Electroencephalography (EEG) reveals a decrease in speed of animacy processing in mild cognitive impairment and an alteration in neural response patterns

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Introduction

Electroencephalography (EEG) has been commonly used to measure the brain alterations in the early stages of Alzheimer's Disease. However, the reported measures are limited to the univariate changes, including activation level and frequency bands. To look beyond the activation level, we used a task-based EEG and applied multivariate pattern analysis (MVPA) to study the changes in the pattern of information processing.

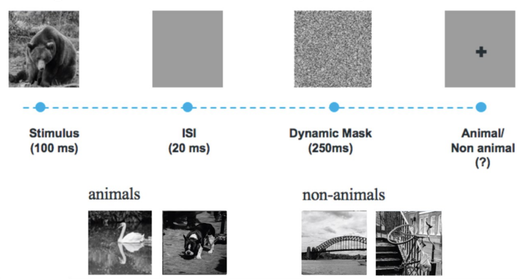
Methods

Participants

Characteristic	HC ($n = 22$)	MCI ($n = 18$)	*p-value*
Age –mean years ±SD	6.18± 63.23	6.40± 63.55	0.87
Education in years –mean ± SD	4.18± 15	5.02± 14.72	0.85
Gender (%female)	(%59) 13	(%55) 10	0.82

EEG Task

ICA is a rapid visual categorization task containing natural objects. Half of the images contain an animal object.

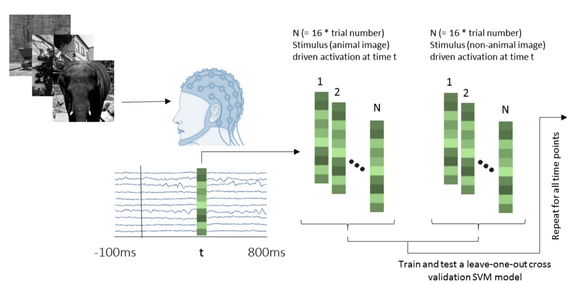


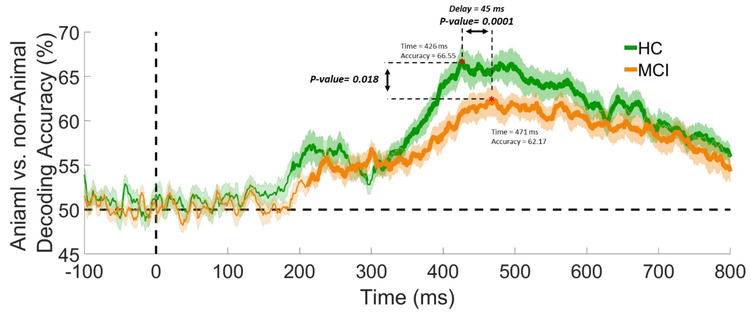
Representational Dissimilarity Matrix (RDM)

An RDM is a square symmetric matrix, in which off-diagonal elements indicate the dissimilarity between the activation patterns associated with two different conditions.

Results

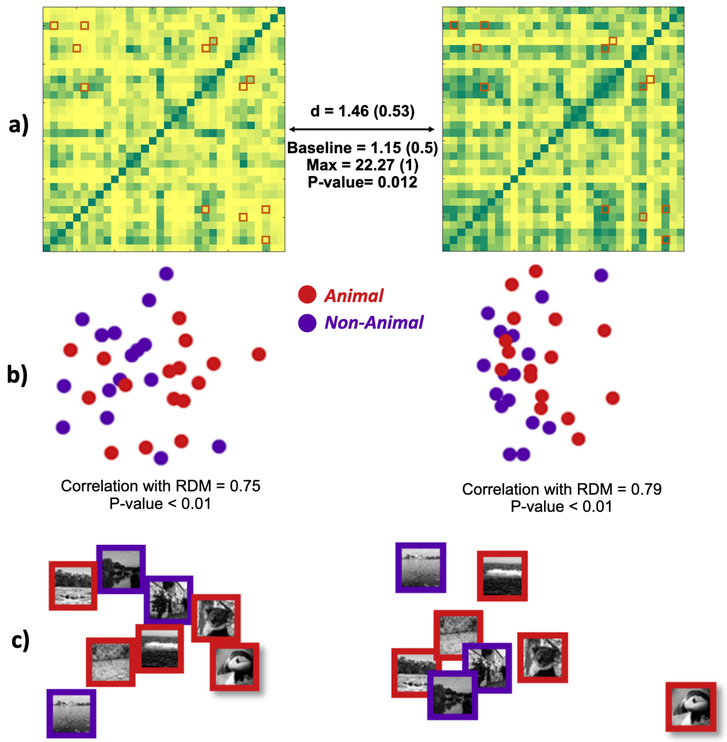
Animal vs. non-Animal Decoding

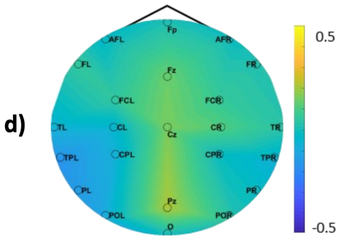




The shaded bar indicates the standard error of the sample mean. The thick portion of the decoding curves illustrates the time-points with significant decoding accuracy (FDR-corrected (fdr=0.05) sign-rank).

Pattern of Visual Information Processing





a) Mean RDMs of two groups at the time-point of the highest Euclidean distance (t = 224 ms, d = 1.46, permutation test p-value = 0.012). Bordered elements of the RDMs illustrate the condition pairs which have significant difference in decoding among two groups (FDR-corrected (fdr=0.05) rank-sum test). **b)** MDS of all conditions at the time-point of the highest Euclidean distance. Correlation with pairwise dissimilarities are 0.75 and 0.79 for HC and MCI, respectively (For the Shepard plot see supplementary). **c)** MDS of conditions with significant decoding difference between two groups (FDR-corrected (fdr=0.05) rank-sum). **d)** The difference of ERP at the time-point of the highest Euclidean distance. No significant amount of difference is observed among regions (FDR-corrected (fdr=0.05) rank-sum)

Conclusions

- In addition to the level of activation (i.e., mean ERP response), the pattern of EEG responses to visual stimuli also carries information about the status of the disease.
- In some of the brain areas where the mean activation shows no difference between HC and MCI, patterns of EEG responses are significantly different and can be used to discriminate MCI from HC.
- MCI patients process the animacy information with a significant delay in comparison with the healthy individuals.