia. Some of the very early evidence for human presence outside of Africa is succeeded in the region by indications of subsequent Lower Palaeolithic dispersals, followed by the earliest movement of anatomically modern humans out of Africa during the Middle Palaeolithic. Our current focus on the Levantine Corridor, to the exclusion of the remainder of Asia, is due to the fact that Central Asian data are almost non-existent to date. R. Dennell provides the few data from Central Asia in his recently published book (Dennell 2009), and the reader is advised to consult this monumental work. Yet even this scholar, who has focused considerable attention on Asia, wrote: “The Palaeolithic record of the west region, covering an area c. 16 times larger than Britain, is largely unknown, and mostly comprises surface artifact collections that are not datable” (Dennell 2009: 325). Central Asia is clearly a key region for the discussion of the most significant questions in early prehistoric archaeology today. Currently, political and geographical difficulties stand in the way of scholars working in these vast regions, but exciting discoveries will surely emerge with the advance of research in the future.

[https://www.academia.edu/10350949/The\\_Early\\_Prehistory\\_of\\_Central\\_and\\_Western\\_Asia](https://www.academia.edu/10350949/The_Early_Prehistory_of_Central_and_Western_Asia)

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## NEWS

### SCIENCE NEWS – Deadly sharp points found in Idaho could be first American-made tools

Spear-tip techniques may have made their way from Japan more than 16,000 years ago.

<https://www.science.org/content/article/deadly-sharp-points-found-idaho-could-be-first-american-made-tools>

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### THE CONVERSATION – How different the world would look if Neanderthals had prevailed

Neanderthals were wiped out by chance changes in the environment. The rise of Homo sapiens wasn't inevitable.

<https://theconversationuk.cmail20.com/t/r-l-tidyihjy-khhilillah-f/>

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## PUBLICATIONS

### American Journal of Biological Anthropology

#### PAPERS

#### TRACY L. KIVELL et al – Form, function and evolution of the human hand

The modern human hand is an intriguing mix of primitive morphology and derived function. Traditionally, its form and function are explained as a functional “trade-off” between the requirements of locomotion and manipulation, but recently acquired comparative, experimental and fossil evidence suggests that this functional trade-off is more complex than conventional wisdom suggests. Moreover, when studying hand evolution within the hominin clade, the only morphological evidence comes from the hard-tissues, and evidence about hand function must be inferred indirectly from the archaeological record. We lack information about critical aspects of hand form (e.g., soft tissues) and function (e.g., neurology) as well as non-lithic evidence about behavior. Thus, comparative anatomical, experimental and ethological studies of modern humans and other primates are critical to making more informed inferences about hand use in the past. We review the relevant fossil and archaeological evidence within the relevant comparative context (e.g., other extant apes and dexterous monkeys) in an attempt to reconstruct hand evolution within the hominin clade. We conclude by summarizing our current understanding—or lack thereof—of the evolutionary history of the modern human hand.

<https://onlinelibrary.wiley.com/doi/full/10.1002/ajpa.24667>

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### Evolutionary Anthropology

#### PAPERS

#### MANVIR SINGH – Subjective selection and the evolution of complex culture

Why is culture the way it is? Here I argue that a major force shaping culture is subjective (cultural) selection, or the selective retention of cultural variants that people subjectively perceive as satisfying their goals. I show that people evaluate behaviors and beliefs according to how useful they are, especially for achieving goals. As they adopt and pass on those variants that seem best, they iteratively craft culture into increasingly effective-seeming forms. I argue that this process drives the development of many cumulatively complex cultural products, including effective technology, magic and ritual, aesthetic traditions, and institutions. I show that it can explain cultural dependencies, such as how certain beliefs create corresponding new practices, and I outline how it interacts with other cultural evolutionary processes. Cultural practices everywhere, from spears to shamanism, develop because people subjectively evaluate them to be effective means of satisfying regular goals.

<https://onlinelibrary.wiley.com/doi/abs/10.1002/evan.21948>

#### CHRISTINA M. BALENTINE & DEBORAH A. BOLNICK – Parallel evolution in human populations: A biocultural perspective

Parallel evolution—where different populations evolve similar traits in response to similar environments—has been a topic of growing interest to biologists and biological anthropologists for decades. Parallel evolution occurs in human populations thanks to myriad biological and cultural mechanisms that permit humans to survive and thrive in diverse environments

worldwide. Because humans shape and are shaped by their environments, biocultural approaches that emphasize the interconnections between biology and culture are key to understanding parallel evolution in human populations as well as the nuances of human biological variation and adaptation. In this review, we discuss how biocultural theory has been and can be applied to studies of parallel evolution and adaptation more broadly. We illustrate this through four examples of parallel evolution in humans: malaria resistance, lactase persistence, cold tolerance, and high-altitude adaptation.

<https://onlinelibrary.wiley.com/doi/abs/10.1002/evan.21956>

## REVIEWS

### ANDREA RAVIGNANI – Language evolution: Sound meets gesture?

Review of 'From signal to symbol: The evolution of language' by R. Planer & K. Sterelny. MIT Press (2021).

<https://onlinelibrary.wiley.com/doi/abs/10.1002/evan.21961>

### CHARLES C. ROSEMAN – Will celebrating complexity get us where we need to go?

Review of 'Race, Monogamy, and Other Lies They Told You: Busting Myths About Human Nature' 2nd Edition by Agustín Fuentes. University of California Press (2022).

<https://onlinelibrary.wiley.com/doi/abs/10.1002/evan.21959>

## Human Nature

### PAPERS

#### AARON D. LIGHTNER & EDWARD H. HAGEN – All Models Are Wrong, and Some Are Religious: Supernatural Explanations as Abstract and Useful Falsehoods about Complex Realities

Many cognitive and evolutionary theories of religion argue that supernatural explanations are byproducts of our cognitive adaptations. An influential argument states that our supernatural explanations result from a tendency to generate anthropomorphic explanations, and that this tendency is a byproduct of an error management strategy because agents tend to be associated with especially high fitness costs. We propose instead that anthropomorphic and other supernatural explanations result as features of a broader toolkit of well-designed cognitive adaptations, which are designed for explaining the abstract and causal structure of complex, unobservable, and uncertain phenomena that have substantial impacts on fitness. Specifically, we argue that (1) mental representations about the abstract vs. the supernatural are largely overlapping, if not identical, and (2) when the data-generating processes for scarce and ambiguous observations are complex and opaque, a naive observer can improve a bias-variance trade-off by starting with a simple, underspecified explanation that Western observers readily interpret as "supernatural." We then argue that (3) in many cases, knowledge specialists across cultures offer pragmatic services that involve apparently supernatural explanations, and their clients are frequently willing to pay them in a market for useful and effective services. We propose that at least some ethnographic descriptions of religion might actually reflect ordinary and adaptive responses to novel problems such as illnesses and natural disasters, where knowledge specialists possess and apply the best available explanations about phenomena that would otherwise be completely mysterious and unpredictable.

