# Tracking the Transition from Stimulus-Specific Object Representations to Category-Level Abstractions During Visual Search

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## Background

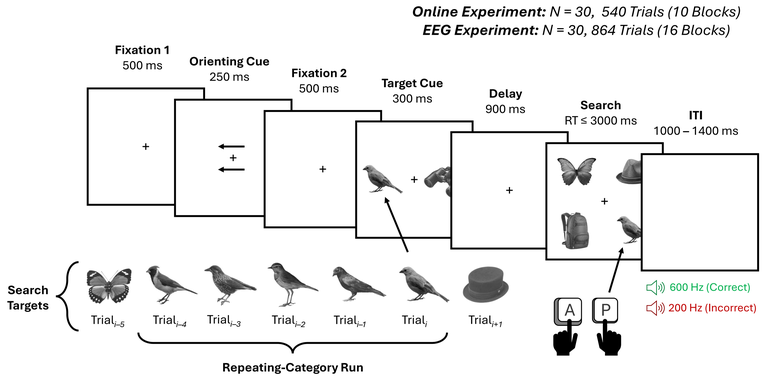
- When individuals search for the same target item over consecutive searches, their search times decrease.
- This speeding of performance is accompanied by a reduction of the contralateral delay activity (CDA)[1,2] – a load-sensitive ERP marker of visual working memory (VWM).
- As such, it is believed that search templates transition away from VWM to long-term memory when search targets are held constant.[3]

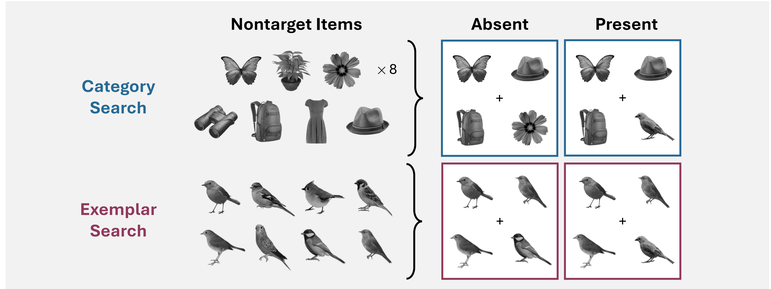
## Research Question

- **When an abstract feature (i.e., category membership) is sufficient for search, do search templates similarly transition away from VWM over time?**

## Method

***Online Experiment:*** *N = 30, 540 Trials (10 Blocks)*
***EEG Experiment:*** *N = 30, 864 Trials (16 Blocks)*

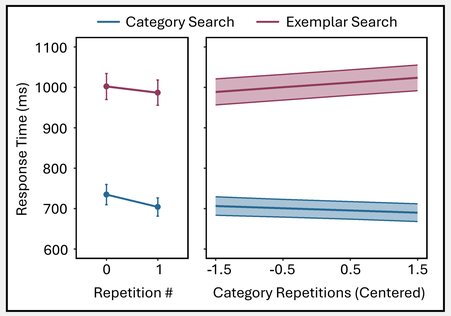



Category and exemplar search conditions were presented across alternating blocks (counterbalanced).

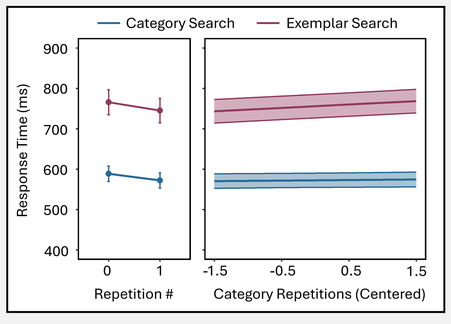
## Behavioral Results

### *Online Experiment*




- First repetition of target category benefits search, regardless of search-type ***(p < .001)***.
- Over subsequent repetitions, the advantage of category search over exemplar search is increased ***(p < .001)***:
  - Repeating-category benefit for category search ***(p = .025)***.
  - Repeating-category cost for exemplar search ***(p = .002)***.

### *EEG Experiment*

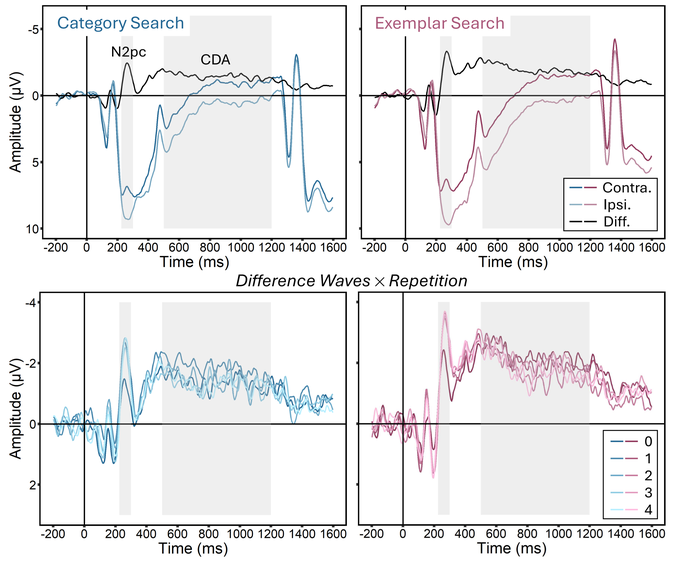



- First repetition of target category benefits search, regardless of search-type ***(p = .005)***.
- Over subsequent repetitions, the advantage of category search over exemplar search is increased ***(p = .038)***:
  - Stable performance for category search *(p = .319)*.
  - Repeating-category cost for exemplar search ***(p = .005)***.

