Independent stores for relative and absolute spatial location in visuospatial working memory

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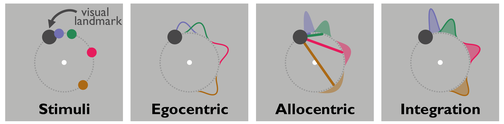
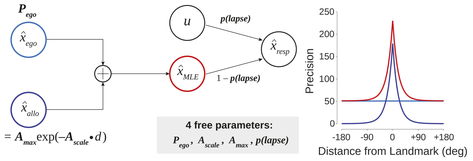
Introduction

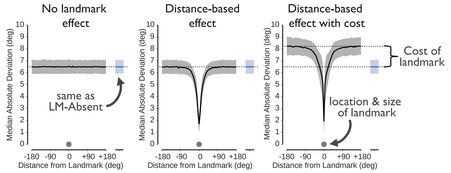
- Visual spatial working memory (VSWM) helps us to deal with interruptions in sensory input - such as blinks, saccades, transient stimuli or environmental occlusions.
- However, the capacity of VSWM is limited, with recall precision decreasing as the number of items increases.
- While visual information is typically encoded retinotopically, relative to the current gaze direction (egocentric), this poses challenges when the eyes move.
- Objects may additionally be encoded relative to other objects in the environment (allocentric) with this information contributing to localisation.



- We proposed that allocentric information represented an additional source of spatial information, optimally integrated with egocentric spatial estimates.

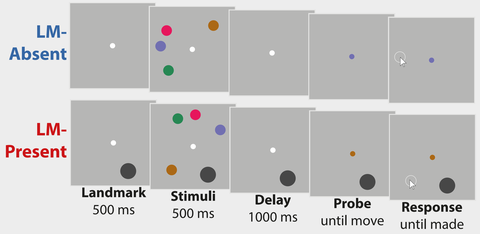


- The precision of allocentric information depends on the distance of the remembered items from the visual landmark, with smaller object-landmark distances more precise.

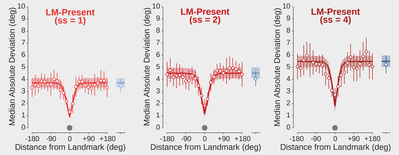


- By comparing conditions with visual landmarks to those without, we can quantify both:
  - Distance-based improvements in precision.
  - Evidence for whether encoding relative information conveys a cost to egocentric memory.

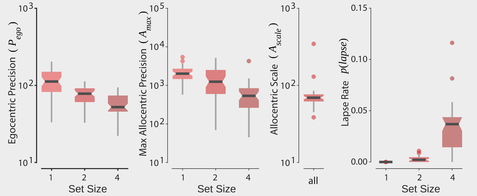
Landmarks convey spatially-specific improvements in localisation precision across multiple set-sizes



- In experiment 1 we examined LM-Absent and LM-Present for three different set sizes of items to remember (1,2,4).

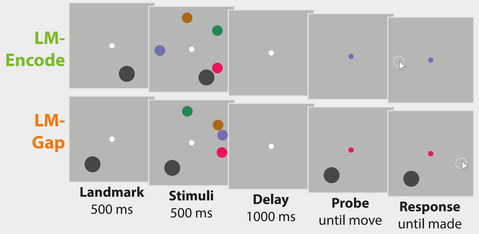


- For all set sizes we observed a substantial decrease in localisation variability for items near a landmark.
- Performance at far locations was identical to that with no landmark - no suggestion of a cost from encoding allocentric.
- Both egocentric and allocentric precision decreased as set size increased, suggesting there was competition for limited resources within both representations.

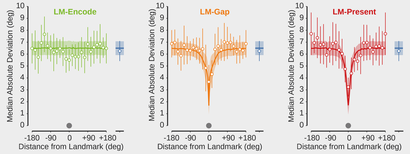


- Explicit model comparison, looking at whether the encoding of allocentric information (or landmark presence) affects egocentric precision confirmed that there was no cost.