<https://link.springer.com/article/10.1007/s12110-022-09437-9>

#### ZE HONG – Combining Conformist and Payoff Bias in Cultural Evolution: An Integrated Model for Human Decision-Making

Most research on transmission biases in cultural evolution has treated different biases as distinct strategies. Here I present a model that combines both frequency dependent bias (including conformist bias) and payoff bias in a single decision-making calculus and show that such an integrated learning strategy may be superior to relying on either bias alone. Natural selection may operate on humans' relative dependence on frequency and payoff information, but both are likely to contribute to the spread of variants with high payoffs. Importantly, the magnitude of conformist bias affects the evolutionary dynamics, and I show that an intermediate level of conformity may be most adaptive and may spontaneously evolve as it resists the invasion of low-payoff variants yet enables the fixation of high-payoff variants in the population.

<https://link.springer.com/article/10.1007/s12110-022-09435-x>

## iScience

### PAPERS

#### CLAIRE A. DE MARCH et al – Genetic and functional odorant receptor variation in the Homo lineage

Humans, Neandertals, and Denisovans independently adapted to a wide range of geographic environments and their associated food odors. Using ancient DNA sequences, we explored the in vitro function of thirty odorant receptor genes in the genus Homo. Our extinct relatives had highly conserved olfactory receptor sequence, but humans did not. Variations in odorant receptor protein sequence and structure may have produced variation in odor detection and perception. Variants led to minimal changes in specificity but had more influence on functional sensitivity. The few Neanderthal variants disturbed function, while Denisovan variants increased sensitivity to sweet and sulfur odors. Geographic adaptations may have produced greater functional variation in our lineage, increasing our olfactory repertoire and expanding our adaptive capacity.

Our survey of olfactory genes and odorant receptors suggests that our genus has a shared repertoire with possible local ecological adaptations.

[https://www.cell.com/iscience/fulltext/S2589-0042\(22\)02181-2](https://www.cell.com/iscience/fulltext/S2589-0042(22)02181-2)

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## Linguistic Anthropology

### PAPERS

#### **LUKE FLEMING – Dispensing with Europe: A comparative linguistic anthropology of honorific pronouns**

The study of pronominal address in European languages is enriched by a comparative linguistic anthropology of honorific registers of person deixis. In European speech communities, token-sourced interdiscursivity plays a crucial role in framing the meaning of honorific (V) and nonhonorific (T) pronouns; the pronouns exchanged between members of an interlocutor dyad in a given discursive event presuppose the use of those same pronouns in sequentially prior events of interaction between that dyad. The shift from V to T within a serially ordered speech chain of discursive events - sanctified in the interaction ritual of 'dispensation' - is the pivot of the system, emblemizing a mutual incorporation of alter into the relatively 'intimate' sphere of interpersonal relationality. Beyond Europe, T-V systems typically rely more heavily on type-sourced interdiscursivity. In these cases, use of T or V stereotypically indexes particular social categories of person or relationship. There are profound formal-functional convergences in honorific person deixis cross-linguistically, like the use of nonsingular number to index deference. Nevertheless, there are important differences too. The pragmatic structures characterizing honorific registers of person deixis are shown to co-vary in important ways with this distinction between token-sourced and type-sourced social meaningfulness of pronominal alternants.

<https://anthrosource.onlinelibrary.wiley.com/doi/abs/10.1111/jola.12386>

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## Mind & Language

### PAPERS

#### **ANSGAR D. ENDRESS – In defense of epicycles: Embracing complexity in psychological explanations**

Is formal simplicity a guide to learning in humans, as simplicity is said to be a guide to the acceptability of theories in science? Does simplicity determine the difficulty of various learning tasks? I argue that, similarly to how scientists sometimes preferred complex theories when this facilitated calculations, results from perception, learning and reasoning suggest that formal complexity is generally unrelated to what is easy to learn and process by humans, and depends on assumptions about available representational and processing primitives. "Simpler" hypotheses are preferred only when they are also easier to process. Historically, "simpler", easier-to-process, scientific theories might also be preferred if they are transmitted preferentially. Empirically viable complexity measures should build on the representational and processing primitives of actual learners, even if explanations of their behaviour become formally more complex.

<https://onlinelibrary.wiley.com/doi/full/10.1111/mila.12450>

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## Nature Human Behaviour

### PAPERS

#### **JEFFREY A. BROOKS et al – Deep learning reveals what vocal bursts express in different cultures**

Human social life is rich with sighs, chuckles, shrieks and other emotional vocalizations, called 'vocal bursts'. Nevertheless, the meaning of vocal bursts across cultures is only beginning to be understood. Here, we combined large-scale experimental data collection with deep learning to reveal the shared and culture-specific meanings of vocal bursts. A total of n = 4,031 participants in China, India, South Africa, the USA and Venezuela mimicked vocal bursts drawn from 2,756 seed recordings. Participants also judged the emotional meaning of each vocal burst. A deep neural network tasked with predicting the culture-specific meanings people attributed to vocal bursts while disregarding context and speaker identity discovered 24 acoustic dimensions, or kinds, of vocal expression with distinct emotion-related meanings. The meanings attributed to these complex vocal modulations were 79% preserved across the five countries and three languages. These results reveal the underlying dimensions of human emotional vocalization in remarkable detail.

