Category Typicality Modulates Goal Directed Retrieval of Living & Nonliving Things

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How do we selectively retrieve task-relevant versus irrelevant conceptual information about objects?

- Behavioral performance decreases during Living vs. Nonliving judgments of atypical objects
- For atypical objects, living status conflicts with ostensible animacy or naturalness
- This response profile is most prominent when executive functioning is:
  - *underdeveloped* [1] (in young children)
  - *impaired* [2] (in elderly adults and Alzheimer's patients)
  - *limited* [3] (requiring speeded responses)

CATEGORY	LIVING?	EXHIBITS ACTIVITY?	NATURAL?
Active Living Things (panda, gorilla, cobra, marlin...)	YES	YES	YES
Static Living Things (starfish, cactus, lily, grass...)	YES	NO	YES
Static Artifacts (slipper, whisk, pencil, vase...)	NO	NO	NO
Active Artifacts (rocket, jeep, vacuum, blender...)	NO	YES	NO
Static Natural Kinds (seashell, pond, coal, ruby...)	NO	NO	YES
Active Natural Kinds (meteor, river, sun, tornado...)	NO	YES	YES

Hypotheses

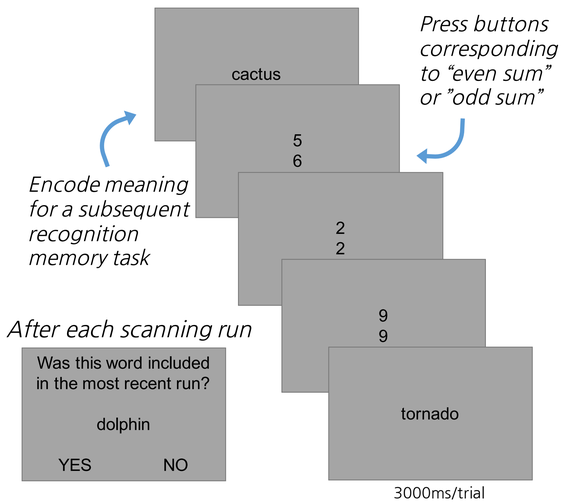
When category membership is task-relevant (during Living vs. Nonliving judgments):

- Increased response times & recruitment of brain areas involved in cognitive control (e.g., prefrontal cortex) for atypical objects
- Stronger activation of category-relevant neural responses in brain regions involved in processing semantic information

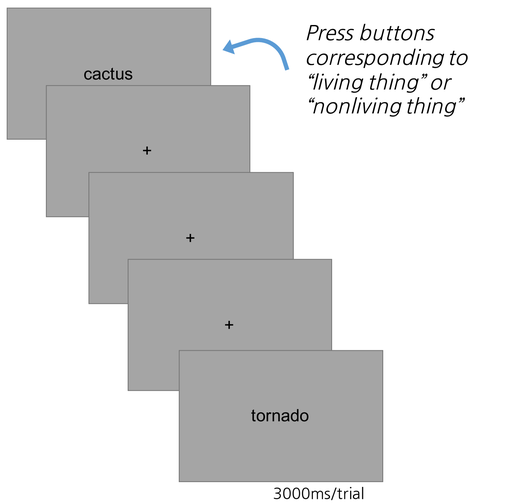
Methods

- Stimuli: 40 words per category (Living Things; Nonliving Artifacts; Nonliving Natural Kinds)
  - 20 typical & 20 atypical objects per category (determined by independent behavioral ratings)
- Living vs. Nonliving category membership is explicitly task relevant in Part B but not in Part A

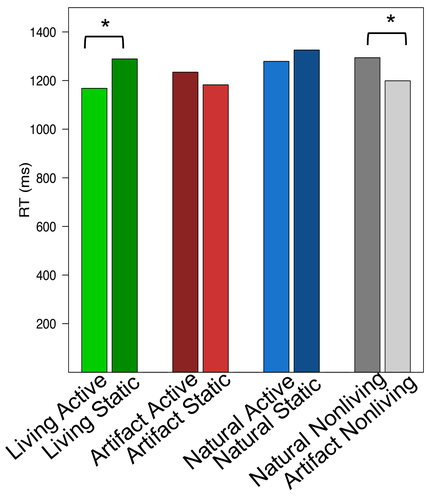
fMRI Scanning runs 1-10: Part A
General Semantic Retrieval

