Evidence for object-based encoding into visual working memory

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

@will_ngiam
wngiam@uchicago.edu

See you at WMS WORKING MEMORY SYMPOSIUM

THE UNIVERSITY OF CHICAGO

Introduction

Most experiments examining memory for conjunction stimuli use **a single probe** on each trial. This misses the distribution of memory across the entire display. We used a **whole-report paradigm** to explore how memory for features is distributed across a display of conjunction stimuli.

This allowed us to examine whether storage success for each feature dimension is **independently determined** or whether the encoded features are **concentrated within a set number of items**, as predicted by item-limit accounts of WM capacity.

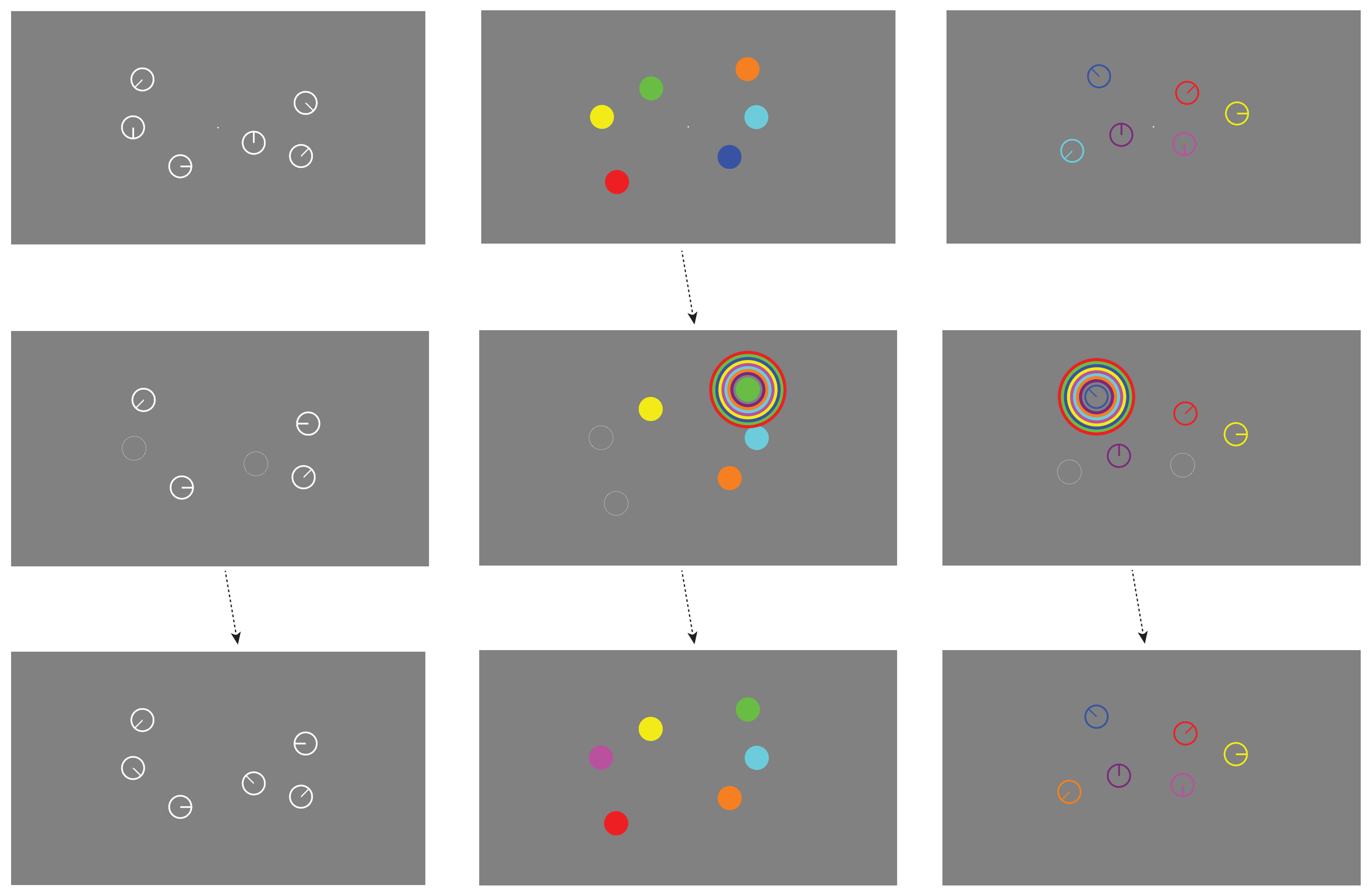
Fixation – 1000 msec

Memory – 500 msec (E2: 150 msec)

Retention – 1000 msec

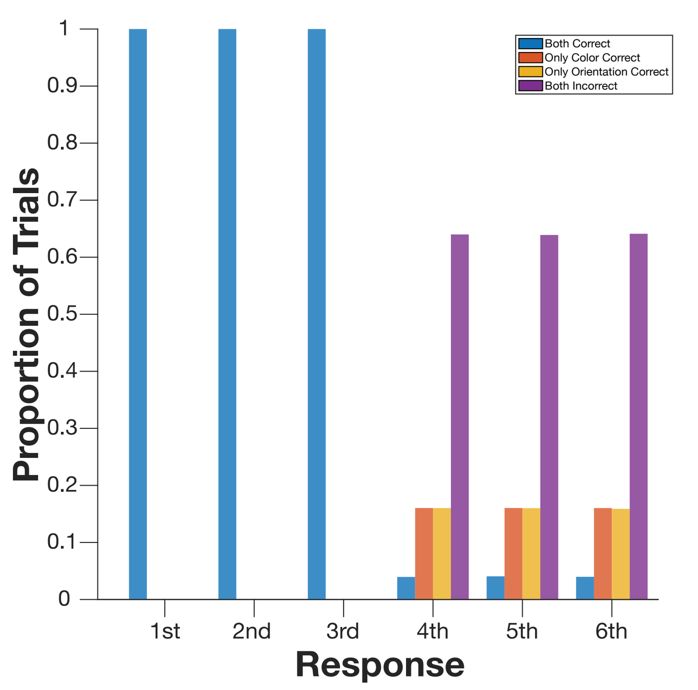
Recall – Until response made to all items

Task Video:

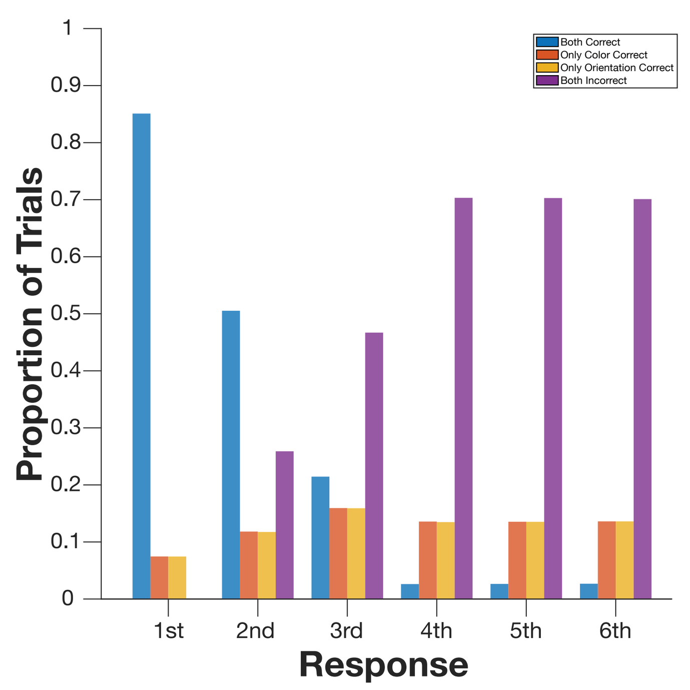


Model Predictions

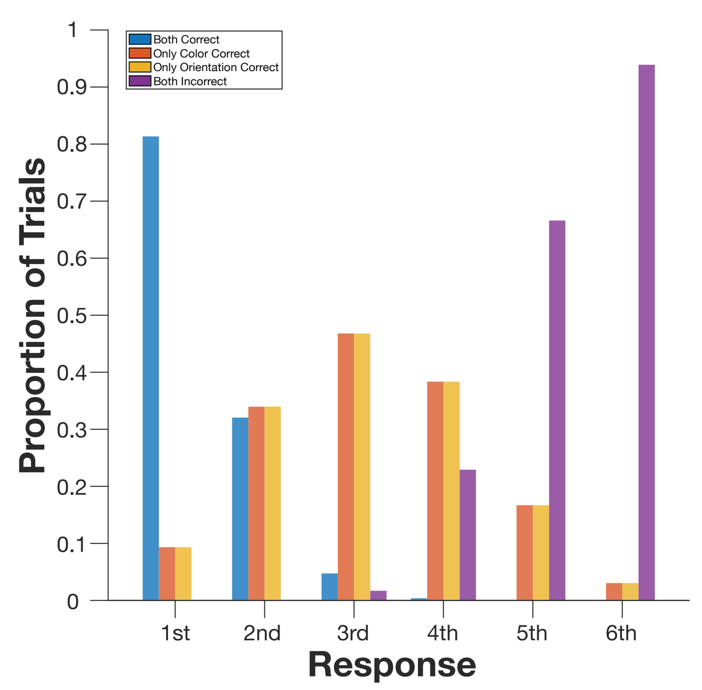
Strong Object Model
Accurate storage of three objects



Pointer Model
Item-based storage with feature loss



Independent Feature Model
Feature storage independent of objecthood



Results

Memory for stimuli with additional features is **not lossless** – less conjunctions overall are fully recalled.

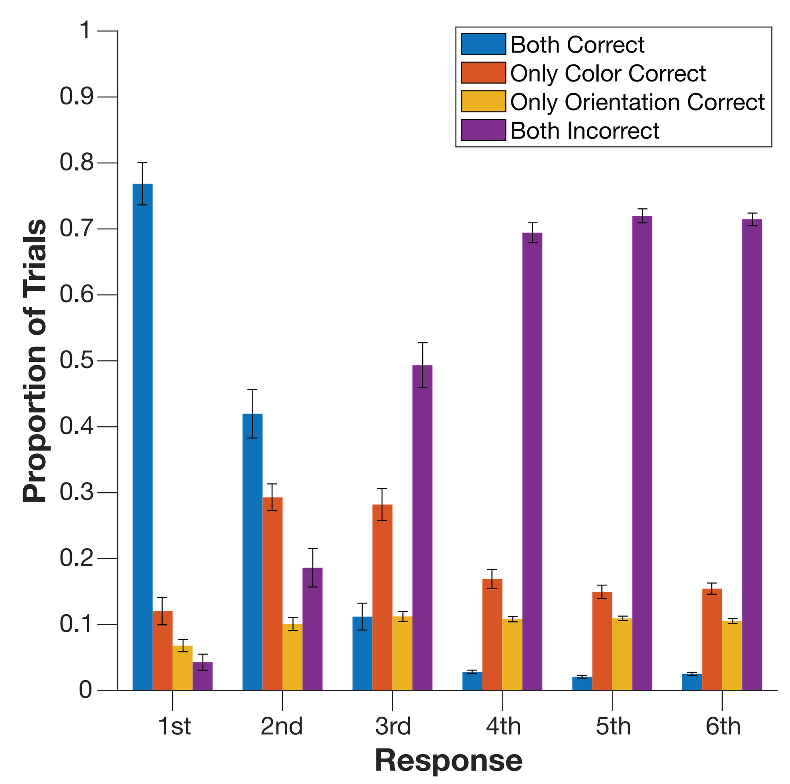
Mean Recall	Experiment 1	Experiment 2	Experiment 3	Experiment 4
Colors	3.21 ± 0.74	2.94 ± 0.64		3.61 ± 0.75
Orientations / Shapes	2.79 ± 0.44	2.45 ± 0.45		3.39 ± 0.64
Conjunctions	**1.62** ± 0.38	**1.38** ± 0.42	**1.47** ± 0.44	**1.92** ± 0.43