<https://www.nature.com/articles/s41562-022-01489-2>

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## New Scientist

### ARTICLES

#### **MICHAEL MARSHALL – When did hominins start cooking? It might be earlier than we thought**

We know for certain cooking isn't unique to our species and that it was going on 750,000 years ago. The evidence of hominins deliberately exposing their food to heat is being pushed back further all the time.

<https://www.newscientist.com/article/mg25634180-300-when-did-hominins-start-cooking-it-might-be-earlier-than-we-thought/>

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**Philosophical Transactions of the Royal Society B**
**PAPERS****N. J. ENFIELD – Linguistic concepts are self-generating choice architectures**

While the idea of a 'concept' has been defined in diverse ways, researchers in the cognitive science of language have largely agreed that linguistic concepts are objects, whether mental or physical, that bits of language stand for. This O-axis view (where O = object), focusing on sign–object relations, sees linguistic concepts as ideas that stand in a static relation to signs, with the function of mediating relations between agents and their environments. But this is only half the story. Because every linguistic concept is moored to a bit of language, and bits of language are mostly learned and encountered in sequences of social interaction, then we must look not only at what signs stand for (their objects), but at the interpretants, or rational responses, that they elicit. By focusing on sign–interpretant relations, and thus taking an I-axis view (where I = interpretant), we not only acknowledge the direct link between concepts and social interaction, we also discover causal mechanisms that explain how linguistic concepts are distributed in relatively stable form in populations. We find that while concepts are indeed mental objects, they function as choice architectures in the dynamic flow of situated language usage.

<https://royalsocietypublishing.org/doi/abs/10.1098/rstb.2021.0352>

**NICHOLAS SHEA – Concepts as plug & play devices**

Research on concepts has focused on categorization. Categorization starts with a stimulus. Equally important are episodes that start with a thought. We engage in thinking to draw out new consequences from stored information, or to work out how to act. Each of the concepts out of which thought is constructed provides access to a large body of stored information. Access is not always just a matter of retrieving a stored belief (semantic memory). Often it depends on running a simulation. Simulation allows conceptual thought to draw on information in special-purpose systems, information stored in special-purpose computational dispositions and special-purpose representational structures. While the utility of simulation, prospection or imagination is widely appreciated, the role of concepts in the process is not well understood. This paper turns to cognitive and computational neuroscience for a model of how simulations enable thinkers to reach novel conclusions. Carried over to conceptual thought, the model suggests that concepts are 'plug & play' devices. The distinctive power of thought-driven simulation derives from the ability of concepts to plug into two kinds of structure at once: the combinatorial structure of a thought at one end and special-purpose structural representations at the other.

<https://royalsocietypublishing.org/doi/full/10.1098/rstb.2021.0353>

**PETER LANGLAND-HASSAN & CHARLES P. DAVIS – A context-sensitive and non-linguistic approach to abstract concepts**

Despite the recent upsurge in research on abstract concepts, there remain puzzles at the foundation of their empirical study. These are most evident when we consider what is required to assess a person's abstract conceptual abilities without using language as a prompt or requiring it as a response—as in classic non-verbal categorization tasks, which are standardly considered tests of conceptual understanding. After distinguishing two divergent strands in the most common conception of what it is for a concept to be abstract, we argue that neither reliably captures the kind of abstraction required to successfully categorize in non-verbal tasks. We then present a new conception of concept abstractness—termed 'trial concreteness'—that is keyed to individual categorization trials. It has advantages in capturing the context-relativity of the degree of abstraction required for the application of a concept and fittingly correlates with participant success in recent experiments.

<https://royalsocietypublishing.org/doi/abs/10.1098/rstb.2021.0355>

**SARA DE FELICE et al – Learning from others is good, with others is better: the role of social interaction in human acquisition of new knowledge**

Learning in humans is highly embedded in social interaction: since the very early stages of our lives, we form memories and acquire knowledge about the world from and with others. Yet, within cognitive science and neuroscience, human learning is mainly studied in isolation. The focus of past research in learning has been either exclusively on the learner or (less often) on the teacher, with the primary aim of determining developmental trajectories and/or effective teaching techniques. In fact, social interaction has rarely been explicitly taken as a variable of interest, despite being the medium through which learning occurs, especially in development, but also in adulthood. Here, we review behavioural and neuroimaging research on social human learning, specifically focusing on cognitive models of how we acquire semantic knowledge from and with others, and include both developmental as well as adult work. We then identify potential cognitive mechanisms that support social learning, and their neural correlates. The aim is to outline key new directions for experiments investigating how knowledge is acquired in its ecological niche, i.e. socially, within the framework of the two-person neuroscience approach.

<https://royalsocietypublishing.org/doi/full/10.1098/rstb.2021.0357>

**HADAR KARMAZYN-RAZ & LINDA B. SMITH – Sampling statistics are like story creation: a network analysis of parent–toddler exploratory play**

Actions in the world elicit data for learning and do so in a stream of interconnected events. Here, we provide evidence on how toddlers with their parent sample information by acting on toys during exploratory play. We observed 10 min of free-flowing and unconstrained object exploration of by toddlers (mean age 21 months) and parents in a room with many

available objects ( $n = 32$ ). Borrowing concepts and measures from the study of narratives, we found that the toy selections are not a string of unrelated events but exhibit a suite of what we call coherence statistics: Zipfian distributions, burstiness and a network structure. We discuss the transient memory processes that underlie the moment-to-moment toy selections that create this coherence and the role of these statistics in the development of abstract and generalizable systems of knowledge.

<https://royalsocietypublishing.org/doi/full/10.1098/rstb.2021.0358>

**FRANZISKA E. VIETTEL, OLIVER REIS & KATHARINA J. ROHLFING – Acquiring religious words: dialogical and individual construction of a word's meaning**

By the age of eight, there is a significant increase in abstract words in the child's lexicon. A crucial contribution can be seen in the linguistic input, i.e. the way how abstract words are presented by caregivers by means of linguistic perspectivation and emotionalization. Following an interactionist way, we were interested in how the semantics of abstract words is constructed by child and caregiver in duet. We focused on a subset of abstract words and studied the acquisition of meaning of the religious concept mercy. We expected religious words to be emotionally anchored and presented with perspectivation, both contributing to learning. Exploring the dialogic constructions, we investigated eight 7- to 8-year olds and their parents during dialogic reading and studied their strategies focusing on the linguistic means of emotionalization and perspectivation in contextualizing the word. In a subsequent test, we analysed these means used by the children and assessed their individual understanding of mercy. Our analyses indicate that during reading, the enrichment of semantics by emotionalization was related between child and caregiver, whereas cross-situationally, a simultaneous enrichment of emotionalization and perspectivation was present. Moreover, the children demonstrated a conceptual understanding of mercy in religious contexts, but not in secular contexts.

