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Temporal memory bias induced by temporal position and age of memory

Abstract

Objective: This study aims to measure the precision of temporal distance estimation in episodic memory and investigate its neural mechanisms. **Methods**: We conducted two experiments: combined behavioral (n=30) and fMRI (n=20). Participants encoded a 22-minute video and performed a temporal distance estimation task. In the memory stage, the participants needed to drag a target frame to its correct temporal positions with respect to two reference frames based on their memory of the encoded video. We varied three factors, temporal interval between two reference frames (12s, 1min, 5min), the relative location of the target frame in the presented timeline (20%, 40%, 60%, 80%) and the segments of the timeline presented (initial 40% of the video, final 40% of the video), while all presented timelines shared identical visual lengths. A Standard Mixture Model with Bias quantified two key indices related to memory precision: estimation precision (SD) and bias (μ). We also take the distance from the report to target frame, namely error, as another scale of memory precision.

Methods

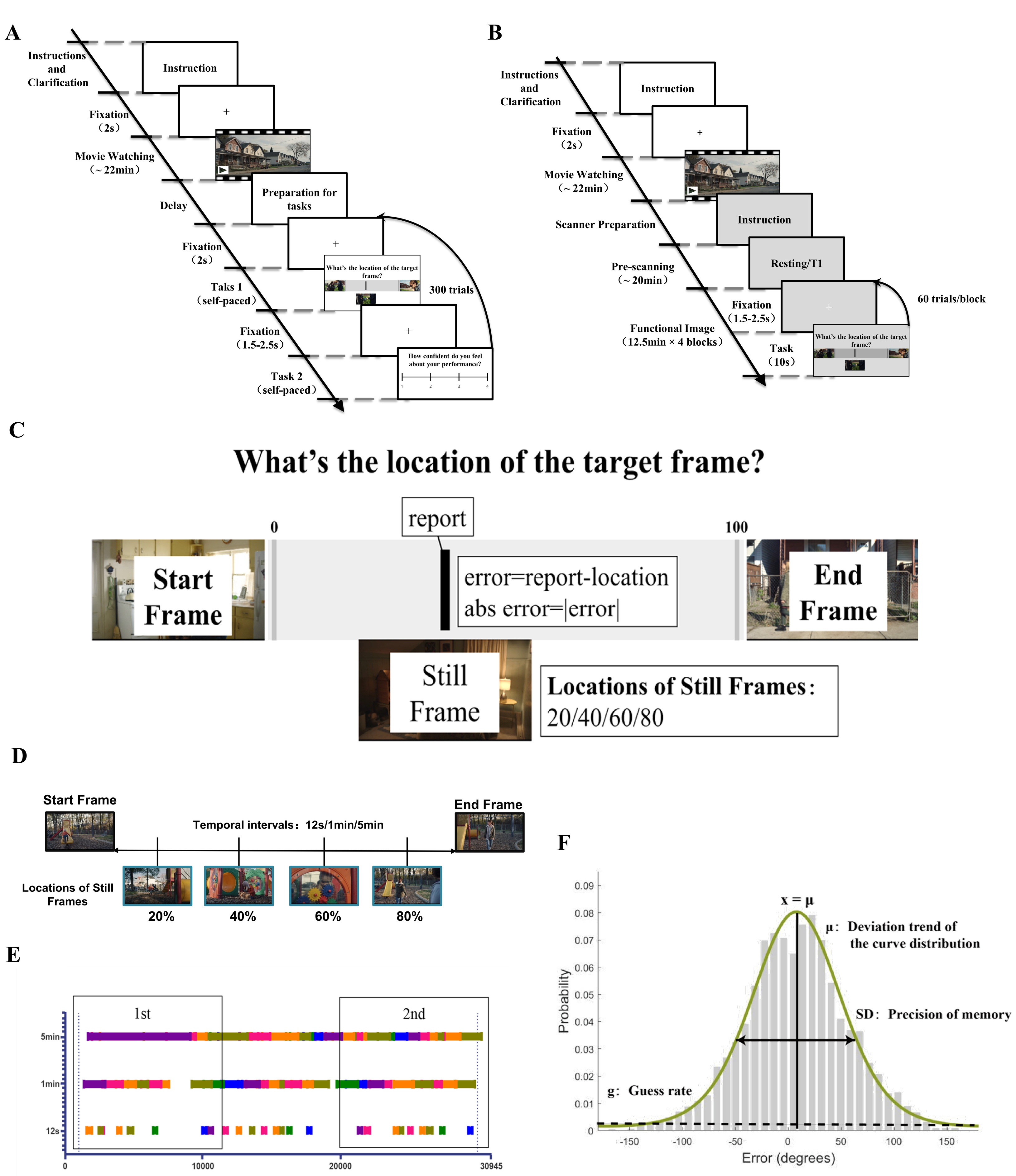

Figure 1: (A-B) Schematic of two experiment paradigms. (C-E) Task for subjects to complete, with three factors, temporal interval between two reference frame (12s, 1min, 5min), the relative location of the target frame in the presented timeline (20%, 40%, 60%, 80%) and the segments of the timeline presented (initial 40% of the video, final 40% of the video). (E) Standard Mixture Model with Bias quantified two key memory precision indices, estimation precision (SD) and precision bias (μ).

Results

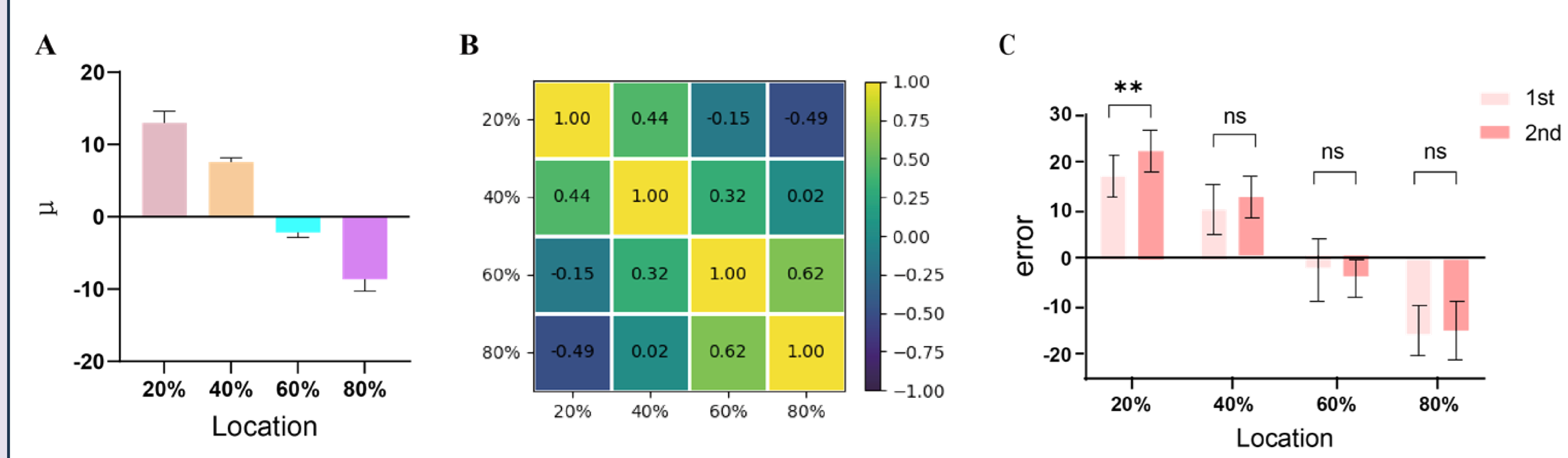

Figure 2: asymmetry of memory precision bias. (A, B) μ was significantly larger for early locations (20%, 40%) compared to later ones (60%, 80%). (C) Going deeper, there is a significant interaction between location and segment.

