Temporal and frontal networks reveal how conceptual memories are organized

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Overview

We studied how the brain represents, organizes, and retrieves conceptual (semantic) information.

We examined recordings from 46 neurosurgical patients as they studied and freely recalled lists of words.

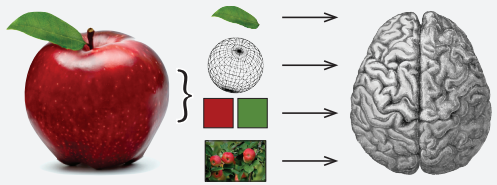

Figure 1. *Distributed memory hypothesis.* Concepts are broken down into constituent semantic features; each feature is represented by a distributed pattern of brain activity.

Results

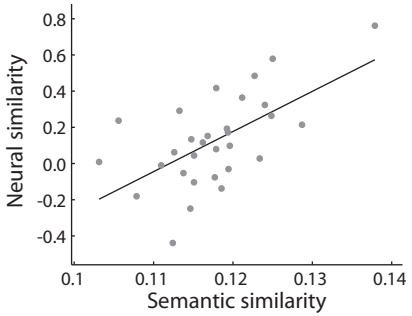

Figure 6. *Neural vs. semantic similarity.* Neural activity is recorded just prior to each recall. The dots indicate the means of 30 equally sized bins.

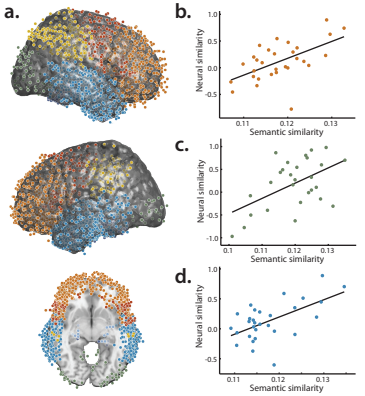

Figure 7. *Regions of interest.* **a.** Each dot marks the location of a single electrode. **b - d.** Neural vs. semantic similarity in (**b**) prefrontal, (**c**) occipital, and (**d**) lateral temporal cortex.

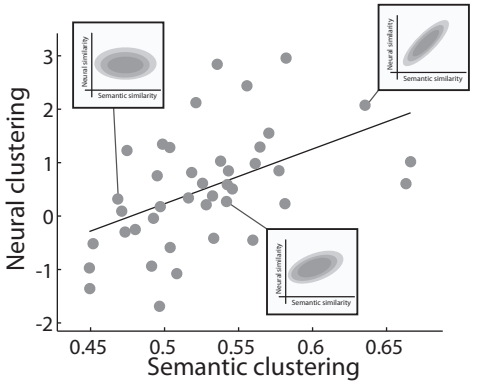

Figure 8. *Neural vs. semantic clustering.* Each dot represents a single participant. Neural clustering indicates the *t*-value from the correlation between neural and semantic similarity. (Data are from PFC.)

Methods

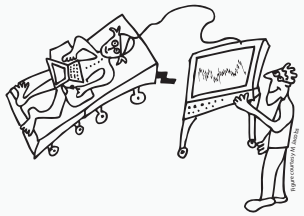

Figure 2. *Our recording setup.* Patients are implanted with subdural and depth electrodes. Experiments are administered on a bedside laptop computer.

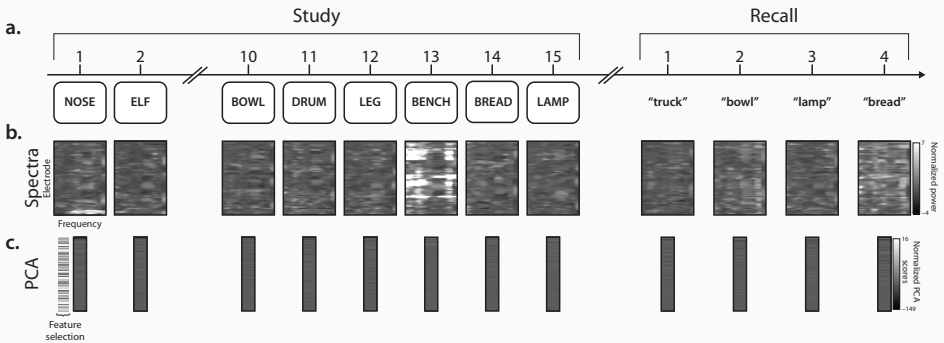

Figure 3. *Analysis.* **a.** Participants study and freely recalls lists of 15 or 20 common nouns. **b.** For each electrode we compute mean power contained in 50 frequencies (2 - 99 Hz) during each study and recall event. **c.** We apply PCA and identify components that vary with the meanings of studied words.

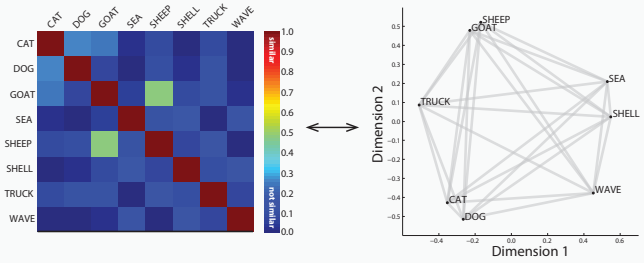

Figure 4. *Feature selection.* We compute the neural and semantic similarity between each pair of studied words. (A seperate neural similarity matrix must be constructed for each neural component.) Correlations between neural and semantic similarity imply that the given neural component represents the meanings of the studied words.

Figure 5. *Semantic clustering.* We assign each participant a semantic clustering score based on their tendancy to successively recall semantically related words, given that the words each appeared on the studied list.

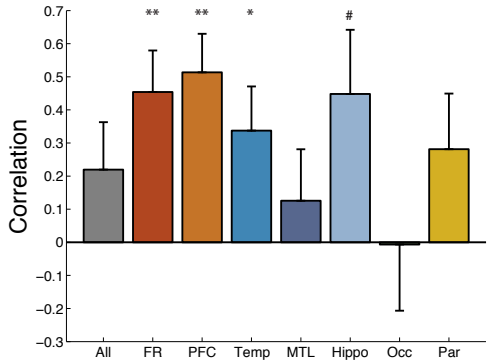

Figure 9. *Regions that predict semantic clustering.* Each bar indicates the correlation between neural and semantic clustering from the indicated region of interest (same color scheme as Fig. 7).

Conclusions

We identified components of brain activity that varied with the meanings of words during study. We examined these same "semantic features" just prior to recall.

The correlation between neural and semantic similarity was preserved in prefrontal, occipital, and lateral temporal cortex, indicating that these regions are involved with representing the meanings of words.

We also found that the correlation between neural and semantic similarity predicted semantic clustering. The prefrontal cortex, lateral temporal cortex, and hippocampus exhibited this effect, indicating that these regions are involved with organizing the memories of the words.

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