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# Reply to 'Language is widely distributed throughout the brain'



We thank Drijvers, Small, and Skipper (Drijvers, L., Small, S. L. & Skipper, J. I. Language is widely distributed throughout the brain. *Nat. Rev. Neurosci.* https://doi.org/10.1038/s41583-024-00903-0; 2025)[1] for their 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)[2], which we respond to below.

The authors state that many parts of the brain respond to language. We agree – the Review[2] explicitly discusses contributions of multiple areas outside the language network (LN) to language processing. In other work[3], we specifically propose a framework that distinguishes language-specific cognitive operations (formal linguistic competence) and non-language-specific processes involved in real-life language use (functional linguistic competence), emphasizing that the LN does not operate in a vacuum. Thus, the substantive difference between our view and the authors' hinges on whether the LN responds consistently and selectively to language.

Drijvers, Small and Skipper argue that the LN is a methodological artefact that "only appears when averaging over … heterogeneous

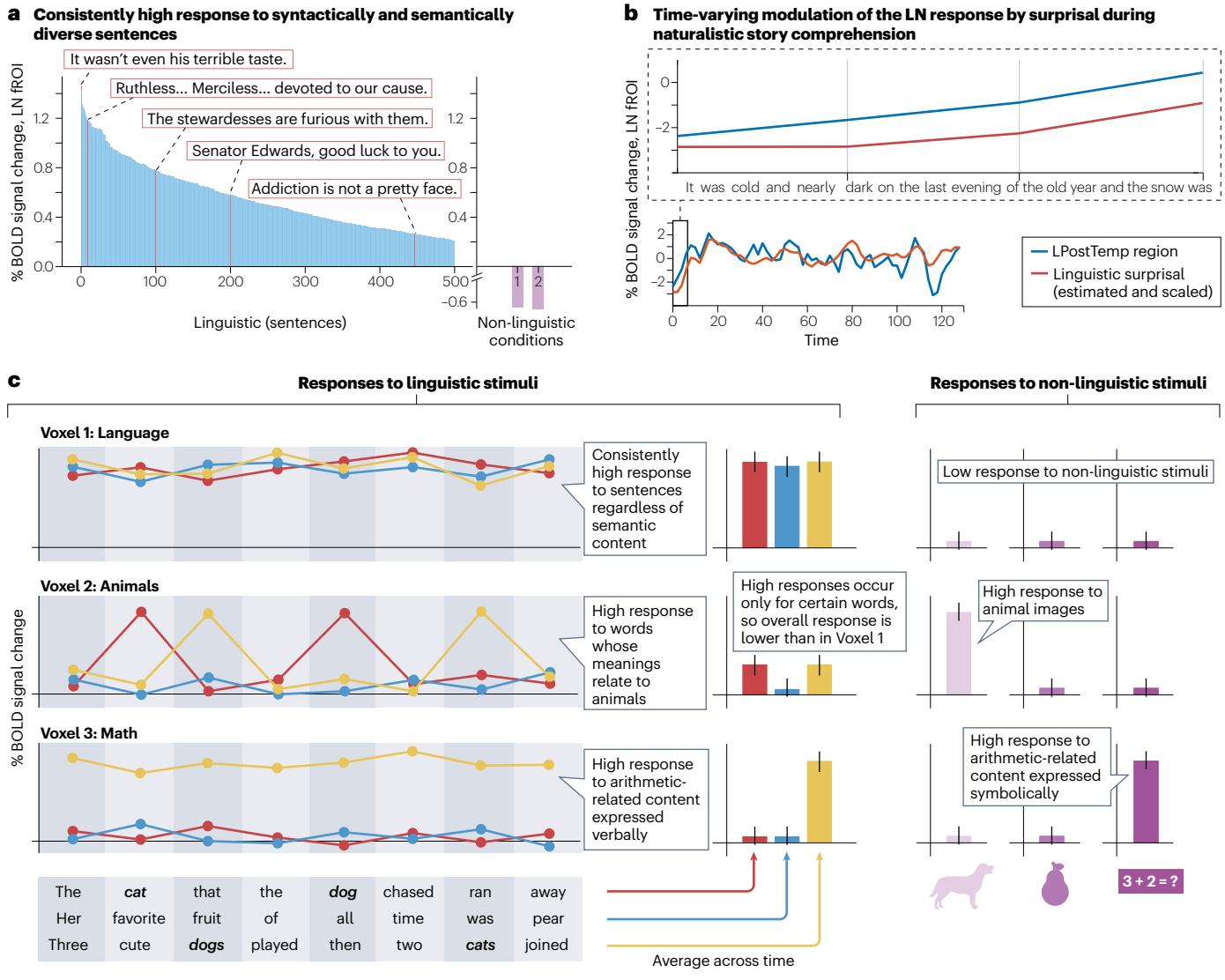

**Fig. 1 | Ubiquitous, amodal and selective responses of the language network to the multi-faceted nature of language, including the time-varying modulation by compositional subroutines. a**, A language network (LN) functional region of interest (fROI) (left posterior temporal (LPostTemp)) showing high, albeit variable, responses to individual syntactically and semantically diverse sentences (samples shown above bars) and a low response to conditions of a non-linguistic (spatial working memory) task. The LN response magnitude to particular sentences depends on linguistic and semantic features (such as grammatical well-formedness). Visualization of BOLD signal changes created using data from ref. 6. **b**, An LN functional region of interest (left posterior temporal) showing time-varying modulation of the BOLD signal as a function of linguistic surprisal (estimated from computational language models) during naturalistic story comprehension. The LN's activity is modulated by predictive and integration-based sub-routines of linguistic composition associated with processing high-surprisal (contextually unexpected) words and words that require formation of non-local syntactic dependencies. Visualization of BOLD signal time course as a function of surprisal created using data from ref. 7. **c**, Schematic responses in three sample voxels (as measured with fMRI) during the processing of three sentences ('responses to linguistic stimuli'; sentences are shown at the bottom) and three non-linguistic stimuli ('responses to non-linguistic stimuli'; object pictures and a symbolic math equation). Voxel 1 is an LN voxel showing high responses to all linguistic stimuli, but low responses to non-linguistic ones. Voxel 2 is a semantically tuned voxel showing high responses to animal-related meanings, conveyed with words or pictures. Voxel 3 is a voxel in the multiple demand network showing high responses to math-related content, conveyed verbally or in symbolic math expressions. Drijvers, Small and Skipper argue for calling voxels or areas with all three response types 'language voxels or areas' given that they can be driven by linguistic inputs; we argue that such labelling would not help to advance scientific understanding of the brain.

