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

Ryan S. Williams[1], Joseph M. Saito[2], Keisuke Fukuda[2] & Susanne Ferber[1]

1. University of Toronto; 2. University of Toronto Mississauga

Background

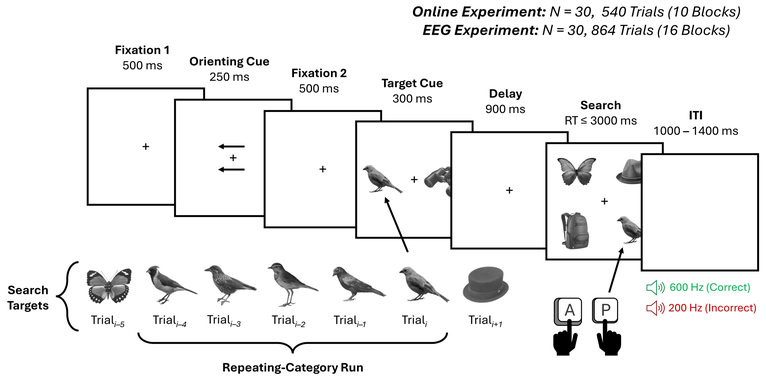
- When individuals search for the same target item over consecutive searches, their search times decrease.
- This speeding of performance is accompanied by a reduction of the contralateral delay activity (CDA)[1,2] – a load-sensitive ERP marker of visual working memory (VWM).
- As such, it is believed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

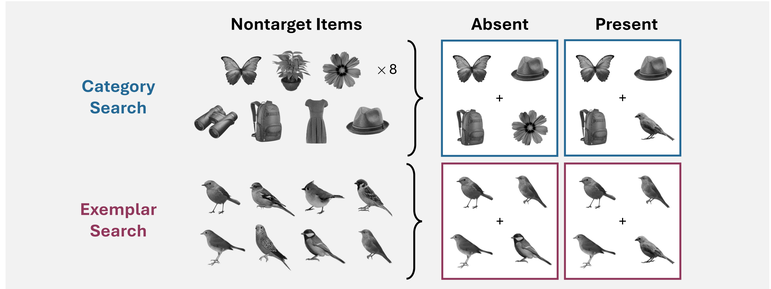
Research Question

- **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)*

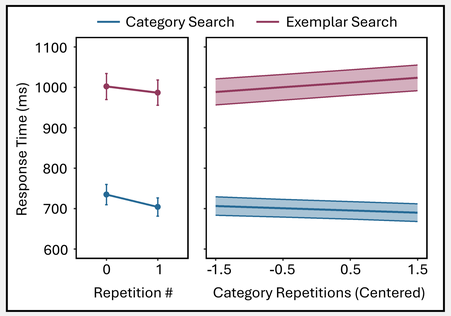




Category and exemplar search conditions were presented across alternating blocks (counterbalanced).

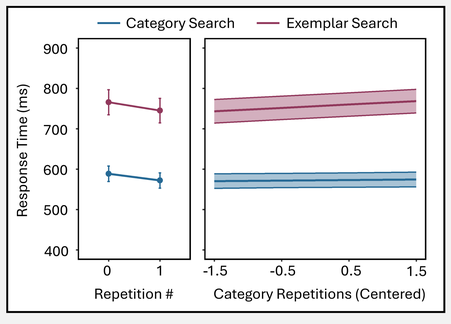
Behavioral Results

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

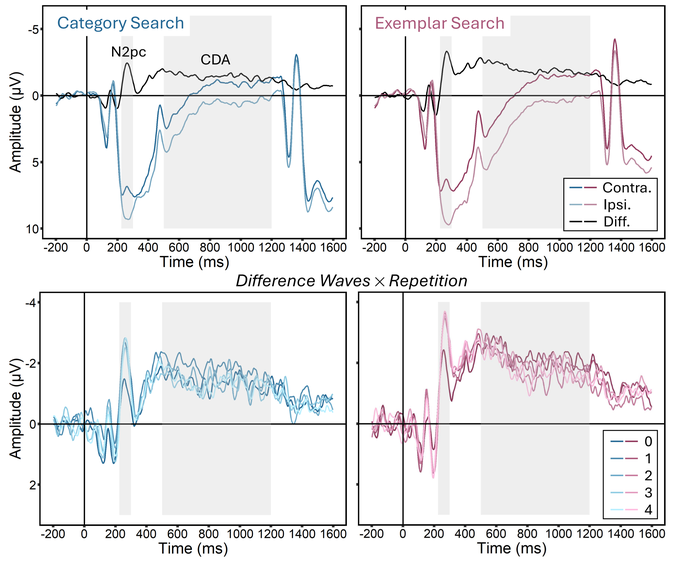


- First repetition of target category benefits search, regardless of search-type ***(p = .005)***.
- Over subsequent repetitions, the advantage of category search over exemplar search is increased ***(p = .038)***:
  - Stable performance for category search *(p = .319)*.
  - Repeating-category cost for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

Cue-Locked ERP Results

Lateralized, Parieto-Occipital (PO7/8)

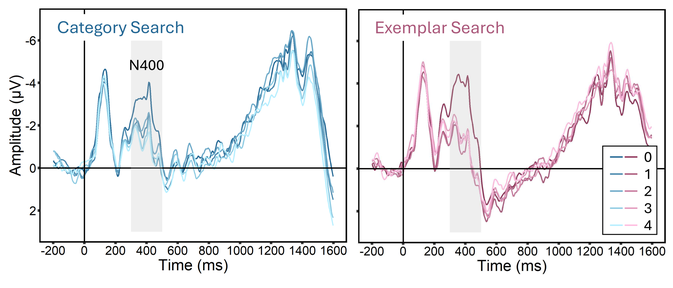
N2pc = Index of attentional selection.
CDA = Marker of posterior VWM maintenance.

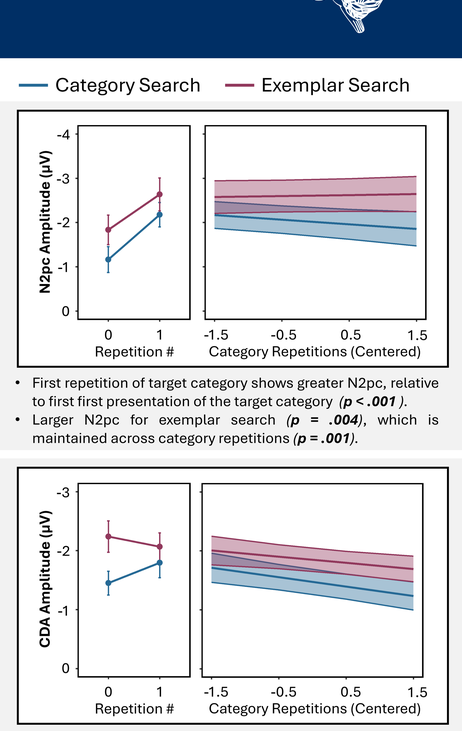


Difference Waves × Repetition

Midline, Centro-Parietal (CPz)

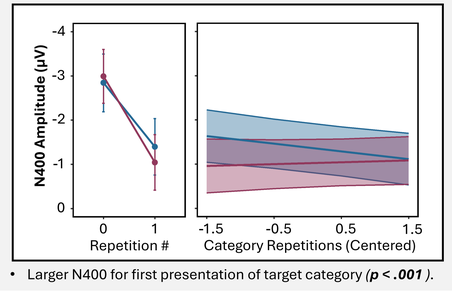
N400 = Detection of semantic violations/incongruencies.





- 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.*