Is Attention Necessary for the Representational Advantage of Good Exemplars over Bad Exemplars?

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Attention and Perception Lab

Introduction

Real-world statistical regularities (rwSR) built over a lifetime (e.g., category representativeness of natural scene images) have:

- *Behavioral advantages*: faster and more accurate at recognizing good exemplars than bad exemplars of scene categories[1];
- *Neural advantages*: more efficient (lower BOLD responses and reduced N300) and decodable (higher decoding scores) representation in scene-responsive areas[2,3].

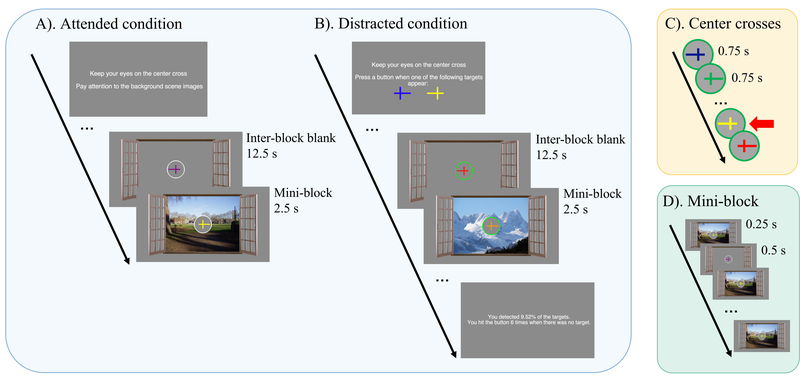
Problem: These observed advantages may be driven by attention instead of rwSR.

Question: Is full attention necessary to observe the neural advantages of highly statistical regular stimuli?

Method

Experiment Procedure:15 subjects each participated in 2 fMRI sessions

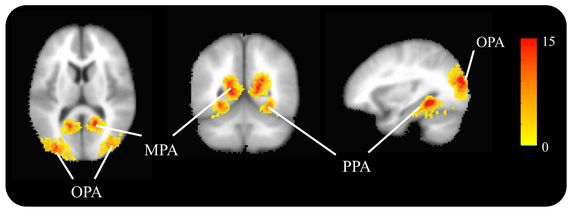
- A main experiment session to manipulate attention and SR orthogonally in a *dual-task paradigm*:
  - Attentional load manipulated by an RSVP task[4] at fixation;
  - SR manipulated by good or bad exemplars of natural scene images[2] from 2 categories: cities and mountains.



- A functional localizer session to find scene-responsive areas: parahippocal place area (PPA), medial place area (MPA), occipital place area (OPA).

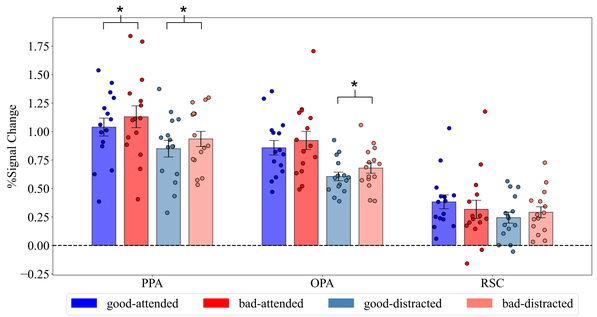
Analysis: *Univariate analysis* was applied to assess processing efficiency for good versus bad exemplars; *Multivariate Pattern Analysis* was applied to assess the clarity of neural representations.

Individual scene-responsive ROIs



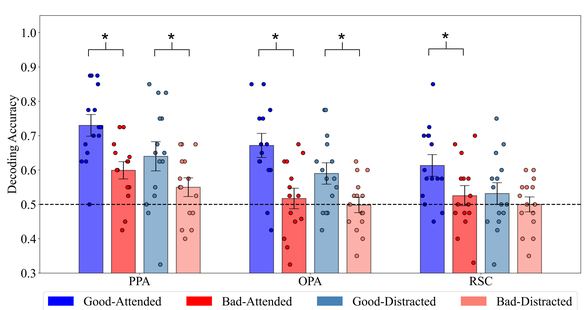
Univariate analysis - processing efficiency

Univariate analysis: % signal change for each condition was extracted using a GLM and averaged within each ROI.



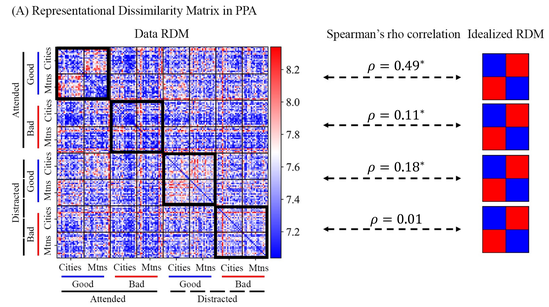
MVPA - neural representation clarity

SVM decoding: A support vector machine (SVM) with a linear kernel was used to classify neural representations of cities vs. mountains in each condition. Leave-one-run-out cross-validation was used to find accuracy.

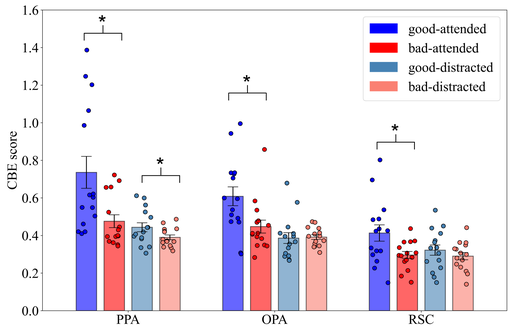


Representation "clarity": A good category representation should maximize both *between-category difference* and *within-category coherence*[5]. While SVM relies more on the former, RSA and CBE measure both.

Representational Similarity Analysis (RSA): Euclidean distance-based trial-wise RSA[6] was applied to visualize the representational space.



Category Boundary Effect (CBE): CBE index[7] is calculated as the difference between the dissimilarities between categories and the dissimilarities within each category, quantifying the visual assessment of distinctiveness and cohesiveness of categories from RDM.



Conclusions

- Efficient processing of good exemplars does not need full attention: good exemplars elicited lower responses not only in attended but also in distracted conditions.
- Clearer neural representation of good exemplars does not need full attention: good exemplars showed both higher decoding accuracy and higher CBE index even when attention is distracted away.

References

[1][Caddigan et al., 2017] [2][Torralbo et al., 2013] [3][Kumar et al., 2021] [4][Schwartz et al., 2015] [5][Rosch et al., 1976] [6][Kriegeskorte, 2008] [7][(Iordan et al., 2016]