## Supplementary Material

# 1. Mixture Model Analysis

## 1.1 Experiment 1

Many studies in the field have modeled the distribution of errors and used a parameter of the distribution to quantify the precision in which items were recalled. We used the 2D model toolbox (MemToolbox2D; Grogan, et al., 2019, https://doi.org/10.5281/zenodo.3355381) that uses the framework of the Memtoolbox (Suchow et al., 2013; MemToolbox.org) to fit the swap model (Bays & Husain, 2008). Due to the special population in this study, and their short attention span, not many trials were included in the distribution of errors of each subject (40), even less when dividing the data to conditions, leading to noisy fit to the mixture model. Thus, we collapsed all the data from all trials of all subjects in the three objects condition.

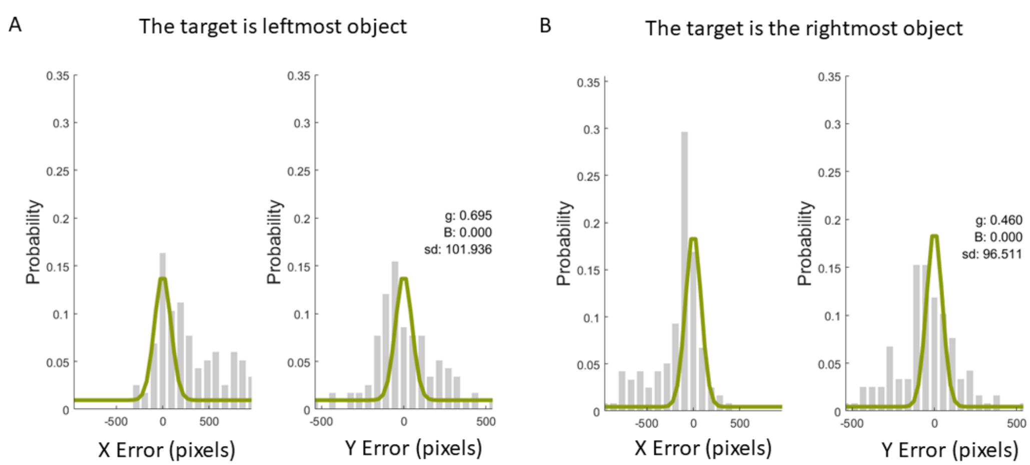


Figure S1. The 2D mixture model fit for trials with leftmost (A) and rightmost (B) target object.

The model results show higher SD ($\alpha$), higher rate of swap errors ($\beta$) and a higher guess rate ($\gamma$) when the target was on the left side. The statistical significance of these results is unclear because the fit was performed for all the data together, and not for each subject independently.

Table 1. 2D swap model results

| | | |
|---|---|---|
| Right | guess | 0.46 |
| | non-target | 4.19E-15 |
| | SD | 96.25 |
| Left | guess | 0.69 |
| | non-target | 1.08E-14 |
| | SD | 101.93 |

## **1.2 Experiment 2**

The Memtoolbox (Suchow et al., 2013; MemToolbox.org) was used to fit the swap mixture-model (Bays & Husain, 2008) to the distribution of errors. As in Experiment 1, due to the low number of trials in the distribution of each participant and condition, the fit was noisy and did not converge is some cases. We collapsed the data across all participants, and multiplied the errors by 2 to reach a scale of 360 degrees to fit the toolbox. The SD result was then divided by two in order to return to the original scale.