linguistic representations and processes"[1] and is highly dependent on the choice of localizer. This critique is not empirically supported. A localizer is an efficient way to identify the LN, but the LN emerges robustly from data-driven voxel-clustering approaches during rest[4] or when processing audiovisual, socially grounded naturalistic stimuli[5] (like those the authors advocate[1]). Moreover, in numerous studies, we have examined the LN's response to thousands of individual sentences[6] (Fig. 1a) and during incremental, word-by-word processing, including of rich naturalistic narratives[7,8] (Fig. 1b). All functional regions of interest (which comprise tens of voxels, not "tens of thousands"[1]) and individual voxels or neural populations in the LN show consistently high responses to language, but also strong, and sometimes differential, modulation by linguistic demands at different timescales (Fig. 1a and Fig. 1c, voxel 1). Therefore, empirical reliance on functional localization does not preclude the discovery of the multi-faceted nature of language processing. Many of these studies have also explicitly shown spatially restricted effects within the LN not present in control brain areas[6,7].

What does it mean to have a language-specific core processing system (the LN) along with content-dependent activations elsewhere in the brain? As we discuss in our Review[2] (see 'The cognitive networks the LN interacts with to support real-life language use'), theory-of-mind areas respond to linguistic (but also non-linguistic) descriptions of mental states whereas multiple demand areas respond to verbal (and symbolic) math problems (Fig. 1c, voxel 3). With respect to concepts, Huth et al.[9] examined neural responses during narrative comprehension and reported semantic tuning in many cortical areas (Fig. 1c, voxel 2), which we later found in single cells outside of the LN[10]. However, similarly to areas in the theory of mind and multiple demand networks, these semantically tuned areas respond to particular meanings in both linguistic and non-linguistic inputs (Fig. 1c, voxels 2 and 3), so calling them 'language areas' would be misleading.

Finally, Drijvers, Small, and Skipper worry that our definition of language is circular and that by limiting language to the computations performed by the LN we enforce an overly restrictive view of 'language'. We discuss this concern in box 2 of the Review[2]: although 'language' is an imperfect cognitive description of what the LN does in the brain, it captures its ubiquitous, amodal and selective response to language stimuli well. Therefore, we feel comfortable calling these regions the LN while recognizing not only that this cognitive-neural mapping is imperfect but also that other brain areas also contribute to language processing, despite not being language-specific.

In short, the LN responds consistently and selectively to language.

## Data availability

The data used to generate Fig. 1a were released as part of ref. 6 and are available for download at https://github.com/gretatuckute/drive_suppress_brains. The data used to generate Fig. 1b were released as part of ref. 7 and are available for download at https://osf.io/ah429/.

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## Competing interests

The authors declare no competing interests.

## Additional information

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