Neural Dynamics of Visual Processes in Challenging Visibility Conditions

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Introduction

• The human brain has the fantastic ability to recognize objects in less that a blink of an eye [1]. Several studies have investigated core object recognition [2]; however, object recognition under challenging visibility conditions is less understood [3, 4, 5].

• Previous studies questioned whether object recognition within IT (infratemporal) cortex along the ventral stream is strictly feedforward, or requires recurrence especially in challenging viewing conditions [4, 6].

• In this work, we examine rapid object recognition in challenging visibility conditions, to compare the decodibility of brain responses to visible and invisible conditions.

Experimental Procedure & Methods

• EEG data were collected from 30 participants while they viewed a rapid series of images each presented for 17 ms.

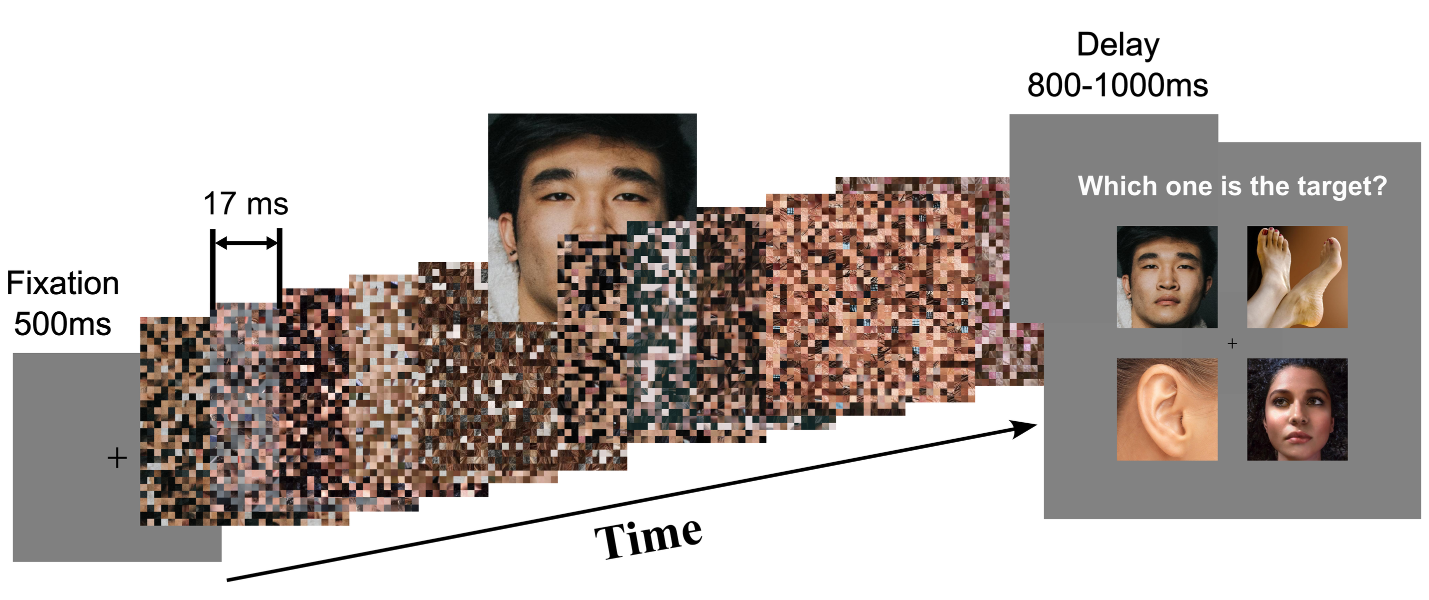


Figure 1. **Experimental Procedure.**
Each trial starts with 500 ms of fixation followed by 11 images with the middle image as the target. The target is chosen from either people category or objects category.. At the end ofeach trial, after a short delay for 800-1000 ms, participants were asked to report the target by choosing it among four options.

• Multivariate Pattern Analysis (MVPA) was performed to extract the brain representations for visible and invisible conditions.