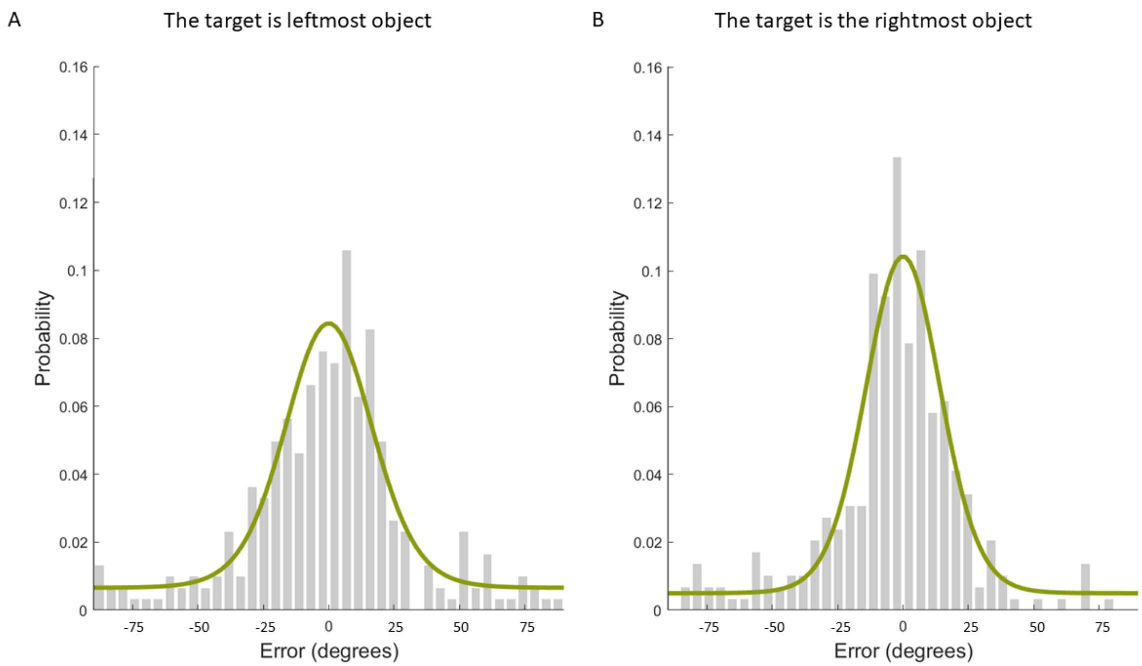


Figure S2. The swap model fit for trials with left (A) and right (B) targets.

Table 2. swap model results

| | | |
|---|---|---|
| Right | guess | 0.19 |
| | non-target | 0.01 |
| | SD | 15.41 |
| Left | guess | 0.23 |
| | non-target | 0.02 |
| | SD | 18.36 |

The model results show higher SD ($\alpha$), higher rate of swap errors ($\beta$) and a higher guess rate ($\gamma$) when the target was on the left side. The statistical significance of the results is unclear as the fit was done only once, on the collapsed data.

## **2. The lateralized binding deficit in the neglect side does not result from a bias for right localizations**

### **2.1 Center location swap direction**

To check if the lateralized binding deficit may simply reflect a response bias: a tendency of neglect patients to recall the location or the orientation of the item displayed on the right side of the screen. The objects that were located in the center of the array were taken, and the direction of the swap error was analyzed. We find an opposite direction of effect, most of the swap errors were to the left (see Figure 4), however this effect is not significant (t(11) = 1.198 *p* = .26, *d* = 0.35).

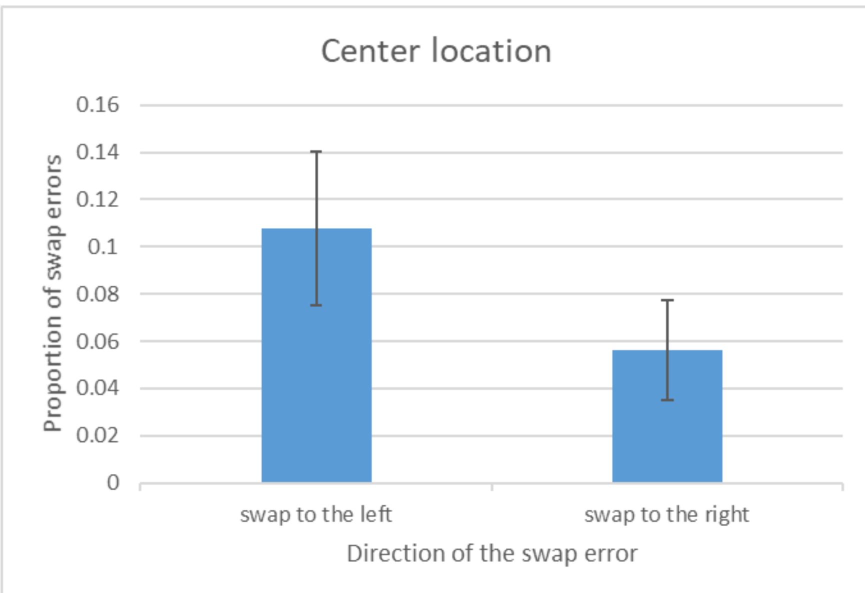


Figure S3. The swap error direction for trials that the target item was in the center of the array. Error bars represent standard errors of the mean.