<https://royalsocietypublishing.org/doi/full/10.1098/rstb.2021.0359>

**EDGAR J. ANDRADE-LOTERO et al – The division of linguistic labour for offloading conceptual understanding**

The division of linguistic labour (DLL), initially theorized by philosophers, has gained the attention of cognitive scientists in the last decade. Contrary to some controversial philosophical accounts of DLL, we propose that it is an extended mind strategy of offloading conceptual understanding onto other people. In this article, we empirically explore this proposal by providing an exploratory experimental paradigm to search for the mechanisms underwriting DLL and how they may work in practice. We developed a between-subjects experiment in which participants had to categorize two pairs of highly confusable dog breeds after receiving categorization training on just one pair of breeds. In the treatment group, participants were grouped in dyads and were allowed to interact with each other by means of the labels of these four dog breeds. In their queries to trained 'experts', novices frequently used labels to refer to breeds that they could not identify themselves. Experts were highly responsive to their paired novices' queries, and the rates of querying for the two members within a dyad were positively correlated. Independent categorization failure and offloading categorization success lead to subsequent increases in querying by novices, indicating adaptive use of offloading. Self-reports of breed knowledge were higher for experts within a dyad compared to isolated experts.

<https://royalsocietypublishing.org/doi/abs/10.1098/rstb.2021.0360>

**KARSTEN OLSEN & KRISTIAN TYLÉN – On the social nature of abstraction: cognitive implications of interaction and diversity**

The human capacity for abstraction is remarkable. We effortlessly form abstract representations from varied experiences, generalizing and flexibly transferring experiences and knowledge between contexts, which can facilitate reasoning, problem solving and learning across many domains. The cognitive process of abstraction, however, is often portrayed and investigated as an individual process. This paper addresses how cognitive processes of abstraction—together with other aspects of human reasoning and problem solving—are fundamentally shaped and modulated by online social interaction. Starting from a general distinction between convergent thinking, divergent thinking and processes of abstraction, we address how social interaction shapes information processing differently depending on cognitive demands, social coordination and task ecologies. In particular, we suggest that processes of abstraction are facilitated by the interactive sharing and integration of varied individual experiences. To this end, we also discuss how the dynamics of group interactions vary as a function of group composition; that is, in terms of the similarity and diversity between the group members. We conclude by outlining the role of cognitive diversity in interactive processes and consider the importance of group diversity in processes of abstraction.

<https://royalsocietypublishing.org/doi/abs/10.1098/rstb.2021.0361>

**GRETA GANDOLFI, MARTIN J. PICKERING & SIMON GARROD – Mechanisms of alignment: shared control, social cognition and metacognition**

In dialogue, speakers process a great deal of information, take and give the floor to each other, and plan and adjust their contributions on the fly. Despite the level of coordination and control that it requires, dialogue is the easiest way speakers possess to come to similar conceptualizations of the world. In this paper, we show how speakers align with each other by mutually controlling the flow of the dialogue and constantly monitoring their own and their interlocutors' way of representing information. Through examples of conversation, we introduce the notions of shared control, meta-

representations of alignment and commentaries on alignment, and show how they support mutual understanding and the collaborative creation of abstract concepts. Indeed, whereas speakers can share similar representations of concrete concepts just by mutually attending to a tangible referent or by recalling it, they are likely to need more negotiation and mutual monitoring to build similar representations of abstract concepts.

<https://royalsocietypublishing.org/doi/full/10.1098/rstb.2021.0362>

**PENNY M. PEXMAN, VERONICA DIVEICA & RICHARD J. BINNEY – Social semantics: the organization and grounding of abstract concepts**

Abstract concepts, like justice and friendship, are central features of our daily lives. Traditionally, abstract concepts are distinguished from other concepts in that they cannot be directly experienced through the senses. As such, they pose a challenge for strongly embodied models of semantic representation that assume a central role for sensorimotor information. There is growing recognition, however, that it is possible for meaning to be ‘grounded’ via cognitive systems, including those involved in processing language and emotion. In this article, we focus on the specific proposal that social significance is a key feature in the representation of some concepts. We begin by reviewing recent evidence in favour of this proposal from the fields of psycholinguistics and neuroimaging. We then discuss the limited extent to which there is consensus about the definition of ‘socialness’ and propose essential next steps for research in this domain. Taking one such step, we describe preliminary data from an unprecedented large-scale rating study that can help determine how socialness is distinct from other facets of word meaning. We provide a backdrop of contemporary theories regarding semantic representation and social cognition and highlight important predictions for both brain and behaviour.

<https://royalsocietypublishing.org/doi/full/10.1098/rstb.2021.0363>

**PAMELA LOPES DA CUNHA et al – Social concepts and the cerebellum: behavioural and functional connectivity signatures in cerebellar ataxic patients**

Neurocognitive research on social concepts underscores their reliance on fronto-temporo-limbic regions mediating broad socio-cognitive skills. Yet, the field has neglected another structure increasingly implicated in social cognition: the cerebellum. The present exploratory study examines this link combining a novel naturalistic text paradigm, a relevant atrophy model and functional magnetic resonance imaging. Fifteen cerebellar ataxia (CA) patients with focal cerebellar atrophy and 29 matched controls listened to a social text (highlighting interpersonal events) as well as a non-social text (focused on a single person's actions), and answered comprehension questionnaires. We compared behavioural outcomes between groups and examined their association with cerebellar connectivity. CA patients showed deficits in social text comprehension and normal scores in the non-social text. Also, social text outcomes in controls selectively correlated with connectivity between the cerebellum and key regions subserving multi-modal semantics and social cognition, including the superior and medial temporal gyri, the temporal pole and the insula. Conversely, brain-behaviour associations involving the cerebellum were abolished in the patients. Thus, cerebellar structures and connections seem involved in processing social concepts evoked by naturalistic discourse. Such findings invite new theoretical and translational developments integrating social neuroscience with embodied semantics.