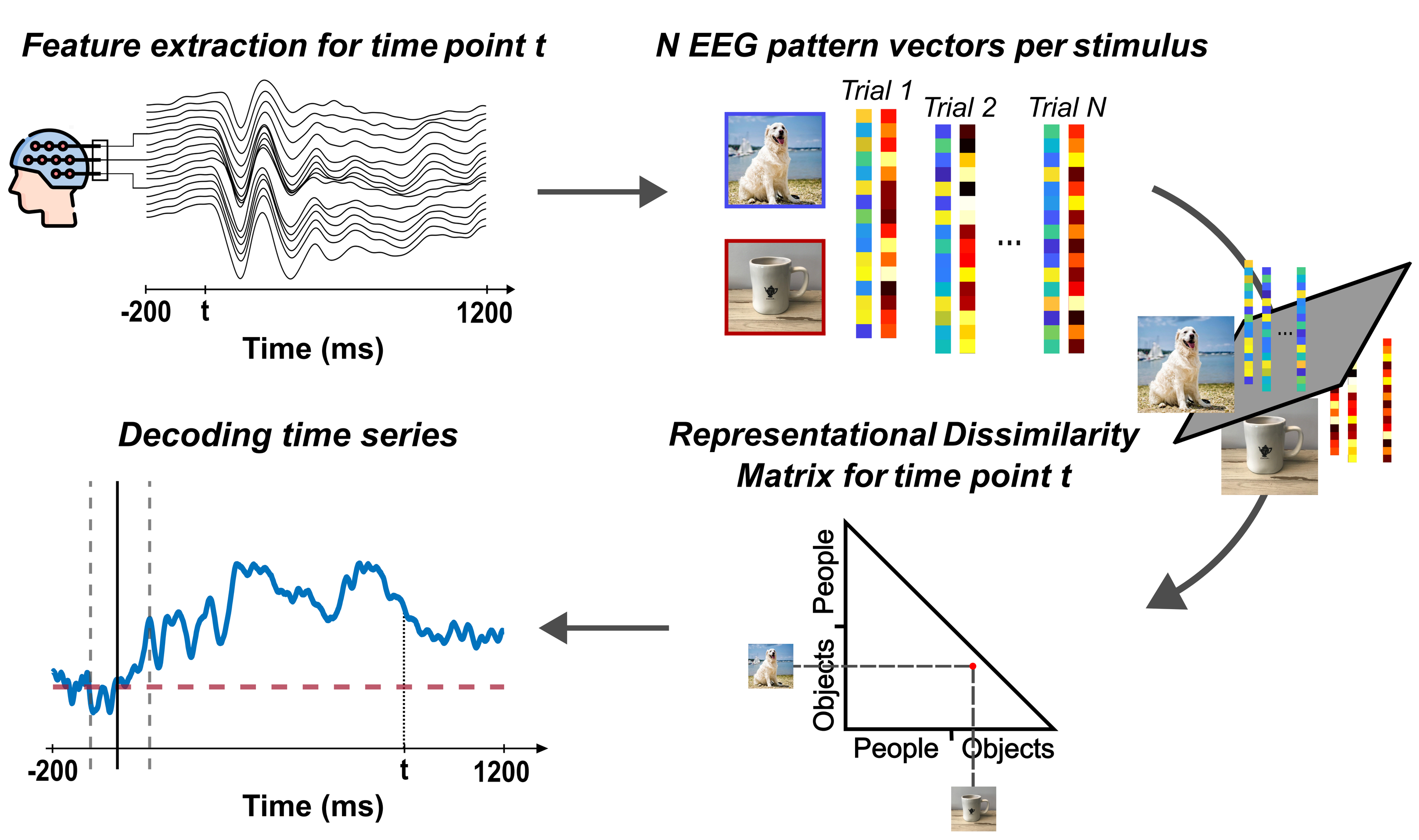


Figure 2. **Multivariate Pattern Analysis.**
EEG pattern vectors were extracted from trials at time point t. A support vector machine (SVM) classifier was used to pairwise classify EEG pattern vectors for target images. Representational Dissimilarity Matrices (RDMs) were formed for each time point using classifier performance.

Results

• Recurrent connections are crucial in order for the objects to become visible to us.