**2.2 Wrong identification swap location**

Next, to see whether there is a response bias, we analyzed the response location in trials that the object was incorrectly identified. WE checked if the objects were localized near the object locations in the left, right or center of the array. We found that there was no specific bias direction (see Figure 5; $F(2,22) < 1$, $p = .77$, $\eta_p^2 = .02$).

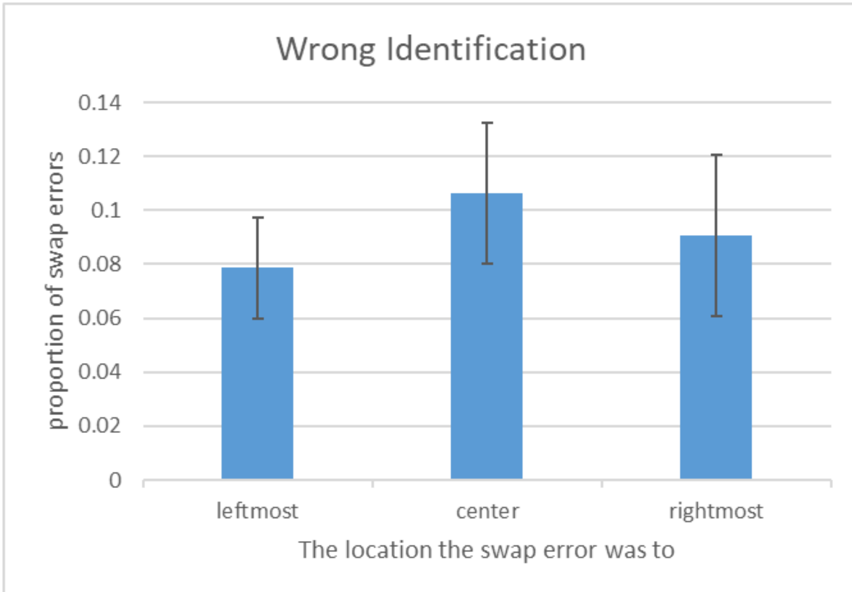


Figure S4. The destination of the swap error for trials that the target item was not identified. Error bars represent standard errors of the mean.

## 3. Figures with single subjects

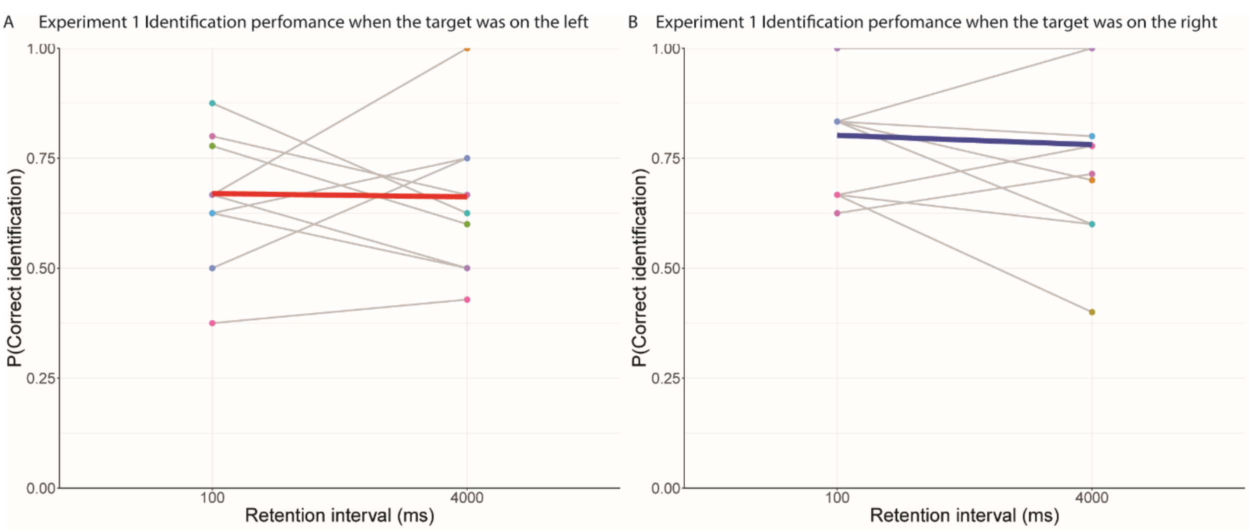


Figure S5. Results of Experiment 1 in the 3 objects condition. (A) Identification performance - % correct responses for when the target was the leftmost object (contra-lesional), the red line marks the mean of the group and each gray line is a single subject. (B) Identification performance - % correct responses for when the target was the rightmost object (ipsi-lesional), the blue line marks the mean of the group, and each gray line is a single subject.