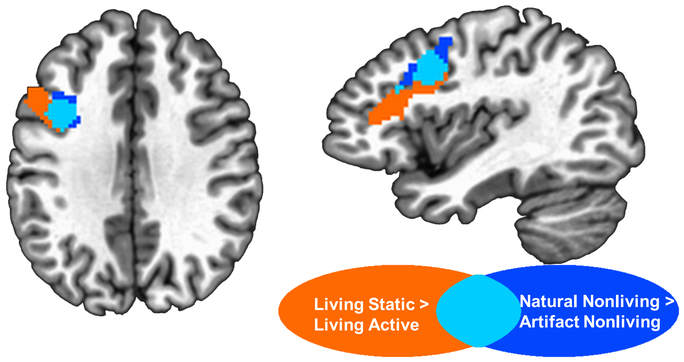


fMRI Scanning runs 11-14: Part B
Goal-Directed Retrieval



Results: delayed responses & increased left prefrontal activity during judgments of atypical objects





- Whole-brain group-level analysis, cluster corrected ($p < .01$)
- *Left middle frontal gyrus:* greater response during judgments of atypical vs. typical living and nonliving things

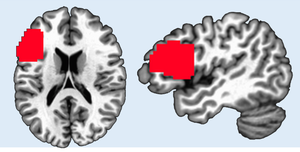
Multi-Voxel Pattern Analysis

Item-level Analysis: Does left prefrontal cortex predict increases in task-relevant responses?

Change in left prefrontal activity:

Mean BOLD response
Part B (vine) - Part A (vine)

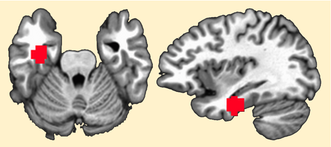
Anatomical ROI:
Left BA 44 & 45
(lPFC)



Change in within-category response:

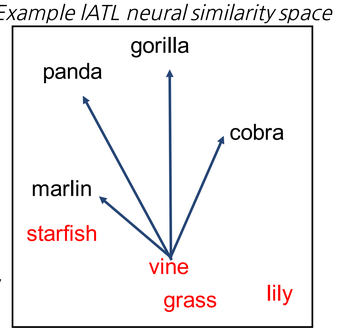
Mean within-category neural similarity
Part B (vine) - Part A (vine)

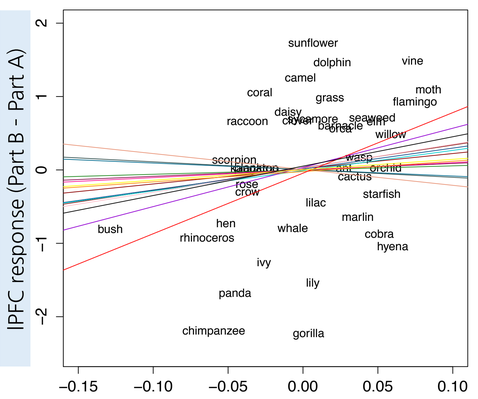
Functional & Anatomical ROI:
Words > Nonwords in
left anterior temporal lobe[4]
(lATL)



1. *For each item:* compute average pairwise similarity to other typical category members, separately for Part A & Part B multi-voxel patterns in lATL
2. *For each category:* compute correlations between z-scored lPFC activity & lATL neural similarity *(Part B - Part A)*

Example lATL neural similarity space





lATL within-category neural similarity
(Part B - Part A)

- *For Living Things:* positive relationship between lPFC increase & lATL within-category neural similarity increase, mean $r = 0.11$, $t(15) = 3.35$, $p = .004$.
- *For Natural Kinds and for Artifacts:* No reliable relationship

Discussion

- lPFC recruitment increases during judgments of atypical vs. typical category members
- During goal-directed retrieval of object knowledge for living things: lPFC response predicts increased expression of task-relevant activity patterns in word-sensitive subregions of lATL
- Effects of category typicality might vary across object categories

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2. Zaitchik, D., & Solomon, G. (2008). Animist thinking in the elderly and in patients with Alzheimer's disease. *Cognitive Neuropsychology, 25,* 27-37.
3. Goldberg, R. F., & Thompson-Schill, S. L. (2009). Developmental "roots" in mature biological knowledge. *Psychological Science, 20,* 480-487.
4. Binney, R.J., et al. (2010). The ventral and inferolateral aspects of the anterior temporal lobe are crucial in semantic memory: evidence from a novel direct comparison of distortion-corrected fMRI, rTMS, and semantic dementia. *Cerebral Cortex,* 20, 2728-2738.