# What, where, when did I find this? Associative learning in hybrid search

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## INTRODUCTION

In **hybrid search**[1], observers look for multiple memorized targets among visual distractors. For example, searching the supermarket for items on your mental shopping list. The context of hybrid search can repeat in space (e.g. the shelf where you find the bagel) and time (e.g. after the bagel, you look for the pear).

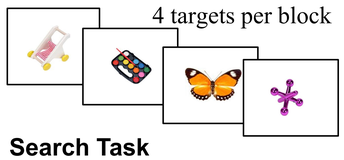
**Can observers incidentally learn and utilize spatial and temporal associations in hybrid search?**

## METHODS

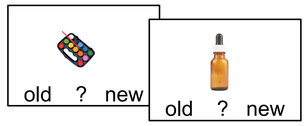
### HYBRID SEARCH TASK (online)

**Memorization**

4 targets per block



**Recognition Test**




**Search Task**

Set Size 8



Set Size 16

200 trials
= 50 repetitions of 4-target-associations

**2 Blocks per Experiment:**

Exp 1:
1. targets appear in a **fixed sequences**
2. targets appear in **random order**

Exp 2:
1. each target appears at a **specific location**
2. targets appear at a **random location** (out of 4)

Exp 3:
1. targets appear at the **same location AND in a fixed sequence**
2. target locations follow a sequence, but target items appear in **random order**

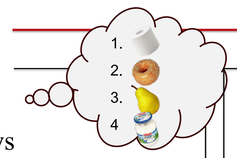
### PARTICIPANTS

recruited via the University's research participation system

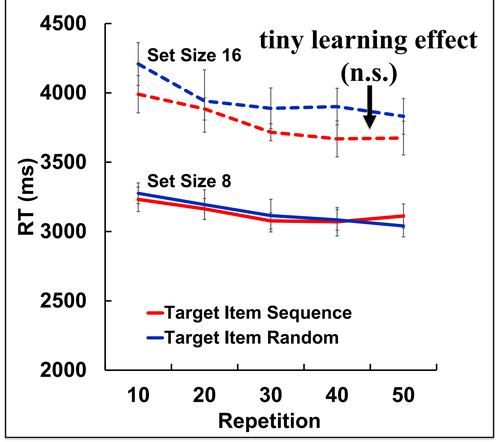
| | Exp 1: N=32 | Exp 2: N=38 | Exp 3: N=34 |
|---|---|---|---|
| Age | 19.89 (1.16) | 19.29 (2.85) | 20.50 (1.75) |
| Gender | 28F, 3M, 1NB | 37F, 1M | 21F, 13M |

## RESULTS

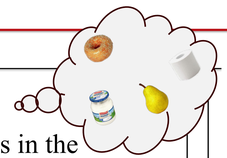
### EXPERIMENT 1 Item Sequence



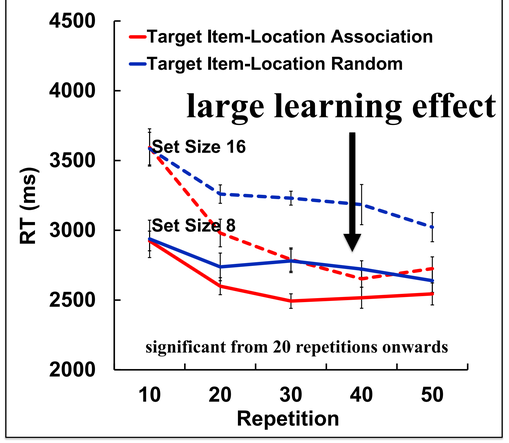

*When*? The pear always follows the bagel..



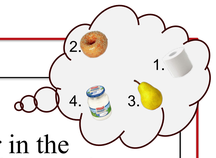

### EXPERIMENT 2 Item-Location Association



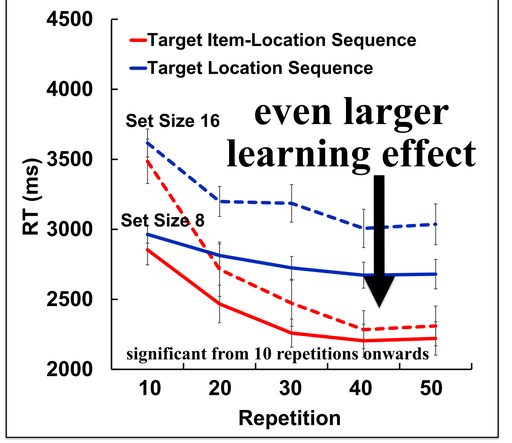
*Where*? The bagel is always in the upper right corner…




### EXPERIMENT 3 Item-Location Sequence




*Where* and *when*? The pear in the lower left corner always follows the bagel in the upper right corner…




## DISCUSSION

### MAIN FINDINGS

Learning of temporal target sequences is weak

- The integration of temporal target associations might be too resource demanding to speed hybrid search[2]

Learning of target item-location associations is fast and speeds search

- Spatial and non-spatial features are integrated automatically
- Item-location associations may guide attention, or serve as retrieval cues[2]

Learning of temporal item-location sequences is fast and makes search highly efficient (eliminates the set size effect)

- Observers can adjust priority states dynamically to temporally predictable, *integrated* spatial and non-spatial features[4]

## CONCLUSION

**Spatiotemporal learning in hybrid search is hierarchical**: When spatial and non-spatial target features are bound, temporal associations can also bias attention dynamically to prioritize task-relevant features expected to occur next.

## REFERENCES

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2. Wiegand, I., Westenberg, E., & Wolfe, J. M. (2021). Order, please! Explicit sequence learning in hybrid search in younger and older age. Memory & Cognition, 49(6), 1220-1235.
3. Postma, A., Kessels, R. P., & van Asselen, M. (2008). How the brain remembers and forgets where things are: The neurocognition of object–location memory. Neuroscience & Biobehavioral Reviews, 32(8), 1339-1345.
4. Wolfe, J. M. (2021). Guided Search 6.0: An updated model of visual search. Psychonomic Bulletin & Review, 28(4), 1060-1092.

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