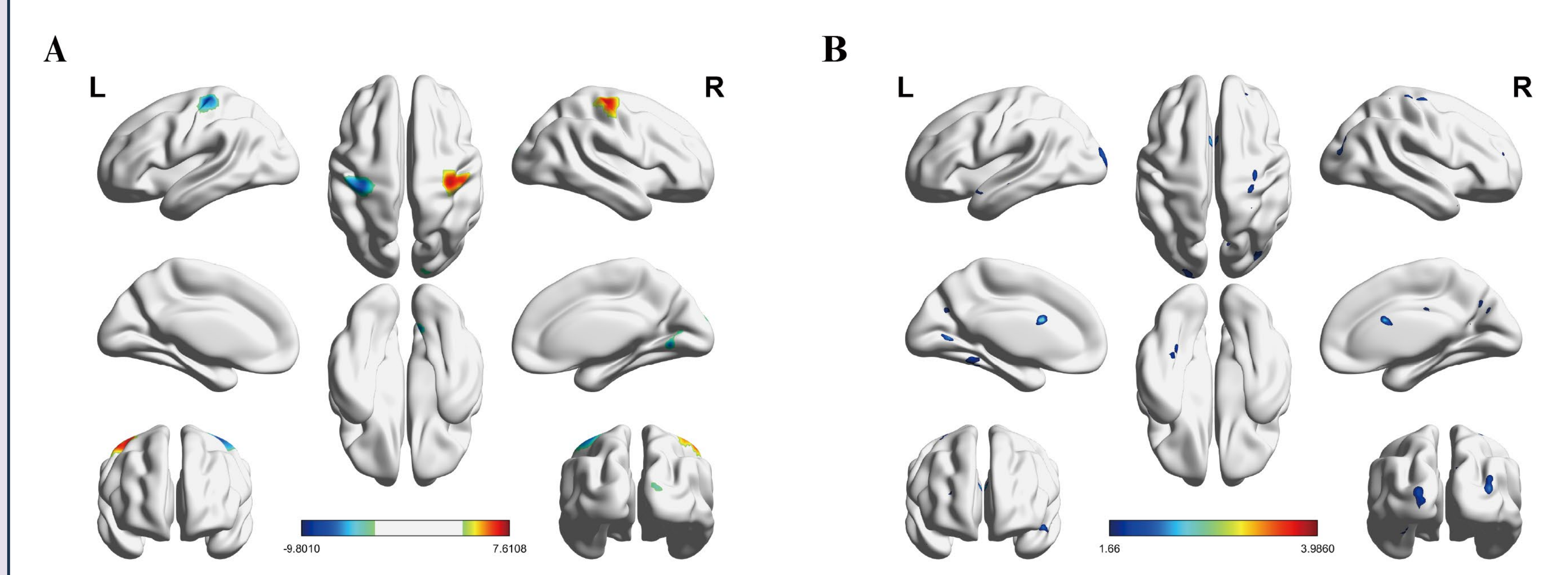

Figure 3: Neural substrate response to behavior results. (A) Left precentral gyrus and lingual gyrus activation were decreased as a function of memory precision bias; (B) A significant cluster in the right frontal lobe is related to interaction pattern.