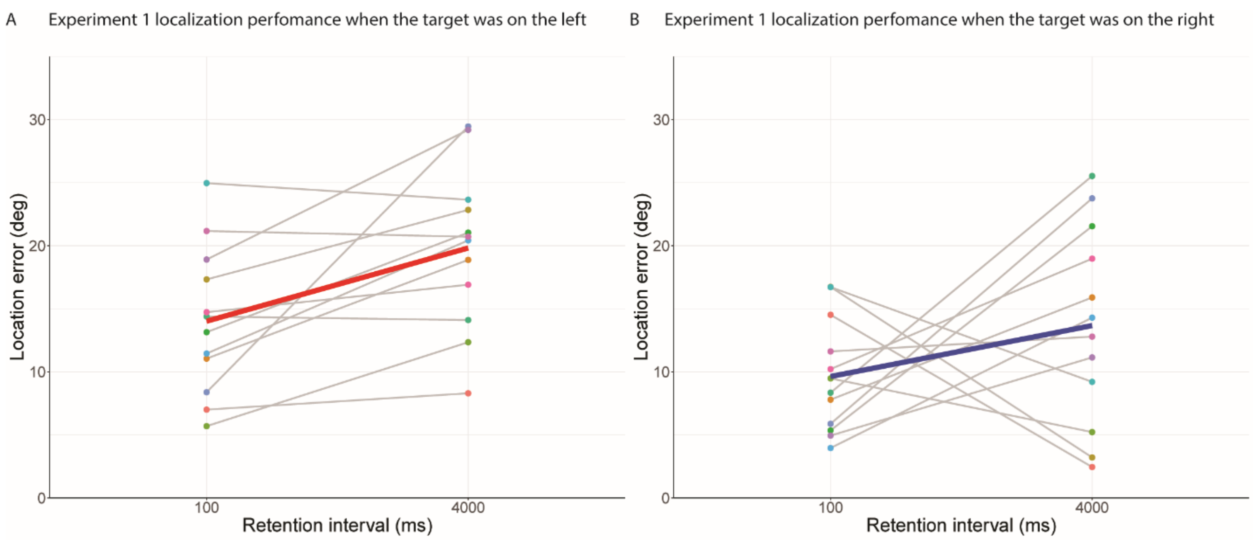


Figure S6. Results of Experiment 1 in the 3 objects condition. Localization performance measured by the distance between the reported location and the true location. (A) The target was the leftmost object (contra-lesional), the red line marks the mean of the group and each gray line is a single subject. (B) The target was the rightmost object (ipsi-lesional), the blue line marks the mean of the group, and each gray line is a single subject.