But we observe an **object-based benefit** – more features are accurately recalled in the conjunction condition than in the single-feature conditions.

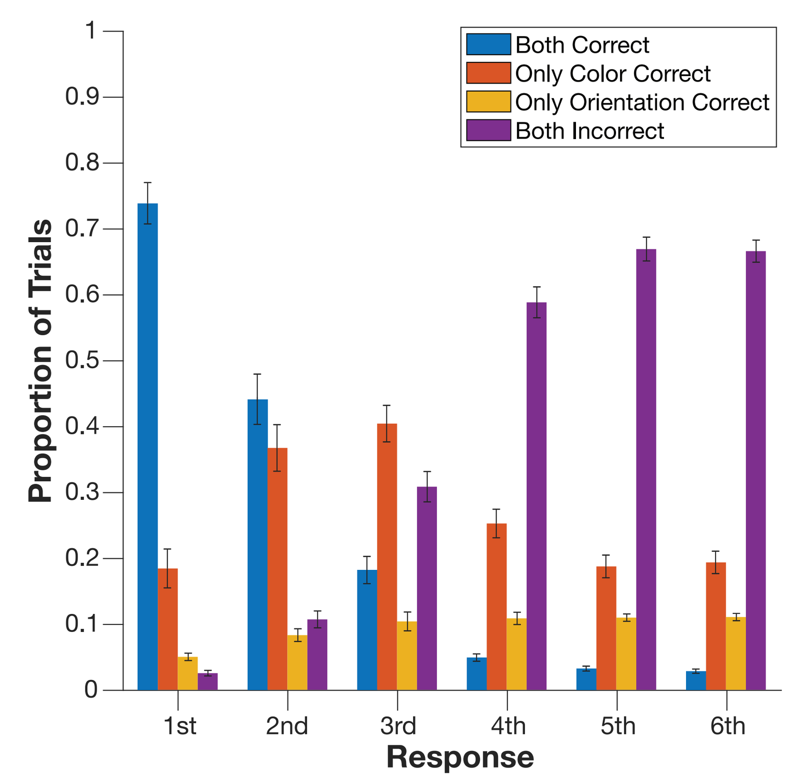
Features of conjunctions	**4.94** ± 0.68	**4.52** ± 0.83	**5.11** ± 0.65	**5.34** ± 0.85

Memory was concentrated to the **first three responses** and the last three responses are **pure guesses.**