<https://royalsocietypublishing.org/doi/abs/10.1098/rstb.2021.0364>

**DIMITRIS BOLIS, GUILLAUME DUMAS & LEONHARD SCHILBACH – Interpersonal attunement in social interactions: from collective psychophysiology to inter-personalized psychiatry and beyond**

In this article, we analyse social interactions, drawing on diverse points of views, ranging from dialectics, second-person neuroscience and enactivism to dynamical systems, active inference and machine learning. To this end, we define interpersonal attunement as a set of multi-scale processes of building up and materializing social expectations—put simply, anticipating and interacting with others and ourselves. While cultivating and negotiating common ground, via communication and culture-building activities, are indispensable for the survival of the individual, the relevant multi-scale mechanisms have been largely considered in isolation. Here, collective psychophysiology, we argue, can lend itself to the fine-tuned analysis of social interactions, without neglecting the individual. On the other hand, an interpersonal mismatch of expectations can lead to a breakdown of communication and social isolation known to negatively affect mental health. In this regard, we review psychopathology in terms of interpersonal misattunement, conceptualizing psychiatric disorders as disorders of social interaction, to describe how individual mental health is inextricably linked to social interaction. By doing so, we foresee avenues for an inter-personalized psychiatry, which moves from a static spectrum of disorders to a dynamic relational space, focusing on how the multi-faceted processes of social interaction can help to promote mental health.

<https://royalsocietypublishing.org/doi/full/10.1098/rstb.2021.0365>

**BRIONY BANKS & LOUISE CONNELL – Multi-dimensional sensorimotor grounding of concrete and abstract categories**

Semantic categories, and the concepts belonging to them, have commonly been defined by their relative concreteness, that is, their reliance on perception. However, sensorimotor grounding must be regarded as going beyond the basic five senses and incorporate a multi-dimensional variety of perceptual and action experience. We present a series of exploratory analyses examining the sensorimotor grounding of participant-produced member concepts for 117 categories, spanning concrete (e.g. animal and furniture) and highly abstract (e.g. unit of time and science) categories. We found that both concrete and abstract



categories are strongly grounded in multi-dimensional sensorimotor experience. Both domains were dominated by vision and, to a lesser extent, head movements, but concrete categories were more grounded in touch and hand–arm action, while abstract categories were more grounded in hearing and interoception. Importantly, this pattern of grounding was not uniform, and subdomains of concrete (e.g. ingestibles, animates, natural categories and artefacts) and abstract (e.g. internal, social and non-social) categories were grounded in different profiles of sensorimotor experience. Overall, these findings suggest that the distinction between abstract and concrete categories is not as clearcut as ontological assumptions might suggest, and that the strength and diversity of sensorimotor grounding in abstract categories must not be underestimated.

<https://royalsocietypublishing.org/doi/full/10.1098/rstb.2021.0366>

**JOANNA RĄCZASZEK-LEONARDI & JULIAN ZUBEK – Is love an abstract concept? A view of concepts from an interaction-based perspective**

Research concerning concepts in the cognitive sciences has been dominated by the information-processing approach, which has resulted in a certain narrowing of the range of questions and methods of investigation. Recent trends have sought to broaden the scope of such research, but they have not yet been integrated within a theoretical framework that would allow us to reconcile new perspectives with the insights already obtained. In this paper, we focus on the processes involved in early concept acquisition and demonstrate that certain aspects of these processes remain largely understudied. These aspects include the primacy of movement and coordination with others within a structured social environment as well as the importance of first-person experiences pertaining to perception and action. We argue that alternative approaches to cognition, such as ecological psychology, enactivism and interactivism, are helpful for foregrounding these understudied areas. These approaches can complement the extant research concerning concepts to help us obtain a more comprehensive view of knowledge structures, thus providing us with a new perspective on recurring problems, suggesting novel questions and enriching our methodological toolbox.

<https://royalsocietypublishing.org/doi/full/10.1098/rstb.2021.0356>

**LAURA BARCA et al – Mapping the mental space of emotional concepts through kinematic measures of decision uncertainty**

Emotional concepts and their mental representations have been extensively studied. Yet, some ecologically relevant aspects, such as how they are processed in ambiguous contexts (e.g., in relation to other emotional stimuli that share similar characteristics), are incompletely known. We employed a similarity judgement of emotional concepts and manipulated the contextual congruency of the responses along the two main affective dimensions of hedonic valence and physiological activation, respectively. Behavioural and kinematics (mouse-tracking) measures were combined to gather a novel ‘similarity index’ between emotional concepts, to derive topographical maps of their mental representations. Self-report (interoceptive sensibility, positive–negative affectivity, depression) and physiological measures (heart rate variability, HRV) have been collected to explore their possible association with emotional conceptual representation. Results indicate that emotional concepts typically associated with low arousal profit by contextual congruency, with faster responses and reduced uncertainty when contextual ambiguity decreases. The emotional maps recreate two almost orthogonal axes of valence and arousal, and the similarity measure captures the smooth boundaries between emotions. The emotional map of a subgroup of individuals with low positive affectivity reveals a narrower conceptual distribution, with variations in positive emotions and in individuals with reduced arousal (such as those with reduced HRV). Our work introduces a novel methodology to study emotional conceptual representations, bringing the behavioural dynamics of decision-making processes and choice uncertainty into the affective domain.

<https://royalsocietypublishing.org/doi/abs/10.1098/rstb.2021.0367>

**BODO WINTER – Abstract concepts and emotion: cross-linguistic evidence and arguments against affective embodiment**

How are abstract concepts such as ‘freedom’ and ‘democracy’ represented in the mind? One prominent proposal suggests that abstract concepts are grounded in emotion. Supporting this ‘affective embodiment’ account, abstract concepts are rated to be more strongly positive or more strongly negative than concrete concepts. This paper demonstrates that this finding generalizes across languages by synthesizing rating data from Cantonese, Mandarin Chinese, Croatian, Dutch, French, German, Indonesian, Italian, Polish and Spanish. However, a deeper look at the same data suggests that the idea of emotional grounding only characterizes a small subset of abstract concepts. Moreover, when the concreteness/abstractness dimension is not operationalized using concreteness ratings, it is actually found that concrete concepts are rated as more emotional than abstract ones. Altogether, these results suggest limitations to the idea that emotion is an important factor in the grounding of abstract concepts.