While landmarks can be transient, they must be present during recall to convey a localisation benefit

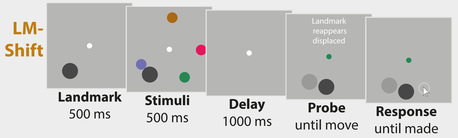


- In experiment 2 we replicated LM-Absent and LM-Present.
- While in LM-Encode the landmark was only visible during encoding, in LM-Gap it returned after the delay.

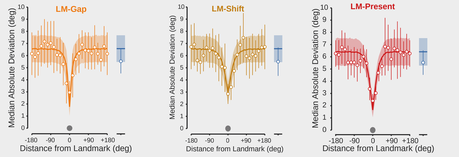


- LM-Encode performance was identical to LM-Absent, indicating that using allocentric information required the landmark to be visible during recall.
- But we observed a robust landmark effect even when the landmark was transiently blanked throughout memory delay.

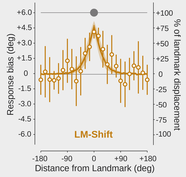
Displacing landmarks during the delay results in systematic biases depending on distance between landmark and item



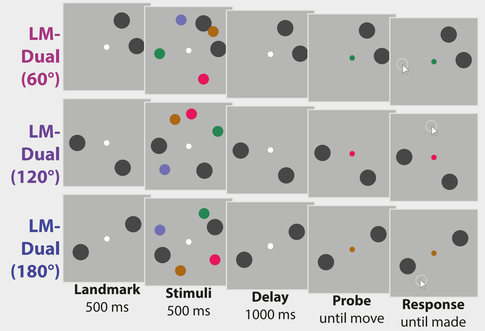
- In experiment 3 we replicated LM-Absent, LM-Gap, LM-Present and introduced LM-Shift.
- LM-Shift is identical to LM-Gap, but the landmark returned at a displaced location.



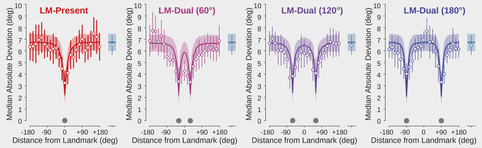
- Even if the landmark was displaced, we saw a robust spatial-specific influence of the landmark on precision.
- Biases revealed distance-dependent cue integration between displaced allocentric and unchanged egocentric.



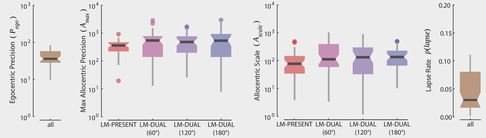
Landmark effects occur also with multiple visual landmarks, with little evidence for competition between landmarks



- In experiment 4 we replicated LM-Absent & LM-Present.
- We introduced the LM-Dual conditions, in which two landmarks were situated 60°, 120°, or 180° apart.



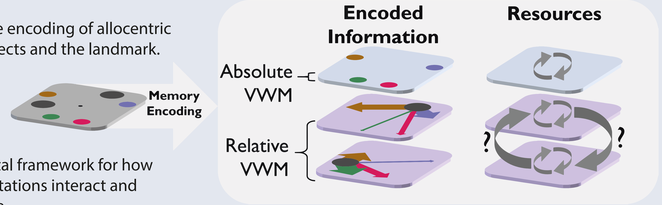
- Each landmark provided an additional source of allocentric information to assist in localising targets.
- No cost to egocentric memory for inorporating a second landmark.



- We find little evidence that increasing the number of landmarks decreased individual allocentric precision.
- Currently investigating whether this reflects true independence or strategic use of landmarks.

Conclusions

- The presence of visual landmarks enables the encoding of allocentric information about the distance between objects and the landmark.
- This information, depending on its precision (which decreases with increasing distance) is then integrated with egocentric estimates to form localisation estimates.
- We provide a computational and experimental framework for how egocentric and allocentric memory representations interact and their integration into a single spatial estimate.



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