

Object-based memories revealed by whole-report for dual-feature stimuli

William X. Q. Ngiam, Krystian B. Loetscher, Edward Vogel, Edward Awh

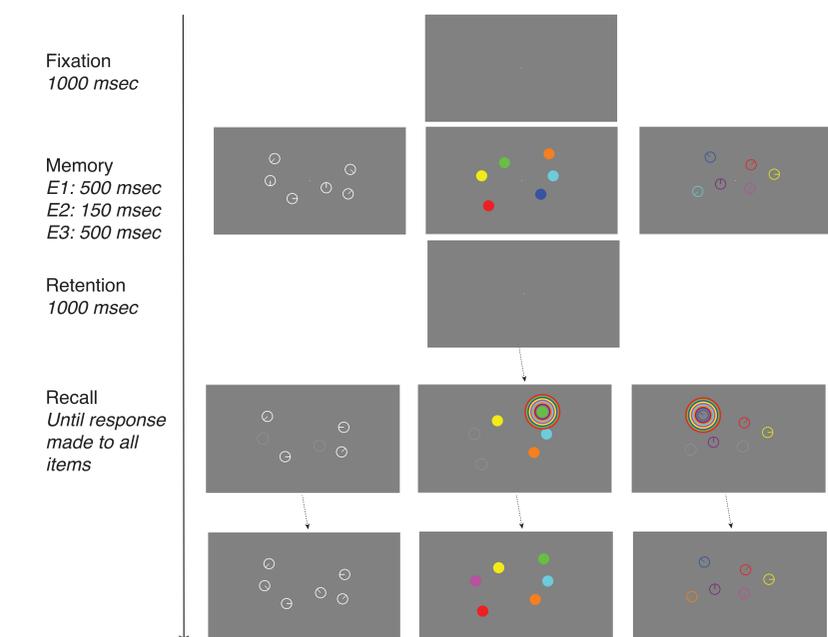
Introduction

A current research topic is how multi-feature objects are stored in visual working memory. Recall tasks with conjunction stimuli have found features of the same item can be forgotten independently (Fougnie & Alvarez, 2011). It has been suggested that memory storage is therefore feature-based.

Most experiments examining memory for conjunction stimuli use a single probe on each trial. This may not accurately reflect memory across the entire display. We used a whole-report paradigm to explore how conjunction stimuli are remembered in visual working memory. Previous whole-report experiments have found an item limit of 3 items using single-feature stimuli (Adam et al., 2017).

Method

In Experiment 1 and 2, 30 participants completed 300 memory recall trials in each condition: colors, orientations, and conjunctions. There were 8 possible colors and orientations. In Experiment 3, participants completed the conjunction condition only. On each trial, participants recalled all 6 items with a click and drag response, enabling a single response to both feature dimensions in the conjunction condition.

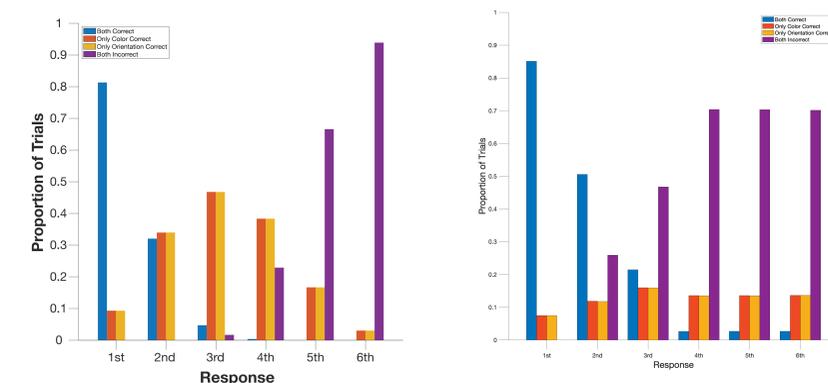


Analysis

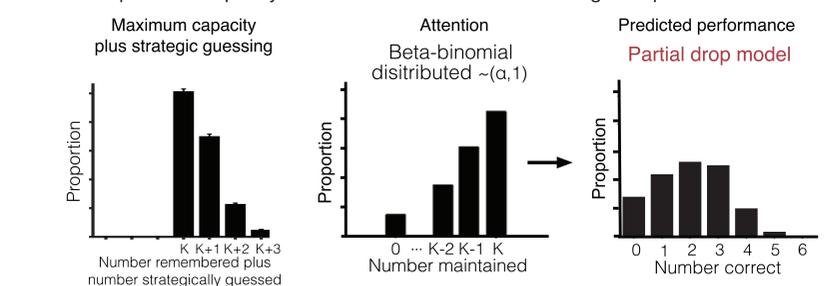
We examined two models that make predictions about how the information might be recalled across the display.