<https://royalsocietypublishing.org/doi/abs/10.1098/rstb.2021.0368>

**OPHELIA DEROY – Olfactory abstraction: a communicative and metacognitive account**

The usual puzzle raised about olfaction is that of a deficit of abstraction: smells, by contrast notably with colours, do not easily lend themselves to abstract categories and labels. Some studies have argued that the puzzle is culturally restricted and that abstraction is more common outside urban Western societies. Here, I argue that the puzzle is misconstrued and should

be reversed: given that odours are constantly changing and that their commonalities are difficult for humans to identify, what is surprising is not that abstract terms are rare, but that they should be used at all for olfaction. Given the nature of the olfactory environment and our cognitive equipment, concrete labels referring to sources seem most adaptive. To explain the use and presence of abstract terms, we need to examine their social and communicative benefits. Here these benefits are spelt out as securing a higher agreement among individuals varying in their olfactory experiences as well as the labels they use, as well as feeling a heightened sense of confidence in one's naming capacities.

<https://royalsocietypublishing.org/doi/abs/10.1098/rstb.2021.0369>

**FRANCESCO MANNELLA & LUCA TUMMOLINI – Kick-starting concept formation with intrinsically motivated learning: the grounding by competence acquisition hypothesis**

Although the spontaneous origins of concepts from interaction is often given for granted, how the process can start without a fully developed sensorimotor representation system has not been sufficiently explored. Here, we offer a new hypothesis for a mechanism supporting concept formation while learning to perceive and act intentionally. We specify an architecture in which multi-modal sensory patterns are mapped in the same lower-dimensional representation space. The motor repertoire is also represented in the same space via topological mapping. We posit that the acquisition of these mappings can be mutually constrained by maximizing the convergence between sensory and motor representations during online interaction. This learning signal reflects an intrinsic motivation of competence acquisition. We propose that topological alignment via competence acquisition eventually results in a sensorimotor representation system. To assess the consistency of this hypothesis, we develop a computational model and test it in an object manipulation task. Results show that such an intrinsically motivated learning process can create a cross-modal categorization system with semantic content, which supports perception and intentional action selection, which has the resources to re-enact its own multi-modal experiences, and, on this basis, to kick-start the formation of concepts grounded in the external environment.

<https://royalsocietypublishing.org/doi/full/10.1098/rstb.2021.0370>

**ANNA M. BORGHI & CHARLES FERNYHOUGH – Concepts, abstractness and inner speech**

We explore the role of inner speech (covert self-directed talk) during the acquisition and use of concepts differing in abstractness. Following Vygotsky, inner speech results from the internalization of linguistically mediated interactions that regulate cognition and behaviour. When we acquire and process abstract concepts, uncertainties about word meaning might lead us to search actively for their meaning. Inner speech might play a role in this searching process and be differentially involved in concept learning compared with use of known concepts. Importantly, inner speech comes in different varieties—e.g. it can be expanded or condensed (with the latter involving syntactic and semantic forms of abbreviation). Do we use inner speech differently with concepts varying in abstractness? Which kinds of inner speech do we preferentially use with different kinds of abstract concepts (e.g. emotions versus numbers)? What other features of inner speech, such as dialogicality, might facilitate our use of concepts varying in abstractness (by allowing us to monitor the limits of our knowledge in simulated social exchanges, through a process we term inner social metacognition)? In tackling these questions, we address the possibility that different varieties of inner speech are flexibly used during the acquisition of concepts and their everyday use.

<https://royalsocietypublishing.org/doi/full/10.1098/rstb.2021.0371>

**QIAWEN LIU & GARY LUPYAN – Cross-domain semantic alignment: concrete concepts are more abstract than you think**

We can easily evaluate similarities between concepts within semantic domains, e.g. doctor and nurse, or violin and piano. Here, we show that people are also able to evaluate similarities across domains, e.g. aligning doctors with pianos and nurses with violins. We argue that understanding how people do this is important for understanding conceptual organization and the ubiquity of metaphorical language. We asked people to answer questions of the form 'If a nurse were an animal, they would be a(n) ...' (Experiments 1 and 2) and asked them to explain the basis for their response (Experiment 1). People converged to a surprising degree (e.g. 20% answered 'cat'). In Experiment 3, we presented people with cross-domain mappings of the form 'If a nurse were an animal, they would be a cat' and asked them to indicate how good each mapping was. The results showed that the targets people chose and their goodness ratings of a given response were predicted by similarity along abstract semantic dimensions such as valence, speed and genderedness. Reliance on such dimensions was also the most common explanation for their responses. Altogether, we show that people can evaluate similarity between very different domains in predictable ways, suggesting either that seemingly concrete concepts are represented along relatively abstract dimensions (e.g. weak–strong) or that they can be readily projected onto these dimensions.

<https://royalsocietypublishing.org/doi/abs/10.1098/rstb.2021.0372>

**MALTE R. HENNINGSEN-SCHOMERS, MAX GARAGNANI & FRIEDEMANN PULVERMÜLLER – Influence of language on perception and concept formation in a brain-constrained deep neural network model**

A neurobiologically constrained model of semantic learning in the human brain was used to simulate the acquisition of concrete and abstract concepts, either with or without verbal labels. Concept acquisition and semantic learning were simulated using Hebbian learning mechanisms. We measured the network's category learning performance, defined as the extent to which it successfully (i) grouped partly overlapping perceptual instances into a single (abstract or concrete)

conceptual representation, while (ii) still distinguishing representations for distinct concepts. Co-presence of linguistic labels with perceptual instances of a given concept generally improved the network's learning of categories, with a significantly larger beneficial effect for abstract than concrete concepts. These results offer a neurobiological explanation for causal effects of language structure on concept formation and on perceptuo-motor processing of instances of these concepts: supplying a verbal label during concept acquisition improves the cortical mechanisms by which experiences with objects and actions along with the learning of words lead to the formation of neuronal ensembles for specific concepts and meanings. Furthermore, the present results make a novel prediction, namely, that such 'Whorfian' effects should be modulated by the concreteness/abstractness of the semantic categories being acquired, with language labels supporting the learning of abstract concepts more than that of concrete ones.