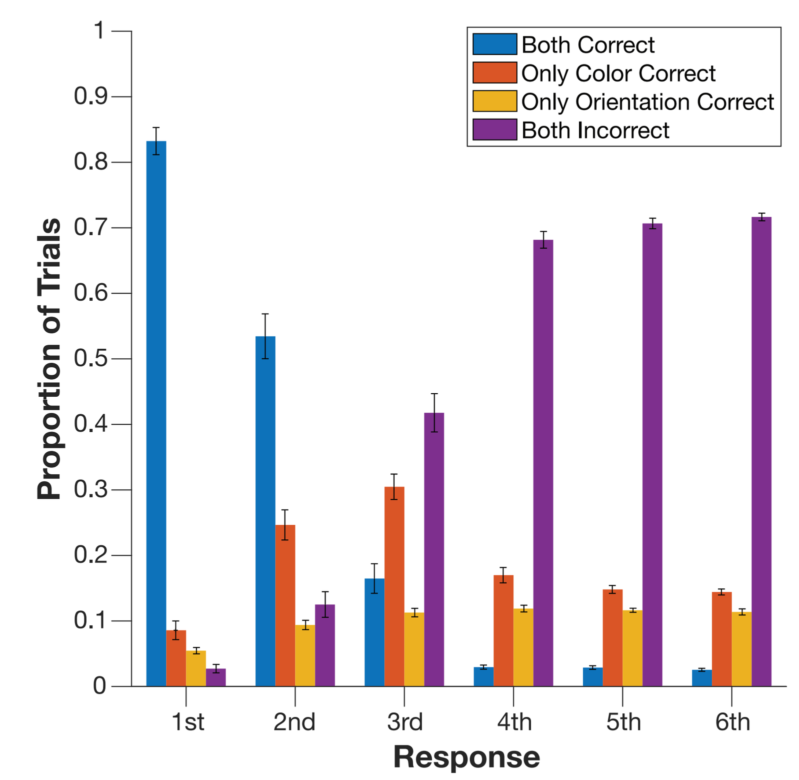
Experiment 1



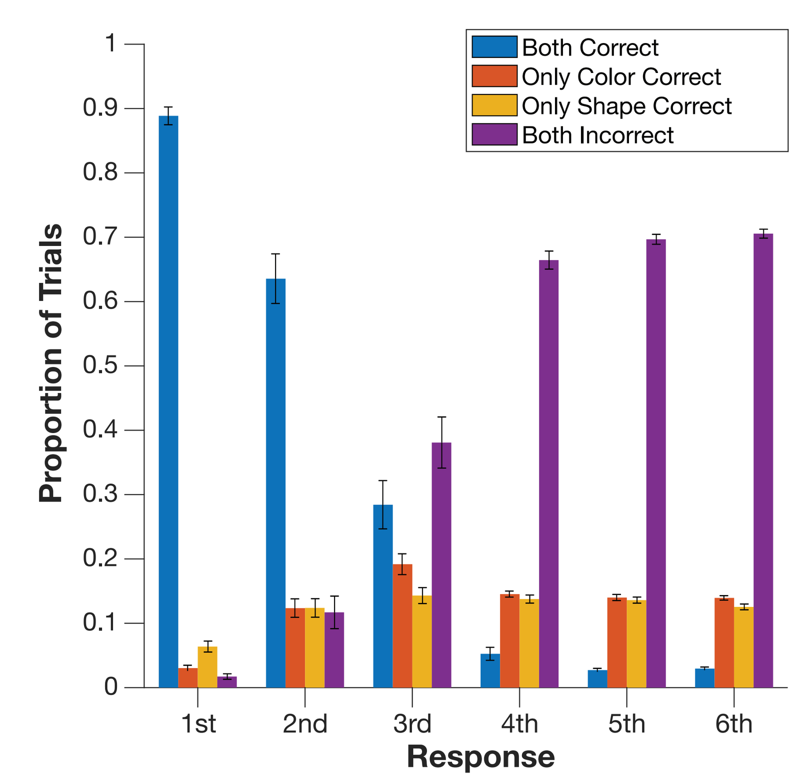
Experiment 2



Experiment 3



Experiment 4



For all subjects (n = 30 per experiment), the pointer model best fit the data compared to the other models.

Model	Strong Object Model	Pointer Model	Independent Feature Model
E1 BIC ($\times 10^3$)	4.9843	3.3372	4.8392
E2 BIC ($\times 10^3$)	4.9128	3.3212	4.7061
E3 BIC ($\times 10^3$)	5.6627	3.5084	4.8761
E4 BIC ($\times 10^3$)	4.7355	3.2225	4.8831

Conclusion

These are the first visual working memory experiments using a **combination of whole-report and multi-featured items.** Independent feature models predict that the recalled features would be randomly distributed across the items in the display. By contrast, we find that all features that subjects could accurately recall were **concentrated within three of the six items**, in line with models asserting item-based capacity limits.