The **feature-based model** assumes storage is independent regardless of object and will be distributed across responses.

The **pointer-based model** assumes storage is concentrated to objects though independent feature decay may occur.

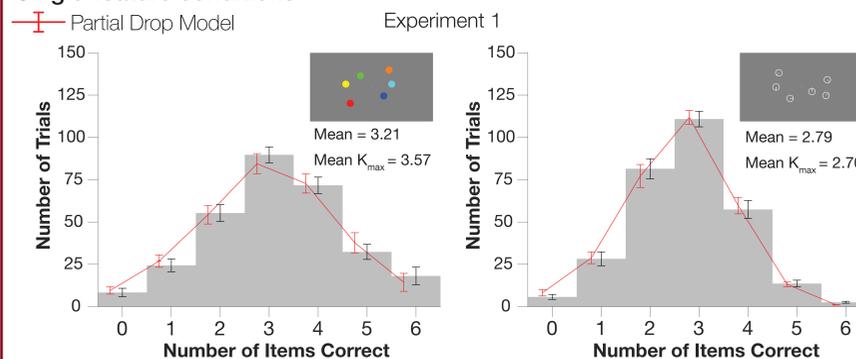


We fit a beta-binomial model to the response distributions to estimate maximum capacity (K_{max}) and attention (α) for each individual (Hakim et al., 2019). This analytical solution provides an individual's potential capacity across conditions while accounting for lapses in attention.

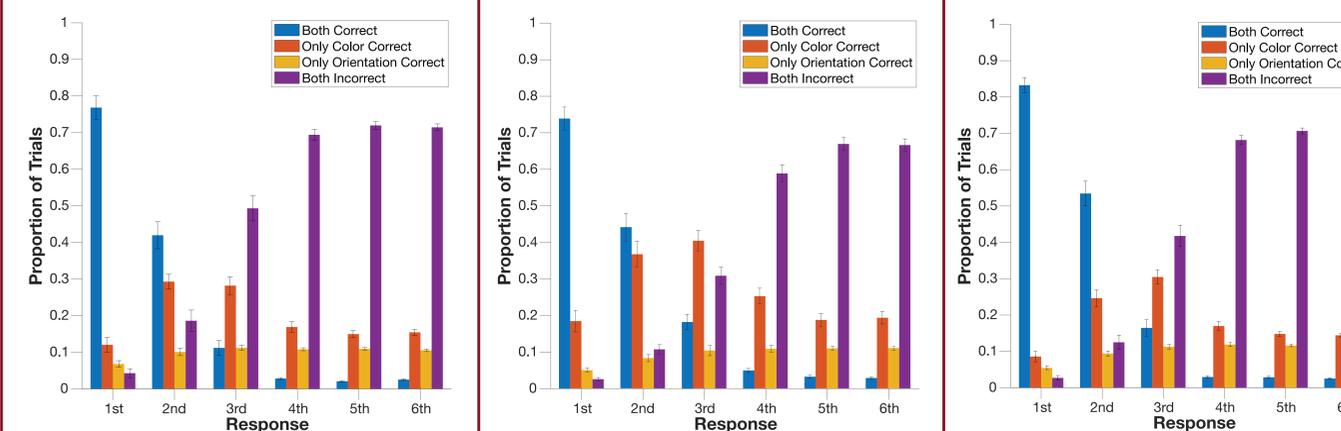
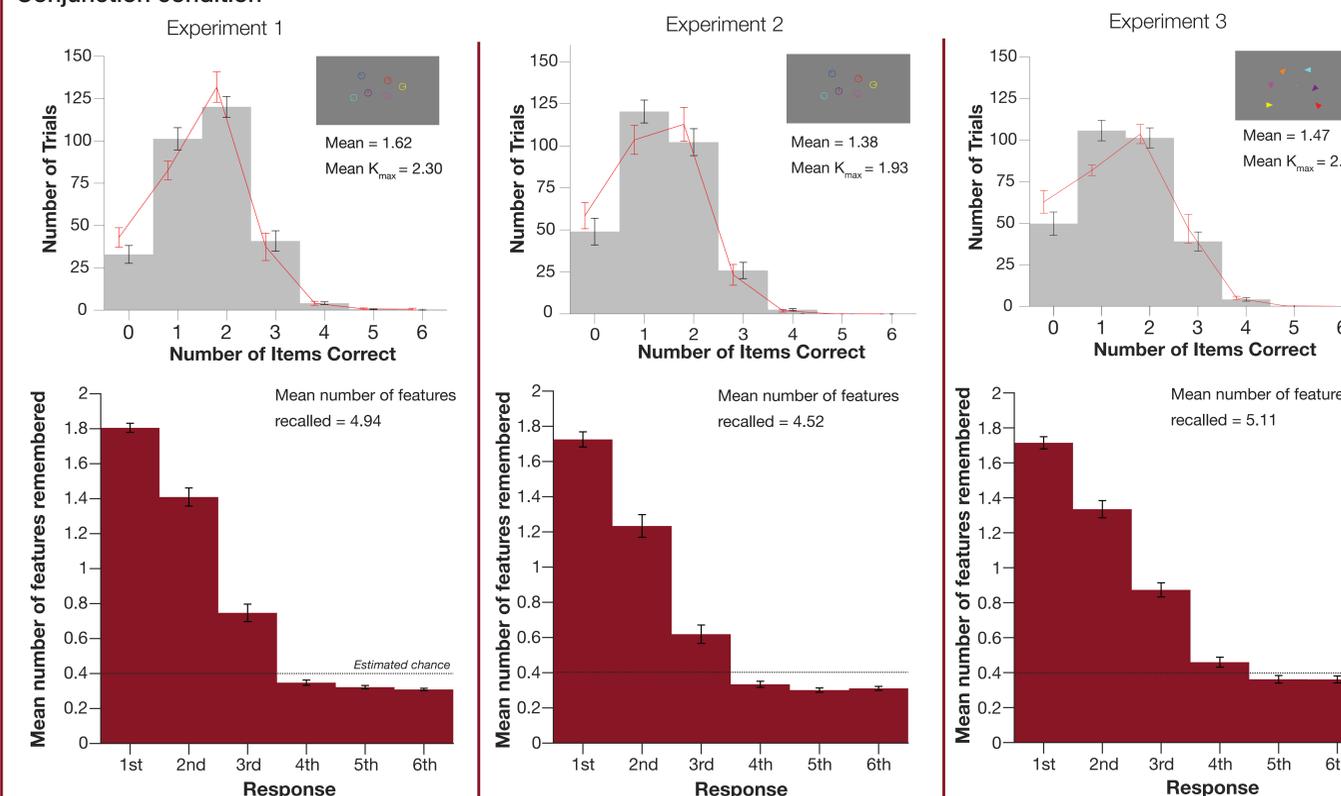