<https://royalsocietypublishing.org/doi/full/10.1098/rstb.2021.0373>

#### **GUY O. DOVE – Rethinking the role of language in embodied cognition**

There has been a lot of recent interest in the way that language might enhance embodied cognition. This interest is driven in large part by a growing body of evidence implicating the language system in various aspects of semantic memory—including, but not limited to, its apparent contribution to abstract concepts. In this essay, I develop and defend a novel account of the cognitive role played by language in our concepts. This account relies on the embodied nature of the language system itself, diverges in significant ways from traditional accounts, and is part of a flexible, multimodal and multilevel view of our conceptual system.

<https://royalsocietypublishing.org/doi/abs/10.1098/rstb.2021.0375>

#### **EXPRESSION OF CONCERN**

##### **PTRSB EDITORS – 'Chimpanzee vowel-like sounds and voice quality suggest formant space expansion through the hominoid lineage' (2022) by Grawunder et al.**

Following the publication of 'Chimpanzee vowel-like sounds and voice quality suggest formant space expansion through the hominoid lineage' Phil. Trans. R. Soc. B377: 20200455 (Published online: 15 November 2021), it has been brought to the attention of the Editorial team that there are concerns regarding this study. An investigation into these aspects is under way, and the journal is, therefore, issuing an expression of concern and will notify readers as to the results of our investigation as soon as possible.

<https://royalsocietypublishing.org/doi/full/10.1098/rstb.2022.0476>

## **PLoS Biology**

### **ARTICLES**

#### **ALEXANDER GAIL – Turning decisions into actions**

Are selection and control of action serial processes of separate neural modules? A new study in PLOS Biology argues against this and in favor of an integrated process distributed across multiple brain regions, each contributing in a distinct way.

<https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.3001927>

### **PAPERS**

#### **DAVID THURA et al – Integrated neural dynamics of sensorimotor decisions and actions**

Recent theoretical models suggest that deciding about actions and executing them are not implemented by completely distinct neural mechanisms but are instead two modes of an integrated dynamical system. Here, we investigate this proposal by examining how neural activity unfolds during a dynamic decision-making task within the high-dimensional space defined by the activity of cells in monkey dorsal premotor (PMd), primary motor (M1), and dorsolateral prefrontal cortex (dlPFC) as well as the external and internal segments of the globus pallidus (GPe, GPi). Dimensionality reduction shows that the four strongest components of neural activity are functionally interpretable, reflecting a state transition between deliberation and commitment, the transformation of sensory evidence into a choice, and the baseline and slope of the rising urgency to decide. Analysis of the contribution of each population to these components shows meaningful differences between regions but no distinct clusters within each region, consistent with an integrated dynamical system. During deliberation, cortical activity unfolds on a two-dimensional "decision manifold" defined by sensory evidence and urgency and falls off this manifold at the moment of commitment into a choice-dependent trajectory leading to movement initiation. The structure of the manifold varies between regions: In PMd, it is curved; in M1, it is nearly perfectly flat; and in dlPFC, it is almost entirely confined to the sensory evidence dimension. In contrast, pallidal activity during deliberation is primarily defined by urgency. We suggest that these findings reveal the distinct functional contributions of different brain regions to an integrated dynamical system governing action selection and execution.

<https://journals.plos.org/plosbiology/article?id=10.1371/journal.pbio.3001861>

**PENNIE HAIGH, NAVEEN HANIF & ANGELA DE BRUIN – Diving into a pool or volcano? Examining the influence of sentence context and task demands on sentence reading in younger and older adults**

Cognitive ageing is often associated with slower lexical processing, which might influence both language production and comprehension. Words are typically used in context, which can further influence word processing and potential age differences. However, it remains unclear how older adults are affected by context during reading. Older adults are reported to have intact semantic knowledge, which could potentially help them to process words predicted by semantic information in the preceding context. However, potential difficulties with semantic control might mean older adults have greater difficulty suppressing interfering information from mismatching contexts. In this study we examined the influence of contexts that either predicted a specific target word (“matched”, e.g., “The man watched the lava erupt from the volcano”) or predicted another word than the target (“mismatched”, e.g., “The swimmer dived into the volcano”) as compared to neutral contexts (e.g., “They went to see the volcano”). We also examined the potential role of task demands by asking participants to either just read the sentences for comprehension or to answer questions. Forty younger adults (18–35 years old) and forty older adults (65–80 years old) completed a self-paced reading task in which we measured reading times for the target words. Older adults showed slower reading times overall. Matched sentence contexts facilitated reading times in both age groups. Surprisingly, mismatched sentence contexts did not hinder reading times in either age group. Furthermore, reading times were not influenced by task demands. Together, this shows the importance of studying language in context. While interference from mismatching sentence contexts might have not been substantial enough to delay reading, reading was faster when processing expected words. This suggests older adults can indeed benefit from semantic knowledge to facilitate word processing during comprehension. This occurred even when no additional task was presented and people were purely reading for comprehension.

<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0279555>

**HELEN L. LONG et al – Perspectives on the origin of language: Infants vocalize most during independent vocal play but produce their most speech-like vocalizations during turn taking**

A growing body of research emphasizes both endogenous and social motivations in human vocal development. Our own efforts seek to establish an evolutionary and developmental perspective on the existence and usage of speech-like vocalizations (“protophones”) in the first year of life. We evaluated the relative occurrence of protophones in 40 typically developing infants across the second-half year based on longitudinal all-day recordings. Infants showed strong endogenous motivation to vocalize, producing vastly more protophones during independent vocal exploration and play than during vocal turn taking. Both periods of vocal play and periods of turn-taking corresponded to elevated levels of the most advanced protophones (canonical babbling) relative to periods without vocal play or without turn-taking. Notably, periods of turn taking showed even more canonical babbling than periods of vocal play. We conclude that endogenous motivation drives infants’ tendencies to explore and display a great number of speech-like vocalizations, but that social interaction drives the production of the most speech-like forms. The results inform our previously published proposal that the human infant has been naturally selected to explore protophone production and that the exploratory inclination in our hominin ancestors formed a foundation for language.

