Various unattended stimulus attributes leave footprints on short-term visual memory
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Attentional Filtering of task-irrelevant information

Using a recognition memory paradigm we examined selective attention’s ability to filter out task-irrelevant information. Stimuli were sinusoidal gratings whose spatial frequencies varied. On each trial, two study items, S1 and S2, were followed by a probe. Subjects judged whether the probe matched either of the study items on the task-relevant dimension. Guided by a noisy-exemplar model (NEMO) (Kahana et al. 2007) we focused on two known determinants of recognition: Summed probe-item similarity and the Inter-item homogeneity of the study items.

Experiment 1
Selective filtering of spatial location

Task
Judge whether probe’s spatial frequency matched that of either study items regardless of location.

Stimuli
1-D vertical sinusoidal gratings. Their perceptual similarity varied parametrically, with spatial frequency differences scaled for individual subjects’ discrimination thresholds (in JND units).

In each trial, study items and probe were presented at various vertices on a virtual hexagon. To quantify filtering, the proximity of probe and study items’ spatial locations was varied parametrically.

Results
- PiYes) is significantly higher when probe is presented at or near the location of more-similar study item, p < .01.
- However, when probe’s frequency falls between that of two study items, the proximity to both items’ locations affected PiYes.

Experiment 2
Selective filtering of an orthogonal Orientation

Task
Attend to one orientation only, judging whether probe’s spatial frequency on that Relevant orientation matches that of either study item.

Theoretically-important probe subtypes
To manipulate similarity, the spatial frequencies of probe and study items were varied on both Relevant and Irrelevant orientations:
- Super-target is a probe that matches a study item on both relevant and irrelevant orientations;
- Sub-target is a probe that matches a study item on only the relevant orientation;
- Super-lure is a probe that doesn’t match study items on either orientation;
- Sub-lure is a probe that matches a study item irrelevant but not relevant orientation;

The irrelevant orientation influences recognition
- Correct recognitions of Super-targets were higher than correct recognitions of Sub-targets: the match or non-match on the irrelevant orientation had a significant effect, p < .001.
- Moreover, subjects’ responses varied systematically with the difference between the probe’s frequency on the relevant orientation and that of the study items.
- However, false recognitions (false alarms) were equivalent for Super-lures and Sub-lures.

References
We thank Joe-Soak Hyyan for his preliminary experiment. Supported by NIH Grant NIMH 68446.
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Examining results through the lens of a Noisy-Exemplar Model (NEMO)

- NEMO asserts that recognition responses reflect computations of summed similarity and inter-item homogeneity. A probe is recognized as a match if the combined value of the two components exceeds a threshold Criterion:

\[ \Sigma \eta_i \eta_j S_{ij} + \frac{1}{L(L-1)} \sum_{i,j=1,i\neq j}^{L} \eta_i \eta_j S_{ij} \]

- To learn how the irrelevant dimension is processed, several variants of NEMO were fit to Exp. 2 recognition data. Model variants differed in (i) whether the irrelevant dimension influenced summed similarity, or homogeneity, or both, and (ii) how relevant and irrelevant dimensions were integrated (Euclidean or city block metric).

Best-fit model variant
- Recognition takes account of (i) inter-item homogeneity, but only on the attended dimension, and (ii) the summed similarity incorporates both relevant and irrelevant dimensions, which are integrated as a Euclidean sum.

Conclusions
- A stimulus’ spatial location exerts a graded effect on visual recognition memory in Experiment 1, even though location is task-irrelevant. This suggests a parametrical binding of relevant and irrelevant dimensions.
- Selective attention has multiple effects. That is, an irrelevant, ignored stimulus dimension differentially influences the several distinct processes that contribute to visual short-term memory (vSTM).
- Within our model’s account of vSTM, task-irrelevant information contributes only to summed similarity, and not to inter-item homogeneity. This selective effect confirms the functional separability of these two influences on vSTM.

Schematic illustration of NEMO
- Attentional filtering succeeds in excluding irrelevant information from the computation of homogeneity. This supports claims that homogeneity is computed late in the recognition process, and is less automatic and more attention-demanding than the computation of summed similarity.