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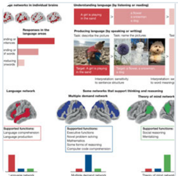
Delighted to share our perspective piece “Language is primarily a tool for communication rather than thought” now out in Nature:
(with long-term collaborators (and friends) @spiantado and @LanguageMIT) 1/n



Language is primarily a tool for communication rather than thought - Nature
Evidence from neuroscience and related fields suggests that language and thought processes operate in distinct networks in the human brain and that language is optimized for communication and not for …
https://www.nature.com/articles/s41586-024-07522-w

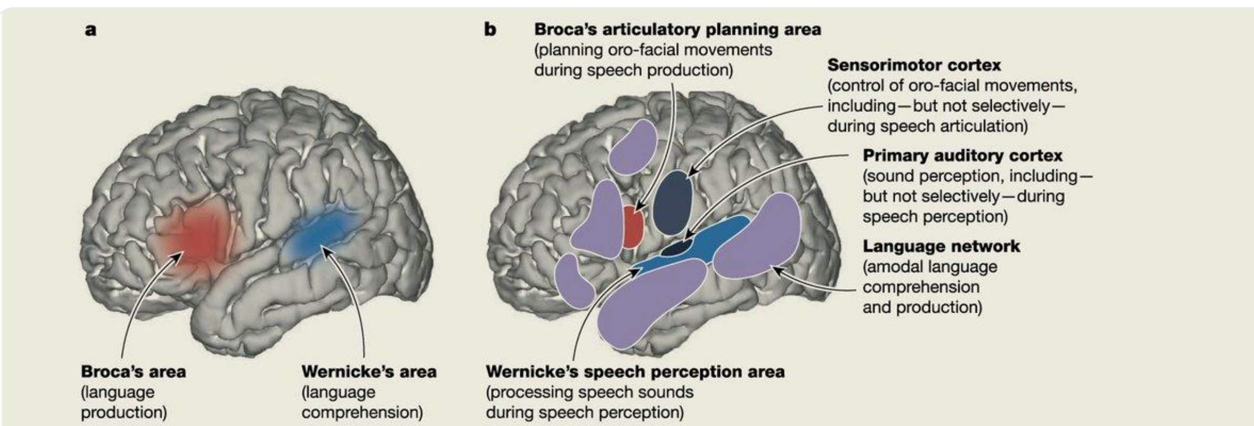
The functions of language and why it emerged have long been debated. We evaluate 2 key hypotheses about the function of language in modern humans: i) language subserves communication and ii) language mediates thinking (see Box 1 for discussion of variants of hypothesis ii). 2/n

These hypotheses make testable predictions. If language mediates thinking then ling. mechanisms should be engaged when we think, and thought should not be possible absent language. If language is a tool for communication, it should show hallmarks of efficient info transfer. 3/n

Why is NOW a good time to take stock? In the last 20yrs a) we've made progress in deciphering the 🧠 basis of language, yielding a clear ‘target’ for testing the role of language in thought, and 2) large lang corpora have become available along with novel analytic tools. 4/n

So: DOES LANGUAGE MEDIATE THOUGHT? TL;DR: No. For us, LANGUAGE: representations+computations that allow us to produce and interpret meaningfully structured word sequences; THOUGHT: knowledge of+reasoning about the world, domain-general reasoning, cross-domain info integration 5/n

Language relies on dedicated 🧠 areas (, purple below). Their key properties include: a) representational abstractness (input+output modality independence) and b) representation+processing of words&syntax—components important to the lang-for-thought hyp. 6/n tinyurl.com/temfzd26



Classic and current models. | a, The classic model of the neurobiology of language. **b**, A model based on the current knowledge of neurobiology of language (alternative proposals are described in refs. 27,198,199). This updated model still includes Broca’s (articulatory planning) area[188–192] and Wernicke’s (speech perception) area[193–197], but additionally includes a set of frontal and temporal areas that jointly support high-level language comprehension and production[28] (also see Fig. 1a). For context, we also show primary auditory cortex, which is likely to provide input to Wernicke’s (speech perception) area, and sensorimotor cortex, to which Broca’s (articulatory planning) area is likely to provide input[189,190].

https://tinyurl.com/temfzd26

Using data from fMRI and patients with aphasia, we argue that the lang. system is NOT NECESSARY for thought (details:). We also argue that having an intact lang. system does not imply being able to reason: i.e., language is NOT SUFFICIENT for thought. 7/n

https://tinyurl.com/ye22b67r

And IS LANGUAGE AN EFFICIENT COMMUNICATION CODE? TL;DR: Yes. An efficient code should be easy to produce+understand, robust to noise, and learnable by humans. Human langs exhibit these properties at all levels of structure, including sounds, word forms+meanings, and syntax. 8/n