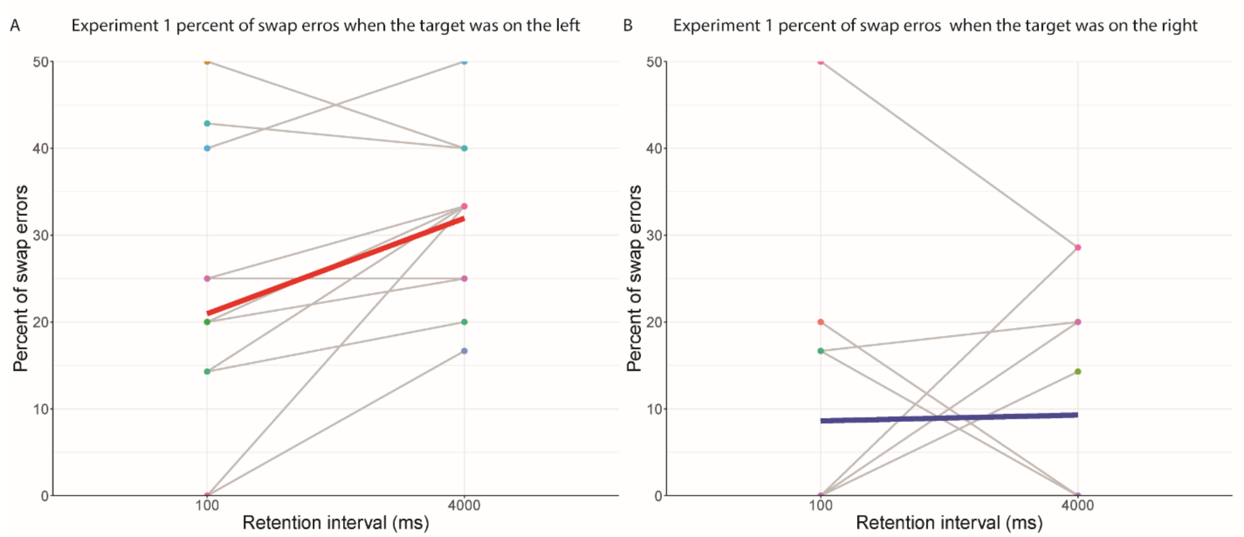


Figure S7. Results of Experiment 1 in the 3 objects condition. Proportion of cases in which the target object was erroneously localized close to an original location of a non-probed object, when the target is the leftmost object (contra-lesional; A), the red line marks the mean of the group and each gray line is a single subject. When the target was the rightmost object (ipsi-lesional; B), the blue line marks the mean of the group, and each gray line is a single subject.

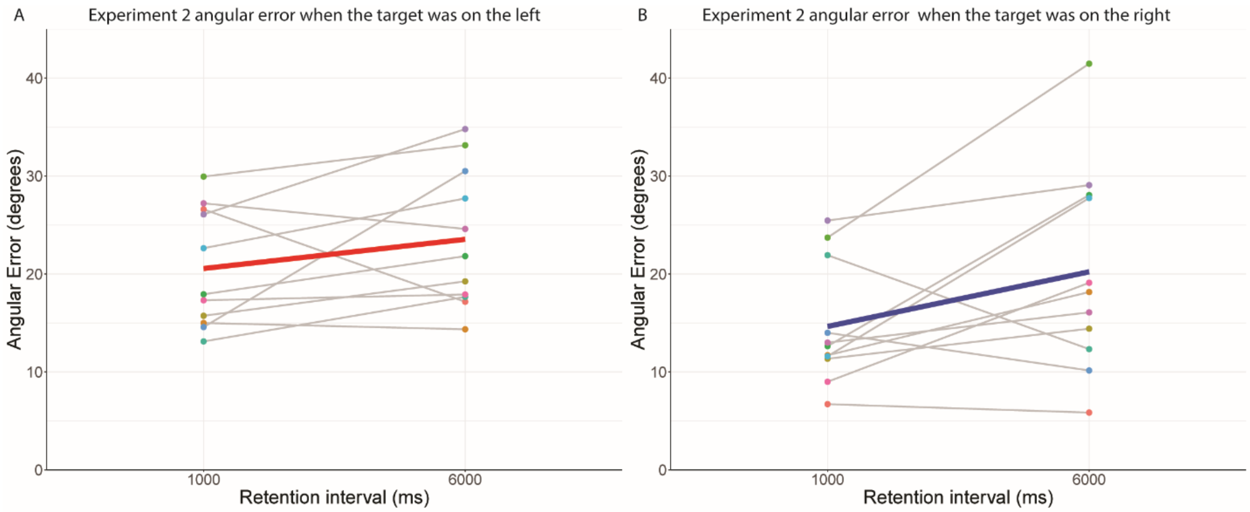


Figure S8. Angular errors in Experiment 2 when the target was on the left (contra-lesional; A )side , the red line marks the mean of the group and each gray line is a single subject. When the target was on the right (ipsi-lesional; B) side, the blue line marks the mean of the group, and each gray line is a single subject.