<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0279395>

**SHARIFAH ZAHHURA SYED ABDULLAH – Menstrual food restrictions and taboos: A qualitative study on rural, resettlement and urban indigenous Temiar of Malaysia**

Menstruation is arguably the first stage in a woman’s reproductive cycle. Among the Temiar, as in many other traditional societies, menstruation represents a time during which a woman is considered to be vulnerable or polluted and there may be food or behavior avoidances and restrictions. The Temiar is one of the eighteen indigenous sub-ethnic groups in Peninsular Malaysia. The objective of this study was to examine the food restrictions and taboos imposed on menstruating Temiar women. A total of 38 participants from four different locations took part in five focus group discussions which represents different lifestyle experiences of the Temiar sub-ethnic group. The findings unfold many practices: foods to be avoided and spirit in the landscape in order to protect the menstruating woman; isolating the menstruating woman in order to protect the community; consequences of not observing the menstruation food taboos and maintenance of the menstrual taboos. The menstruating women in all locations were prohibited from consuming salt, cooking oils, wild or domesticated animals, and Monosodium glutamate to protect themselves from the excessive flow of menstrual blood and future ill-health. They must eat separately from others because they are deemed polluted and dangerous to the community. The study concludes that the taboos directed towards the menstruating women often do have a caring and protective intention. Menstrual restrictions function not only to protect the menstruating women and the community but also to keep intact the symbolic boundary between human and the non-human world from which disease and weakness comes.

<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0279629>

**KAI-YIN LIN & JEFFREY C. SCHANK – Small group size promotes more egalitarian societies as modeled by the hawk-dove game**

The social organization of groups varies greatly across primate species, ranging from egalitarian to despotic. Moreover, the typical or average size of groups varies greatly across primate species. Yet we know little about how group size affects social organization across primate species. Here we used the hawk-dove game (HDG) to model the evolution of social organization as a function of maximum group size and used the evolved frequency of hawks as a measure of egalitarian/despotism in societies. That is, the lower the frequency of hawks, the more egalitarian a society is, and the higher the frequency of hawks, the more despotic it is. To do this, we built an agent-based model in which agents live in groups and play the HDG with fellow group members to obtain resources to reproduce offspring. Offspring inherit the strategy of their parent (hawk or dove) with a low mutation rate. When groups reach a specified maximum size, they are randomly divided into two groups. We show that the evolved frequency of hawks is dramatically lower for relatively small maximum group sizes than predicted analytically for the HDG. We discuss the relevance of group size for understanding and modeling primate social systems, including the transition from hunter-gatherer societies to agricultural societies of the Neolithic era. We conclude that group size should be included in our theoretical understanding of the organization of primate social systems.

<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0279545>

**PALOMA DE LA PEÑA, MARC THOMAS & TUMELO R. MOLEFYANE – Particle size distribution: An experimental study using southern African reduction methods and raw materials**

We experimentally created a particle size dataset that is based on reduction sequences and raw materials typical of the Middle and Later Stone Age in southern Africa. The reason for creating this new dataset is that current particle size frameworks are based, almost exclusively, on flint and western European knapping methods. We produced the dataset using knapping methods and raw materials frequently encountered in the southern African archaeological record because we wanted to test whether it has the same distribution as particle size datasets experimentally created in Europe, and to initialise the production of a database for use in the analysis of lithic assemblages from southern African Late Pleistocene deposits. We reduced 117 cores of quartz, quartzite, jasper, chalcedony, hornfels, and rhyolite. The knapping methods selected were unidirectional, discoidal, Levallois recurrent and bipolar flaking. In this article we compare this new particle size distribution dataset with the results obtained from previous experiments. We found that the southern African dataset shows a wider size range distribution, which seems to be explained by differences in knapping methods and raw materials. Our results show that there is overlap between the distribution of the southern African experimental knapping dataset and the sorting experiment conducted by Lenoble on flint artefacts in a runoff context. This article shows that a particle size analysis is not sufficient on its own to assess the perturbation of an archaeological assemblage and must be coupled with other analytical tools.

<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0278867>

**ANTONIO CABRALES, RYAN KENDALL & ANGEL SÁNCHEZ – The effectiveness of prosocial policies: Gender differences arising from social norms**

We study policies aimed at discouraging behavior that produces negative externalities, and their differential gender impact. Using driving as an application, we carry out an experiment where slowest vehicles are the safest choice, whereas faster driving speeds lead to higher potential payoffs but higher probabilities of accidents. Faster speeds have a personal benefit but create a negative externality. We consider four experimental policy conditions: a baseline situation, a framing condition in which drivers are suggested that driving fast violates a social norm, and two punishment conditions, one exogenous and one endogenous. We find that the most effective policies use different framing and endogenously determined punishment mechanisms (to fast drivers by other drivers). These policies are only effective for female drivers which leads to substantial gender payoff differences. Our data suggest that these results arise from differences in social norms across genders, thus opening the way to designing more effective policies.

<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0275383>

**PNAS****PAPERS****BRIAN LEAHY et al – Minimal representations of possibility at age 3**

Young children do not always consider alternative possibilities when planning. Suppose a prize is hidden in a single occluded container and another prize is hidden in an occluded pair. If given a chance to choose one container and receive its contents, choosing the singleton maximizes expected reward because each member of the pair might be empty. Yet, 3-y-olds choose a member of the pair almost half the time. Why don't they maximize expected reward? Three studies provide evidence that 3-y-olds do not deploy possibility concepts like MIGHT, which would let them represent that each container in the pair might and might not contain a prize. Rather, they build an overly specific model of the situation that correctly specifies that the singleton holds a prize while inappropriately specifying which member of the pair holds a prize and which is empty. So, when asked to choose a container, they see two equally good options. This predicts approximately 50% choice of the singleton, observed in studies 1 and 3. But when asked to throw away a container so that they can receive the remaining contents (study 2), they mostly throw away a member of the pair. The full pattern of data is expected if children construct overly

specific models. We discuss whether 3-year-olds lack possibility concepts or whether performance demands prevent deployment of them in our tasks.

<https://www.pnas.org/doi/full/10.1073/pnas.2207499119>

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