Results

Single-feature conditions



Conjunction condition



Conclusions

We conducted novel experiments using a **whole-report paradigm** with conjunction stimuli. **More featural information is remembered with conjunctions compared to single-feature items.**

We observe memory information is concentrated to the first three responses. Rather than features being stored stochastically, the memory appears to be **object-based**.

However, it is not lossless as features may be forgotten independently. We believe there is a limit of three location-based pointers for the storage of visual information.

References

- Adam, K. C., Vogel, E. K., & Awh, E. (2017). Clear evidence for item limits in visual working memory. *Cognitive psychology*, 97, 79-97.
- Fougnie, D., & Alvarez, G. A. (2011). Object features fail independently in visual working memory: Evidence for a probabilistic feature-store model. *Journal of vision*, 11(12), 3-3.
- Hakim, N., deBettencourt, M., Awh, E., & Vogel, E. K. (2019). Attention fluctuations impact ongoing maintenance of information in working memory. *PsyArXiv*.

Accuracy data separated by the response order is extremely consistent across the three experiments.

Compared to items in the single-feature conditions, the K_{max} drops approximately half to one object's worth in the conjunction condition.

However, if we do the same analysis for responses with at least one feature correct, the K_{max} estimate is similar to those for orientations.

Number of features recalled in the conjunction condition was significantly higher than number of items recalled in the single feature conditions (~3 items). Thus, there appears to be an **object-based benefit for memory**.

Accurate memory recall is constrained to the first three responses; the last three responses appear to be at chance performance. This replicates previous findings using single feature stimuli (Adam et al., 2017).

The estimate for chance derived by assuming three items were stored and calculating expected value from guessing.

Memory for features of an object can fail independently, replicating Fougnie & Alvarez (2011). However, there is above chance recall for both features of an object in the third response. This suggests that three objects were encoded in memory at some point.