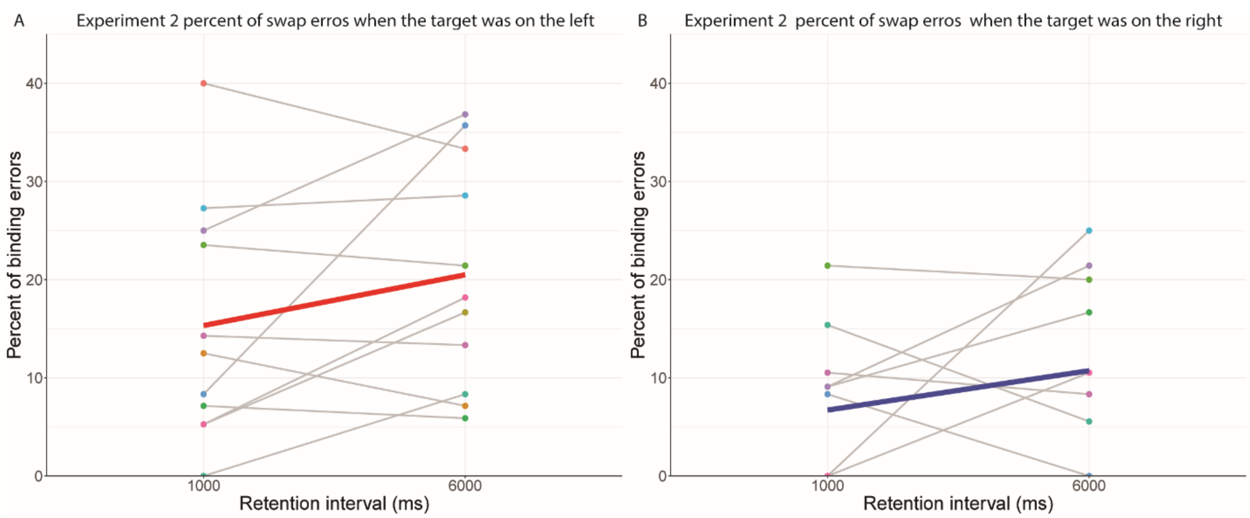


Figure S9. Results of Experiment 2 for the Percent of binding errors. (A) For the when the target is on the left (contra-lesional), the red marks the mean of the group and each gray line is a single subject. (B) For the when the target is on the right (ipsi-lesional) side, the blue marks the mean of the group, and each gray line is a single subject.

## 4. Healthy Participants

The current study's focus was understanding lateralized deficits in patients with Unilateral Neglect Syndrome (USN), for this reason the comparison was between the contra-lesional and ipsi-lesional sides. Thus, the ipsi-lesional (un-neglected) side served as a control for the contral-lesional (neglected) side. However, USN patients also suffer from non-laterlized deficits (Husain & Rorden, 2003), and specifically in spatial working memory (Malhotra et al., 2005). Such, non-laterlized deficits could be assessed by comparing USN patients with healthy participants. Pertzov, Heider, Liang and Husain (2015) could be used for such a purpose, as it used an almost identical experimental design- the only difference is in the length of the short retention interval (in Pertzov et al., 2015: 1000 ms, in this study 100 ms). Pertzov et al., (2015) studied the effects of healthy aging on binding and precision in VWM. They divided the participants to 4 age groups. The USN patients can be compared to groups three and four (ages 40 – 83). As expected, regardless of the location of the target, identification and localization performance of USN patients was clearly worse than in healthy controls. The healthy participants identification proportion in the three items condition ranged from around 0.85 to 0.9, for the USN patients the proportion correct average was 0.72 (*SD* = .07). The healthy participants localization error ranged from around 6 dva to 8 dva. The average localization error for the neglect patients in this experiment was 14.29 dva (*SD* = 3.13). This general impairment in localization errors also precludes a detailed comparison of swap errors, as larger localization error may lead to less detected swap errors, due to larger proportion of localizations just outside the threshold used to define swap errors (see distribution of errors around nearest item in the main text in Figure 5). For this reason, when comparing the percent of swap errors, the difference between the healthy aging group and the neglect patients is less clear (healthy aging between 10-15%, neglect group average of 17.7%, *SD* = 6.88). Thus, we can conclude that USN patients have an un-laterlized deficit in location memory, consisting with previous studies (Malhotra et al., 2005).

**References**

Bays, P. M., & Husain, M. (2008). Dynamic shifts of limited working memory resources in human vision. *Science (New York, N.Y.)*, *321*(5890), 851–854. https://doi.org/10.1126/science.1158023

Husain, M., & Rorden, C. (2003). Non-spatially lateralized mechanisms in hemispatial neglect. *Nature Reviews Neuroscience Neuroscience*, *4*(1), 26–36. https://doi.org/10.1038/nrn1005

Malhotra, P., Jäger, H. R., Parton, A., Greenwood, R., Playford, E. D., Brown, M. M., … Husain, M. (2005). Spatial working memory capacity in unilateral neglect. *Brain*, *128*(2), 424–435. https://doi.org/10.1093/brain/awh372

Pertzov, Y., Heider, M., Liang, Y., & Husain, M. (2015). Effects of healthy ageing on precision and binding of object location in visual short term memory. *Psychology and Aging*, *30*(1), 26–35. https://doi.org/10.1037/a0038396