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Reply to 'The core language network separated from other networks during primate evolution'

We thank Friederici and Becker for insightful comments on our Review (Fedorenko, E., Ivanova, A. A. & Regev, T. I. The language network as a natural kind within the broader landscape of the human brain. *Nat. Rev. Neurosci.* **25**, 289–312 (2024))[1], which we respond to below (Friederici, A. D. & Becker, Y. The core language network separated from other networks during primate evolution. *Nat. Rev. Neurosci.* https://doi.org/10.1038/s41583-024-00897-9 (2024))[2].

Friederici and Becker focus on one distinction we described in our Review — between lower-level auditory and premotor areas that are selective for speech perception and articulation, respectively, and the language network areas, which support comprehension and production across modalities and implement computations related to word retrieval and composition. The authors highlight a body of work that has revealed a similar dissociation based on the anatomy of white matter tracts: distinct dorsal tracts connect lower-level temporal auditory to frontal motor speech areas versus the temporal to frontal components of the language network. Moreover, whereas the former tract is evolutionarily conserved, the latter is substantially expanded in the human brain relative to the chimpanzee brain[3], along with the expansion of the temporal and frontal cortical association zones[4].

This neuroanatomical cross-species difference that Friederici and Becker describe[2] is exciting and may provide critical clues about the evolution of the human language system. It also naturally raises an intriguing question about what brain system or systems non-human primates (NHPs) use to interpret and generate meaningful communicative signals. Let us unpack this question. The authors reasonably suggest that the lower-level auditory and motor circuits that support the perception and production of vocalizations in NHPs are homologous with human speech perception and articulation circuits (as also suggested in we discuss in our Review, in humans these circuits are not sensitive to meaning. But NHPs certainly communicate meaningful information to one another using a combination of auditory and visual signals[6]. Indeed, many features of NHP communication systems resemble language, including referentiality[7] and compositionality[8]. So, what neural mechanisms do NHPs use to communicate, beyond these lower-level perceptual and motor circuits?

For simplicity, let us focus on the comprehension side of communication. One possibility is that the lower-level auditory vocalization–perception circuits in NHPs are functionally broader than the human speech perception areas and support communicative-signal perception and interpretation. Alternatively, if the distinction between perception and interpretation is evolutionarily conserved, then areas outside of the auditory–motor network in NHP brains must support meaning comprehension. Functional neuroimaging in macaques[5] and marmosets[9] is starting to provide some clues: observation of social (including communicative) signals engages areas on lateral frontal and temporal cortical surfaces, which broadly resemble the language network topography in humans (Fig. 1).

The topographic similarity between parts of the language network and these social-processing areas in NHPs is tantalizing and may suggest that language arose out of basic social–perceptual abilities. But establishing homologies on the basis of broad anatomical resemblance is precarious (for reasons discussed in box 1 in our Review[1]), especially given the functional heterogeneity of both lateral temporal and lateral frontal areas. Luckily, recent advances in single-cell transcriptomics — analyses of gene expression based on RNA concentration levels — are providing a suite of exciting novel transformative

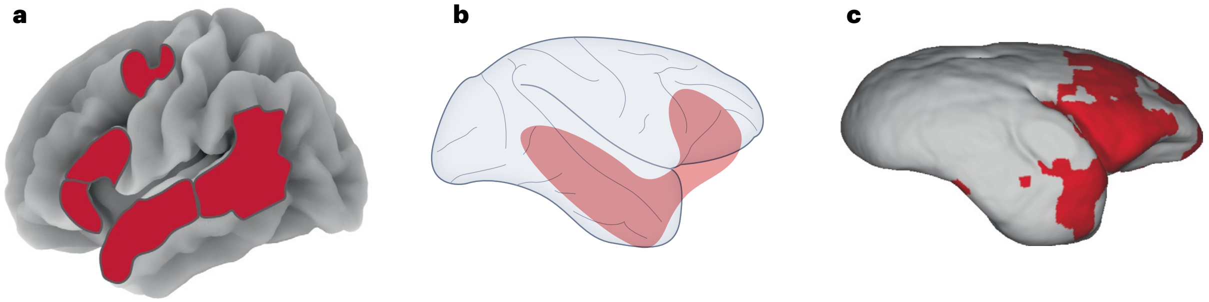

Fig. 1 | Broad topographic resemblance between parts of the human language network and areas in non-human primate brains that are engaged during observation of conspecifics. a, The human language network. A set of five masks that denote the typical locations of the language areas, which support comprehension and production across modalities[1]. **b**, A schematic illustration of the areas in the macaque brain that are engaged when watching videos of conspecifics (the critical social condition) relative to a perceptually similar control condition (phase-scrambled videos)[5]. The social condition includes both third-party observation (the individual in the video is not looking directly at the camera) and second-party observation (the individual in the video is looking directly at the camera, to simulate typical face-to-face interaction). **c**, A group-level functional map of the areas in the marmoset brain that are engaged when watching videos of two conspecifics engaging in social interaction (such as grooming or sharing food) relative to control, non-social videos (two individuals shown side by side, in which each individual is engaging in non-social actions (such as eating or scratching))[9]. Panel **a** adapted from ref. 1, Springer Nature Ltd; panel **b** adapted with permission from ref. 5, Elsevier; and panel **c** adapted from ref. 9, CC BY 4.0 (https://creativecommons.org/licenses/by/4.0/).

approaches for establishing direct functional homologies (even for areas that may vary in their anatomical location across species) and distilling the critical functional changes in the human brain[10]. Therefore, despite the established neuroanatomical differences between humans and NHPs that Friederici and Becker highlight[2], we may be on the brink of discovering which functional areas in the NHP brain served as the precursor to the human language areas.

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Competing interests

The authors declare no competing interests.