Researchers identify neural circuits used in processing basic linguistic phrases

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New York University researchers have isolated neural activity that reflects basic mechanisms used by the brain to combine elementary pieces of language in order to construct complex ideas.

The study, which appears in the Journal of Neuroscience, was conducted by Douglas Bemis, a graduate student in NYU's Department of Psychology, and Liina Pylkkänen, an associate professor in NYU's Department of Psychology and Department of Linguistics.

Researchers have long studied the neural regions that underlie the processing of complete sentences and other complex linguistic expressions. However, much less attention has been devoted to how we comprehend minimal language combinations, such as a simple two-word, adjective-noun phrase.

To better understand how the brain functions during such simple language processing, the researchers conducted an experiment using native English speakers in which subjects were shown simple nouns presented either by themselves or preceded by a simple adjective. The subjects' brain activity during the processing of the nouns was then gauged using magnetoencephalography (MEG), a technique that maps neural activity by recording magnetic fields produced by the electrical currents produced by our brain.

During the experiment, subjects were shown common nouns ("boat") that were either part of a simple noun phrase ("red boat") or preceded by

an unrelated noun ("cup, boat") or non-pronounceable consonant string ("xhl boat"). By comparing neural activity generated during the phrases with the control conditions, the researchers were able to isolate brain activity that increased during basic combinatorial processing (i.e., the adjective and the noun) compared to when no linguistic combination was present. To ensure that the subjects were processing the words correctly, they had to assess whether a following colored shape (e.g., a red boat) matched the words they had just seen.

Surprisingly, the regions of the brain typically identified with the processing of complex linguistic expressions—"Broca's" and "Wernicke's" areas—appeared to play no role in the comprehension of such basic phrases.

Instead, the MEG results revealed increased activity in the left anterior temporal lobe (LATL), followed by increased activity in the ventromedial prefrontal cortex (vmPFC) region of the brain during the processing of simple adjective-noun phrases. While these parts of the brain have previously been shown to be involved in the processing of more complex linguistic expressions, this evidence suggests that these regions play a pivotal role in the most fundamental aspects of language processing. This result, in conjunction with the absence of increased activity in Broca's and Wernicke's areas, indicates that traditional neural models of language processing must be expanded in order to encompass a wider network of brain areas than are typically included.

"Surprisingly, direct investigations into the neural underpinnings of basic combinatorial processing in language have been virtually nonexistent," the authors wrote. "This research introduces a powerful method for directly investigating these operations by allowing the linguistic expressions under consideration to be reduced to the absolute minimum: a simple adjective composed with a noun."

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