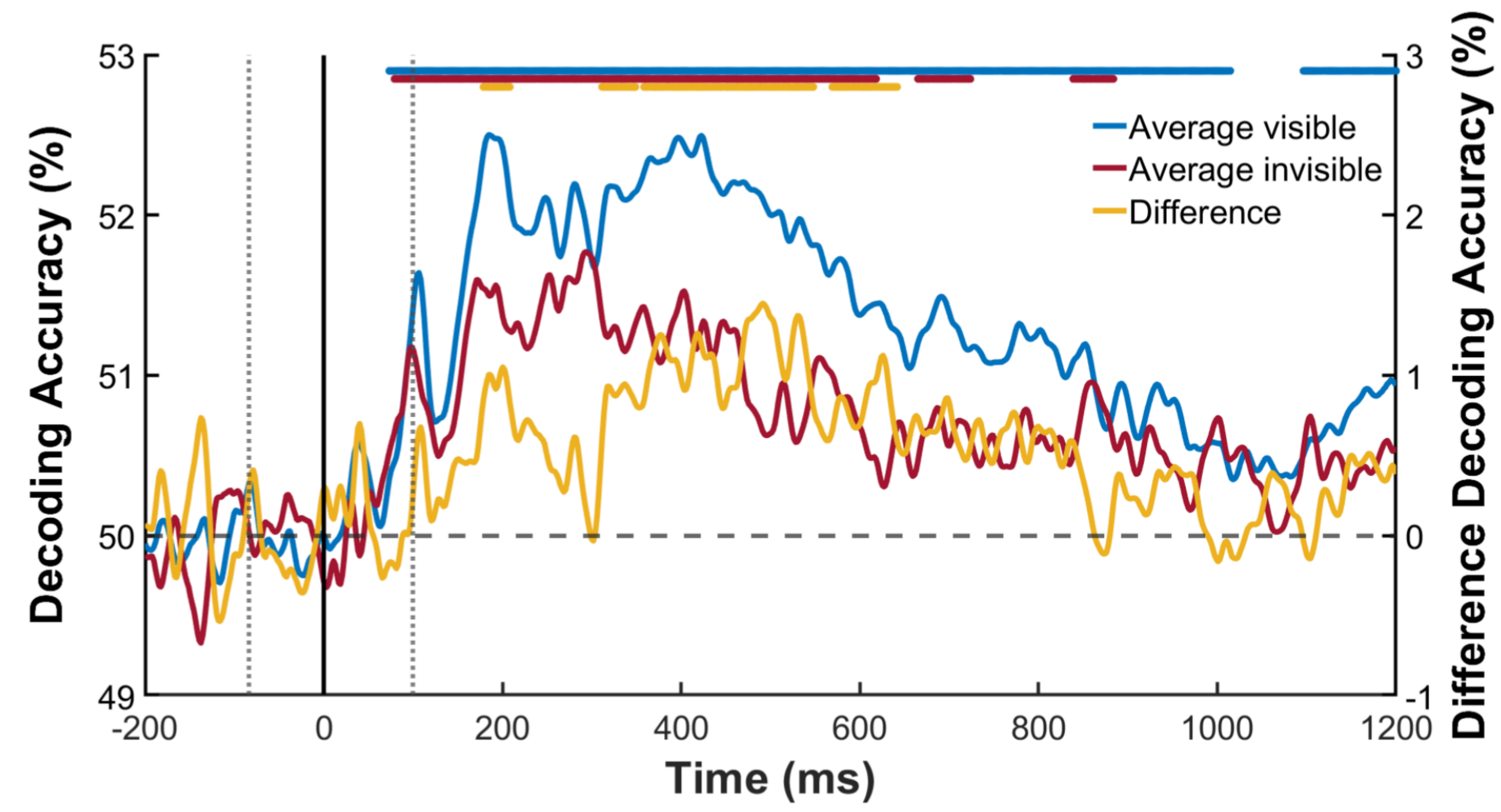
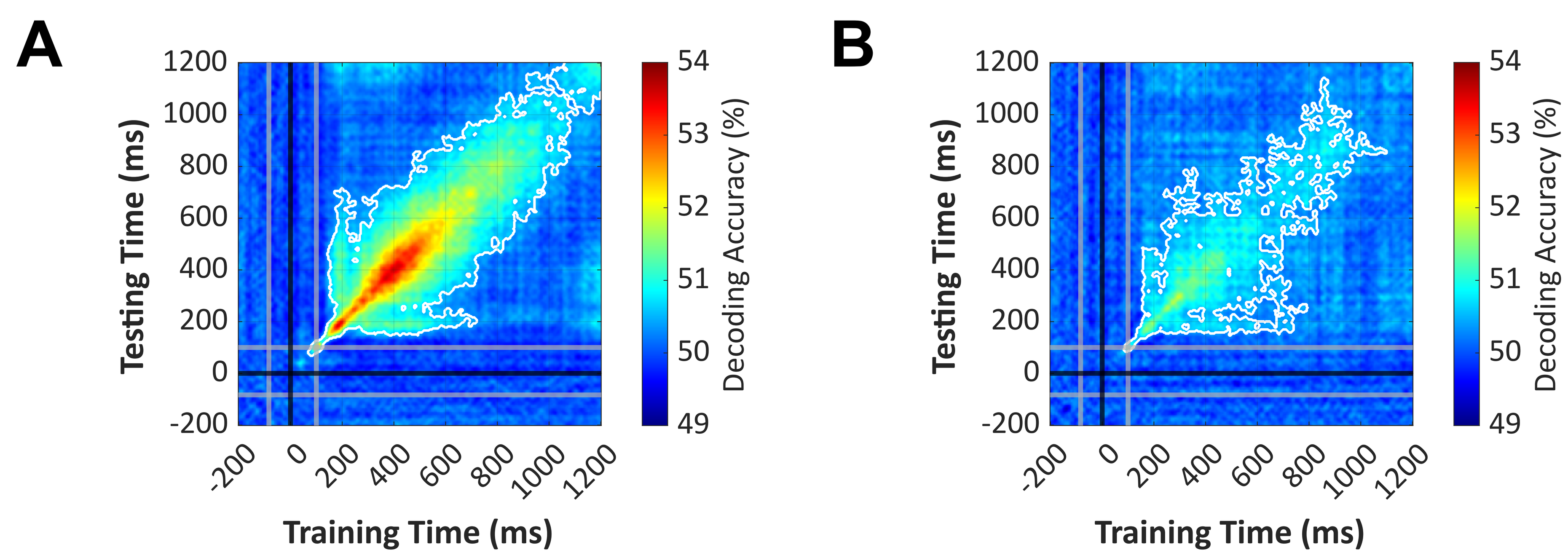