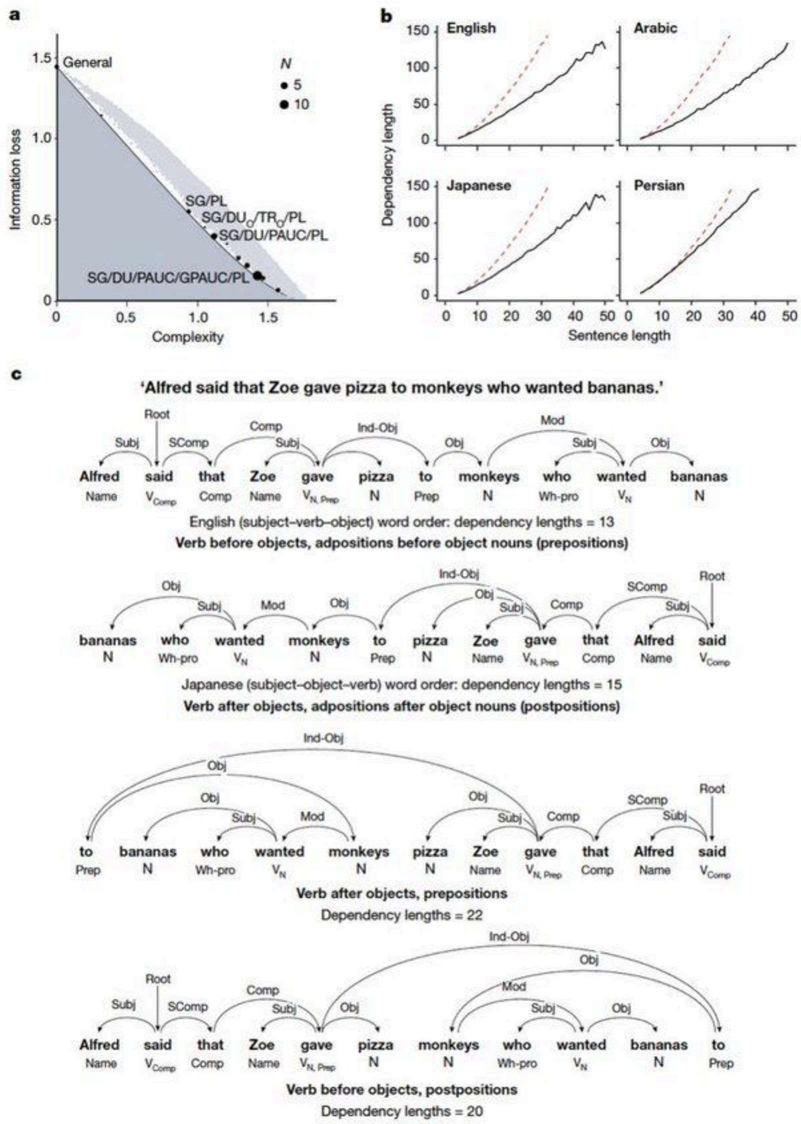


Fig. 2 | Human languages are shaped by communicative pressures. **a**, Words across many semantic domains trade-off between complexity and informativeness. This pattern is as predicted for efficient communication systems (here, shown for the domain of grammatical number markers[135]). Attested inventories (black dots; sizes correspond to the number of languages with a given inventory (N)) and unattested systems (grey dots) are plotted in the space of all possible grammatical systems. Systems that achieve optimal trade-offs lie along the Pareto frontier (solid line); the shaded region below the line shows trade-offs that are impossible to achieve. DU, dual; GPAUC, greater paucal (a bunch); PAUC, paucal (a few); PL, plural; SG, singular; TR, trial. Optional values are shown with the subscript '$_o$'. **b**, Languages minimize syntactic dependency lengths cross-linguistically[146]. Observed average dependency lengths (black lines in each graph) for sentences of 1 to 50 words across four typologically diverse languages, based on analyses of large language corpora. For each sentence in the corpus, a single value was computed by summing the lengths of all dependencies as shown in **c**. The red dashed line shows a random baseline created by first scrambling the words, preserving the hierarchical dependency structure and disallowing crossing dependencies, and then recomputing dependency lengths[146]. All lines are fitted using a generalized additive model. Across languages (ref. 146 for data from 37 languages), the observed dependency lengths fall below the random baseline, suggesting that languages evolve to make dependencies shorter, presumably to facilitate production and comprehension. **c**, Examples of minimization of syntactic dependency lengths in different languages. Top row, syntactic dependency structure for a subject–verb–object word order language (for example, English). Verbs appear before object nouns; prepositions appear before object nouns. Here and in the other examples, the syntactic category of a word is shown under each word and the relationships between words are shown with directed arcs; the type of the relationship is marked above each arc. The total dependency length of a sentence is the sum of all dependency distances—for example, the dependency between 'Alfred' and 'said' is 1; for dependencies between non-adjacent words, the dependency length is the number of intervening words plus 1. For this sentence, there are 7 local dependencies of length 1 and 3 dependencies of length 2, for a total sentence dependency length of 7 + 6 = 13. Second row, syntactic dependency structure for a subject–object–verb word order language (for example, Japanese). Verbs appear after object nouns; prepositions (postpositions) appear after object nouns. Two word orders that rarely occur in natural languages, putatively because they introduce long-distance dependencies: in the third row, verbs appear after object nouns, and prepositions appear before object nouns; in the fourth row, verbs appear before object nouns, and prepositions (postpositions) appear after object nouns. Comp, complementizer; Ind-Obj, indirect object; Mod, modifier; N, noun; Obj, object; root, the root of the sentence; SComp, sentence complement; Subj, subject; V_{Comp}, verb taking a complementizer argument; V_N, verb taking a noun argument; $V_{N, Prep}$, verb taking a noun and a preposition argument; Prep, preposition; Wh-pro, wh-pronoun (for example, 'who').

