Working memory for sequentially presented objects does not rely on location to bind features

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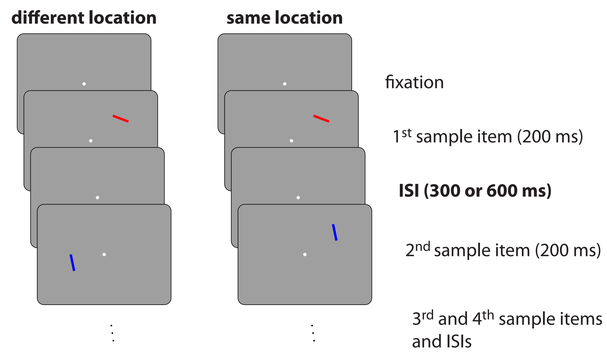
Introduction

- Several studies have proposed that spatial location takes a privileged role in binding other visual features (Treisman & Zhang, 2006; Schneegans & Bays, 2017). Supporting this view, Pertzov & Husain (2014) found that presenting sample items sequentially at the same location leads to an increase in misbindings between their features.
- However, a recent study investigating crowding effects in visual working memory did not observe an impairment of binding when stimuli were presented sequentially in close proximity (Harrison & Bays, 2018).
- Here we test how general the same-location effect on binding is, and whether the conflicting results may be explained by differences in the timing of stimulus presentation in the two studies.

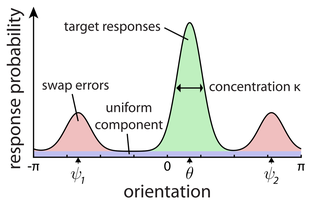
Behavioral task

We used a four-item cued recall task adapted from Pertzov & Husain (2014), but introduce a variation in inter-stimulus interval (ISI) as a new within-subjects variable.



Item locations are task-irrelevant and uninformative in all task conditions.

Analysis

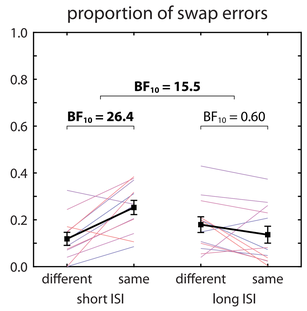


We fit responses for each subject as a mixture of von Mises and uniform distributions:

$$p_{resp}(\phi) = p_{target} \cdot \Phi_{vm}(\phi - \theta, \kappa) + p_{swap} \cdot \sum_i \frac{1}{n} \Phi_{vm}(\theta - \psi_i, \kappa) + p_{uniform} \cdot \frac{1}{2\pi}$$

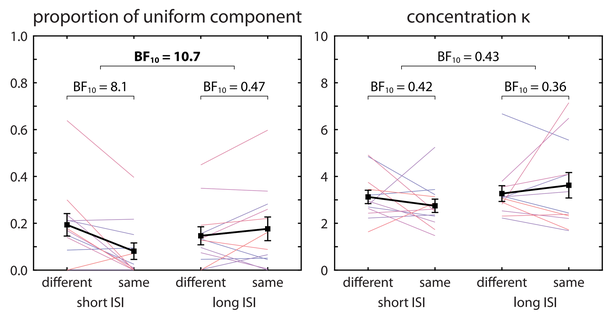
We used p_{swap} as a measure of binding performance, and employed Bayesian statistics to determine whether it was differently affected by the location condition for short and long ISIs (Bayesian stopping criterion of BF > 10 for difference of differences in p_{swap}, reached after 12 subjects).

Results



Confirming earlier results, we found strong evidence for a location effect with short ISIs (impaired binding in the same-location condition).

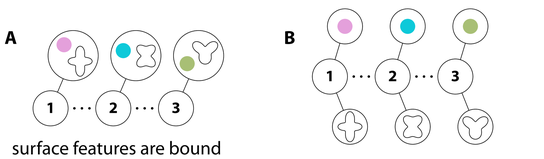
Critically, the effect was not observed for longer ISIs (weak evidence against difference and strong evidence for interaction), suggesting that it is caused by temporal interference (Yeshurun, Rashal & Tkacz- Domb, 2015).



Unlike in the original study, we also observed a complementary effect of location condition on the contribution of the uniform component. Concentration did not vary with either location condition or ISI.

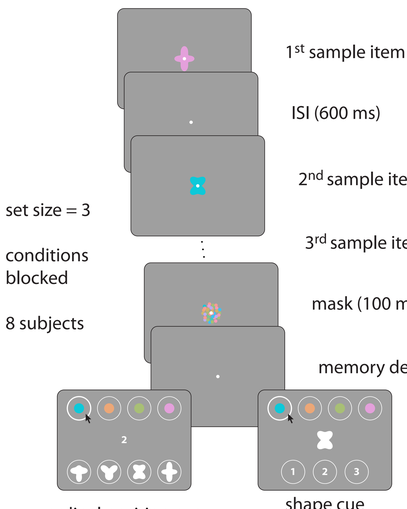
Interpretation of results

- The findings show that feature bindings can be successfully stored for items presented sequentially at the same location. This poses a challenge for models assuming a central role of location for binding.
- The results may be explained by two possible mechanisms:

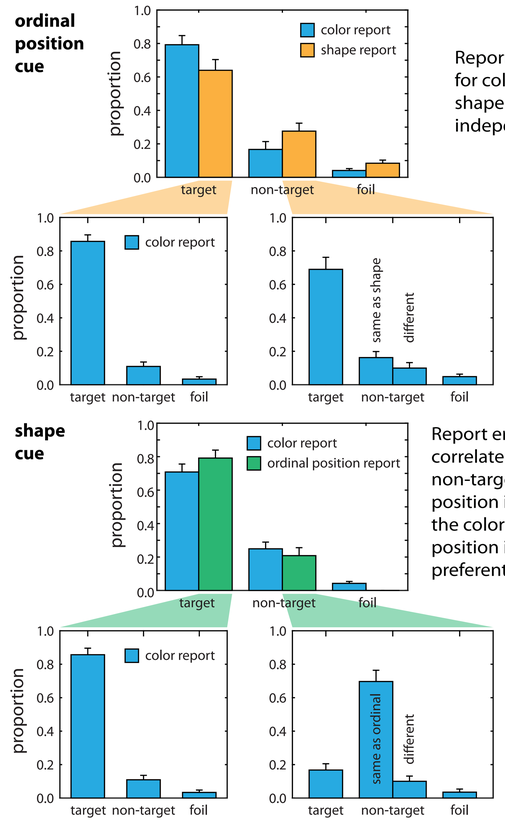


Follow-up experiment

We tested binding for sequentially presented items using a dual-report paradigm adapted from studies investigating independence of feature stores (Bays, Wu & Husain, 2011) and spatial binding (Schneegans & Bays, 2017).



Results



Report errors for color and shape occur independently.

Report errors are correlated: When a non-target ordinal position is selected, the color for that position is reported preferentially.

These results are consistent with mechanism B.

Discussion

- Our results indicate that feature binding is not exclusively mediated by space, as binding memory is not impaired for items presented sequentially at the same location if enough time is given.
- However, we still found no evidence for direct binding of surface features in memory. Instead, different features appear to be bound independently to ordinal position.

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