Figure 3. **Visible & invisible decoding time series.**
Average decoding accuracies for visible condition, invisible condition, and difference of visible and invisible conditions for all participants. The color-coded bars above the plots show significant time pointsfor each condition. (N=30; significant time points were evaluated with one-sided sign permutation tests, cluster defining threshold $p < 0.01$, and corrected significance level $p < 0.05$)

• Visible condition shows more sustained and persistent activities in comparison ro invisible conditions.



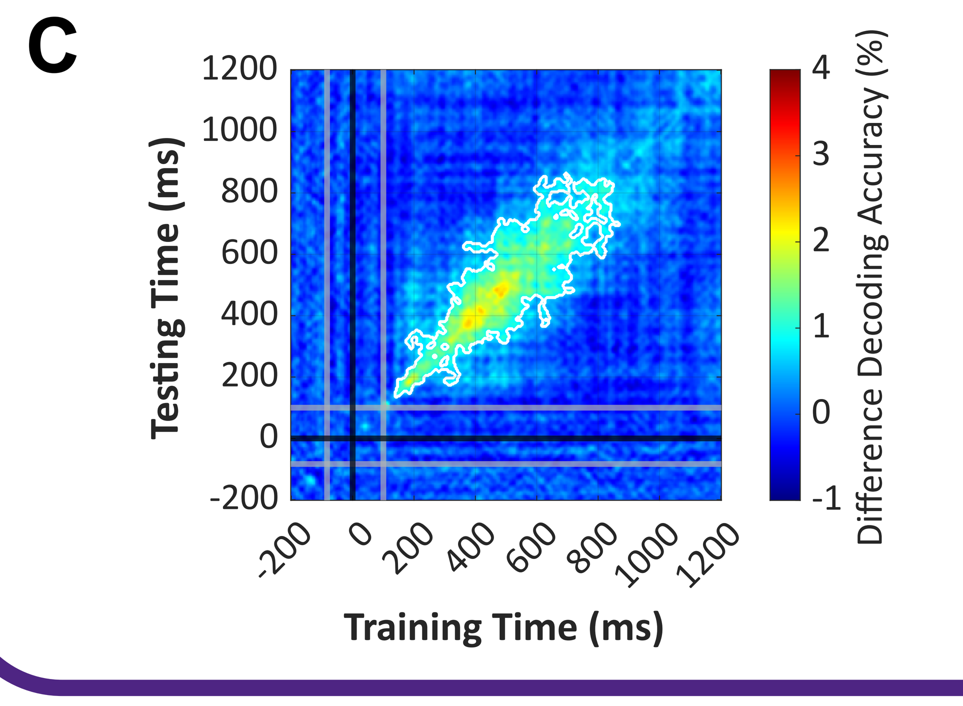


Figure 4. **Temporal Generalization Maps.**
(A, B, C) Temporal generalization matrices for visible and invisible conditions and the difference between these two conditions. The SVM classifier was trained on data at time point t and then tested on data at time point t'. The white contours show significant decoding values. (N=30; one-sided sign permutation tests, cluster defining threshold $p < 0.01$, and corrected significance level $p < 0.01$)

Conclusion

• The results indicate that visible and invisible conditions share a similar temporal dynamic during the first stages of visual processing, reflected by the initial fast feedforward processing.

• However, during the later stages of processing, there is a significant difference between these two conditions. This difference might be related to the recurrent processing in the human brain, which is not completely triggered in the invisible condition.

References

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