A common argument against language having evolved for communication is the prevalence of ambiguity. But ambiguity can be mathematically shown to be communicatively useful: it allows leaving out info that listeners already know, and enables re-use of short, easy-to-say forms. 9/n

ZOOMING OUT TO EVOLUTION: The view that lang. is simply a communic. system aligns with a continuity view of human evolution, where lang. properties—including its complexity—result from the multifaceted landscape in which it has evolved, where the system must be useful+usable.10/n

The alternative—that language is the substrate for thinking—implies a sharp discontinuity between our species and others. This view centers language—perhaps innately—as the mechanism of change, which endowed us with a novel representational format for mental computations. 11/n

Why does an intimate relationship between language and thought have an intuitive appeal? There are many reasons (see Supp Info in the paper). One important one is the desire for parsimony in explaining differences between humans and non-human animals: 12/n

Humans differ from other animals both the sophistication of their communication system and of their thoughts and cognition. A parsimonious account favors a single-factor explanation: i.e.,humans evolved language, and the change in cognition was simply a consequence of this. 13/n

BUT: Evidence from human 🧠 evolution suggests parallel increases in the sophistication of multiple cognitive systems. The association cortex—which houses processes above and beyond perception and motor control—expanded disproportionately in humans eg, @fennamk @RandyLBuckner 14/n

