Experiential Semantic Representations in the Cerebellum

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BACKGROUND

- The cerebellum is often thought of as being only involved in motor control, with little attention given to the cognitive roles it plays.
  - This is how cerebellar function is summarized in a popular neuroscience textbook:

"The cerebellum plays a vital role in the integration, regulation, and coordination of motor processes."[1]

- Cerebellar Cognitive Affective Syndrome (CCAS) indicates that the cerebellum plays a role in language functions.[2]
- Functional neuroimaging studies have also implicated the cerebellum in semantic cognition.[3]

HYPOTHESIS

We hypothesized that neural activity patterns in the cerebellum encode features of word meaning during language comprehension.

METHODS

- 39 healthy adults underwent functional MRI while performing concept familiarity judgments on 320 nouns belonging to 8 conceptual categories.
- Words were presented visually in a rapid-event related design (Figure 1), and word-specific activation maps were generated via a GLM.
- Neural representational dissimilarity matrices (RDMs) were generated from voxels within a cerebellar ROI (Figure 2).
- Neural RDMs were compared to RDMs based on taxonomic or experiential features of word meaning.
  - Experiential features were based on subjective ratings of feature importance.[4]

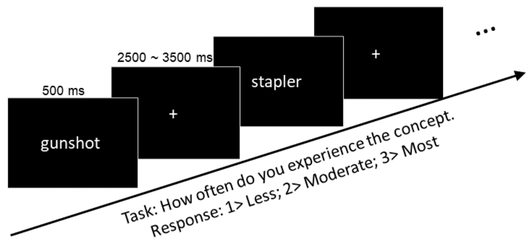
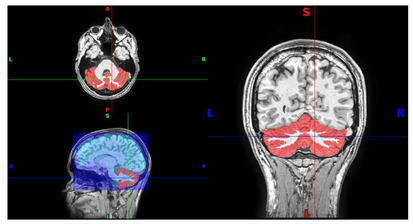


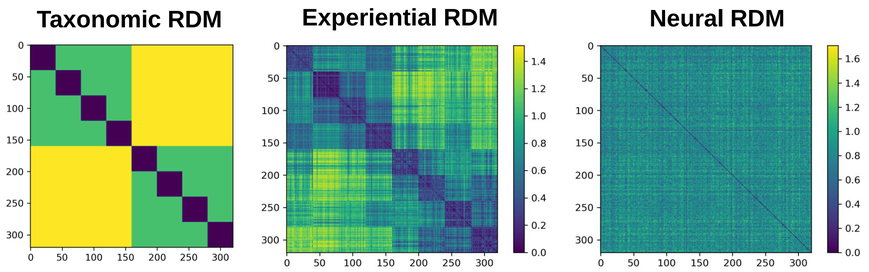
Figure 1

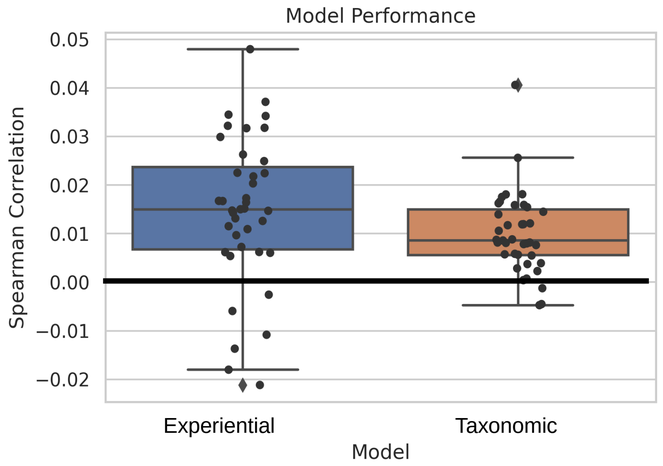


Coverage and Segmentation

Figure 2

RESULTS





Both models of semantic representation were significantly correlated with the neural RDM (Wilcoxon signed-rank test, $p < .001$).

CONCLUSION

- Activation patterns in the cerebellum correlate with semantic category information and with experiential information about word meaning.
- Activation is not explainable by low-level perceptual differences as concepts were lexically presented.
- Explicit visual imagery was not required by the task, indicating the cerebellum is involved in concept retrieval.

Future Directions

- Determine what experiential features have strongest representation in the cerebellum.
- Explore general computational function of cerebellum by examining the type of semantic errors made by cerebellar stroke patients.

REFERENCES

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[3]LeBel, A., Jain, S. & Huth, A. G. Voxelwise Encoding Models Show That Cerebellar Language Representations Are Highly Conceptual. *J Neurosci* **41**, 10341–10355 (2021).

[4]Binder, J. R. *et al.* Toward a brain-based componential semantic representation. *Cognitive Neuropsych* **33**, 1–45 (2016).