## Cue-Locked ERP Results

### *Lateralized, Parieto-Occipital (PO7/8)*

**N2pc** = Index of attentional selection.
**CDA** = Marker of posterior VWM maintenance.

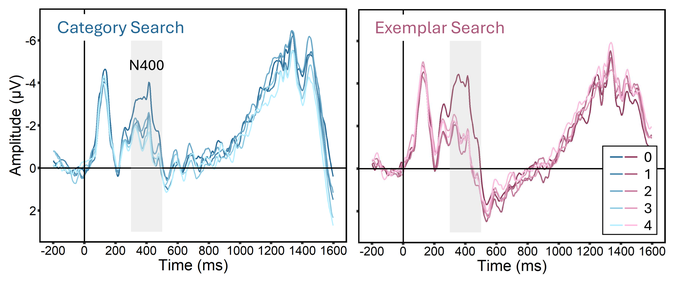


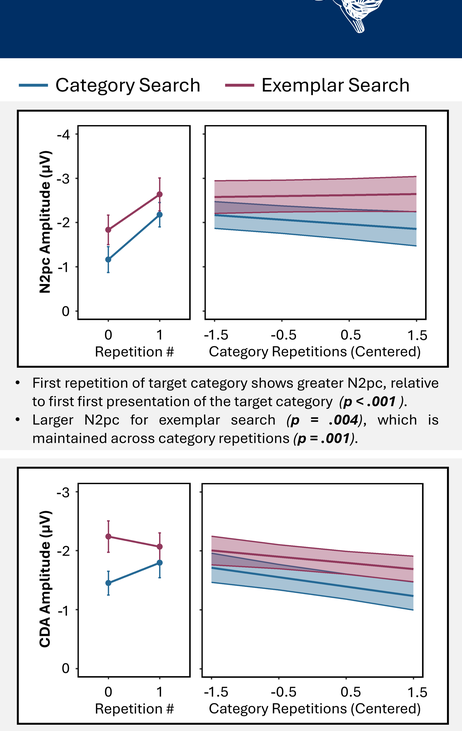

*Difference Waves × Repetition*




### *Midline, Centro-Parietal (CPz)*

**N400** = Detection of semantic violations/incongruencies.

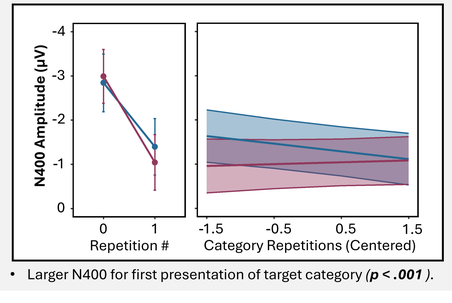



- First repetition of target category shows greater N2pc, relative to first first presentation of the target category ***(p < .001)***.
- Larger N2pc for exemplar search ***(p = .004)***, which is maintained across category repetitions ***(p = .001)***.




- Larger CDA for exemplar search ***(p < .001)***, which is maintained across category repetitions ***(p = .005)***.
- Linear reduction of CDA across category repetitions, regardless of search-type ***(p = .023)***.




- Larger N400 for first presentation of target category ***(p < .001)***.

## Conclusions

- Category search uses less attentional and VWM resources than exemplar search.
- When searching for targets consistently defined by the same object category, individuals form category-based expectations, leading to a reduction of the N2pc and enhancement of the N400 when violated at encoding (independent of search-type).
- Over consecutive category repetitions, the content of the information encoded into VWM becomes less specific.
- In the case of category search, this abstraction of search templates comes at no cost (and may benefit performance), whereas search performance becomes increasingly worse during exemplar search.

## References

1. Carlisle, N. B., Arita, J. T., Pardo, D., & Woodman, G. F. (2011). Attentional templates in visual working memory. *Journal of Neuroscience, 31(25)*, 9315–9322.
2. Gunseli, E., Olivers, C. N., & Meeter, M. (2014). Effects of search difficulty on the selection, maintenance, and learning of attentional templates. *Journal of Cognitive Neuroscience, 26(9)*, 2042-2054.
3. Woodman, G. F., Carlisle, N. B., & Reinhart, R. M. (2013). Where do we store the memory representations that guide attention? *Journal of Vision, 13(3), 1–17.*