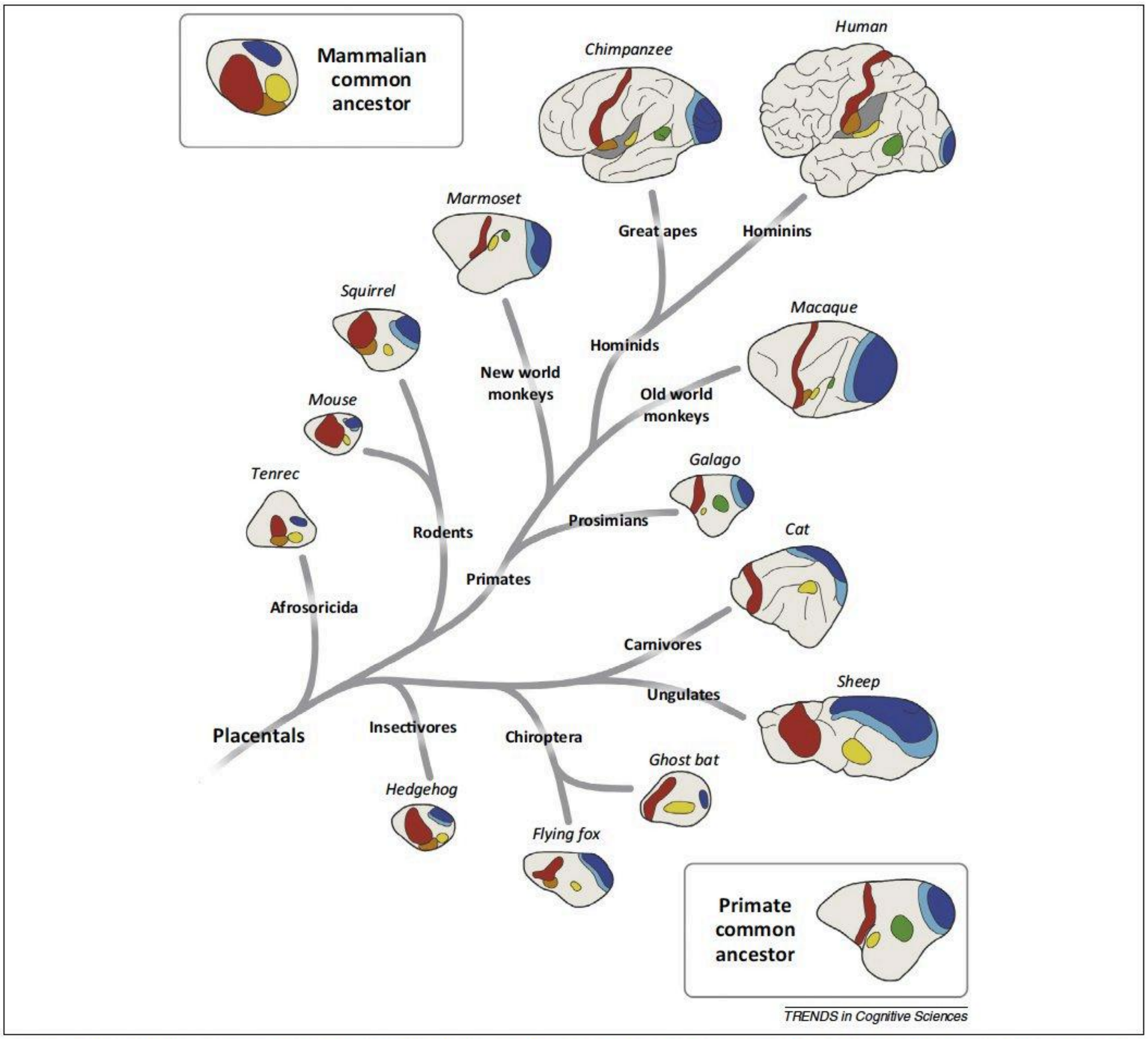


Figure 1. Phylogeny of the cortical mantle. Schematic depictions of the cortex of placental mammals are shown with the size and positions of several conserved areas. Two organizational features are apparent in the phylogenic tree. Across all species, the relative positions of the areas are preserved, suggesting they arise from an ancient developmental template, or Bauplan, that is conserved. Second, as the brain is enlarged in primates a greater percentage of the cortical mantle falls between the sensory systems. The insets represent hypothetical estimates of the mammalian common ancestor (top left) and the primate common ancestor (bottom right). The mammalian common ancestor is taken directly from [22–24] based on a larger sample of mammals that includes marsupials and monotremes. Dark blue, primary visual area (V1); light blue, secondary visual area (V2); green, middle temporal (MT) visual area; yellow, primary auditory area (A1); red, primary somatosensory area (S1); orange, secondary somatosensory area (S2). Adapted, with permission, from [22–24].

Human association cortex comprises multiple large-scale networks. The lang. network is just one of them. Several networks have been identified that support thinking and reasoning, including the Multiple Demand network, the Theory of Mind network, and the Default Network. 15/n

All these networks have expanded over the course of human evolution, and this expansion was associated with increases in many cognitive abilities (@CantlonLab @spiantado). 16/ntinyurl.com/yz8mcr7v

In sum: Lang. serves a primarily communicative function and reflects, rather than gives rise to, the sophistication of human cognition. Instead of providing the substrate for thinking, language likely transformed our species through its external usage: 17/n

Language enabled cross-generational transmission of acquired knowledge. The cumulative effect of this transmission along with increased sophistication of our social and problem-solving abilities plausibly enabled us to create human civilizations. (eg, @JoHenrich) 18/n

See figure for some open questions. And thank you to so many of you (see Acknowledgments!) for help and comments over the last few months! 19/19

Open questions

Our understanding of human linguistic and cognitive capacities and the relationships between them remains incomplete. Here we highlight a few open questions.

(1) What is the nature of *linguistic representations* that the language-selective brain network stores and the *computations* that it performs during comprehension and production? Recent advances in artificial intelligence—the development of neural network models that excel at language[201]—have provided language researchers with a suite of powerful tools to probe the neural codes of linguistic processing[48,202–205] (reviewed in ref. 206). These tools, combined with the increasing sophistication of neural recording approaches[207,208], should enable advances in our understanding of the human language system in the coming years.

(2) Does our *thinking* rely on *symbolic representations*[209–212], *sub-symbolic or connectionist representations*[213,214], or some combination of these? How do representations that mediate abstract thought arise from the biological neural networks that are our brains[215,216]? Are any thought-related computations and the underlying neural circuits distinctly human, or do humans simply have more neural and cognitive resources[163,173] that lead to greater sophistication?

(3) How does the language network *develop* as children learn language? What cognitive functions do brain areas that are selective for language by age four[92,93] support before language is acquired? Although a number of studies have investigated responses to speech in newborn and infant brains[217–219], the functional changes that happen in the brain during the second half of the first year of life and during toddlerhood (age 6 months to 3 years), when children begin to link words to meanings and to use language communicatively, remain unknown because experimentation with spatially precise brain imaging approaches such as fMRI is challenging at this age.

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