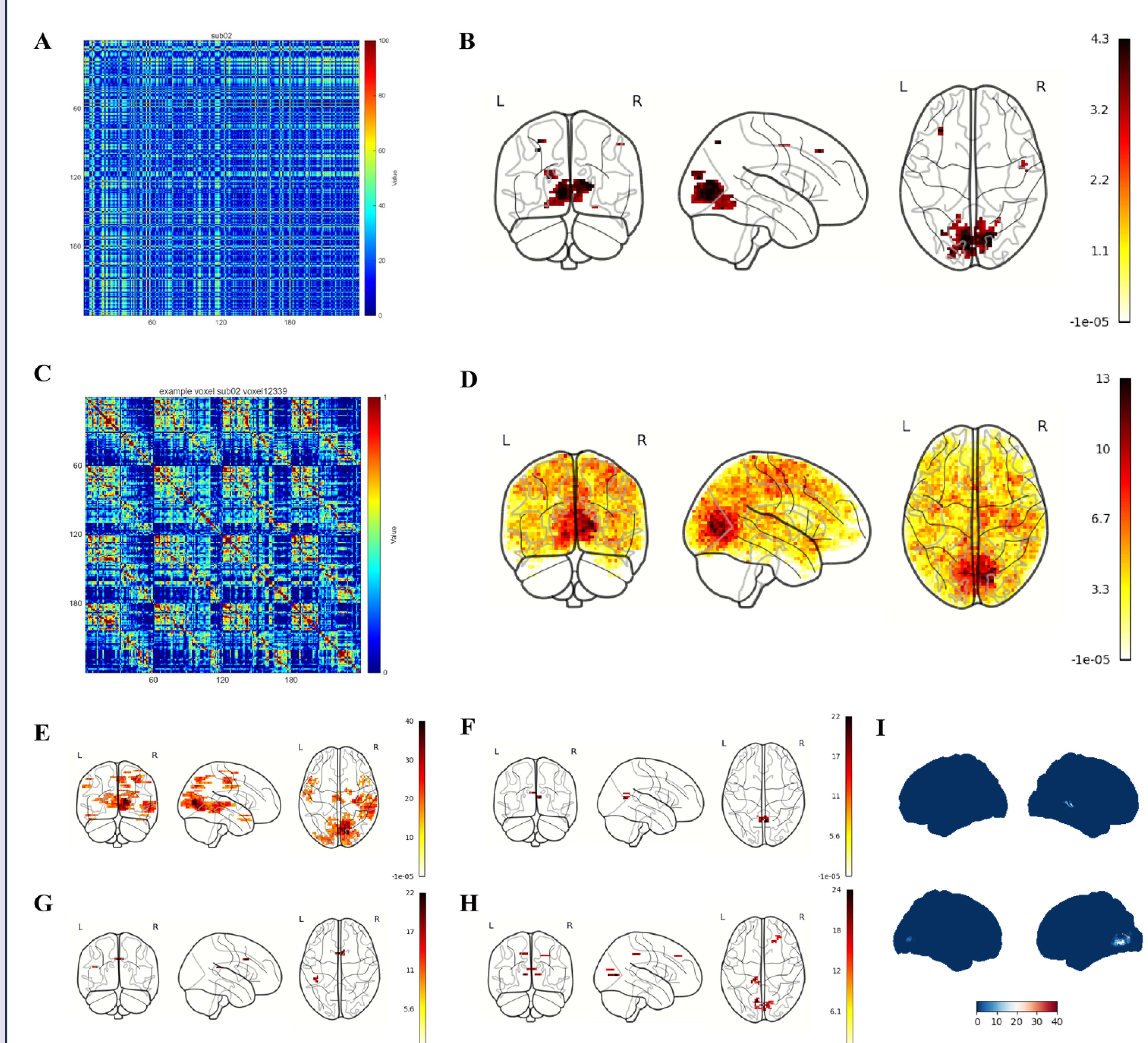

Figure 4: Model-RSA and SVM-based MVPA shows that the lingual gyrus also serves as a core region during the retrieval stage in encoding the temporal relative positions of episodic memories. (A) Dissimilarity matrix of actual choice on the left and the similarity matrix of a significant voxel in a subject on the right. (B) Model-RSA result showing more than 40% voxel in the central lingual gyrus can present temporal location (presented at $p < 0.001$ peak level uncorrected, $q < 0.05$ cluster-level FWER corrected). (C) Average SVM-supported MVPA result across all positions (values represent model accuracy minus misclassification rate), using leave-one-out cross-validation.(D) MVPA classification results of locations (20%, 40%, 60%, 80%), among which result of 20% location was more pronounced. (E) A cluster of 88 voxels involved at right lingual gyrus survived 20 accuracy thresh-hold to identify 20% locations correctly.

Conclusion

Our results show that there are a larger bias (μ) for early locations and a minor memory precision (SD) was observed at initial segment, with the interaction effect between these factors showing segment only significantly influence error at 20% location. Additional model-RSA and SVM-based MVPA analyses revealed that the lingual gyrus plays a critical role during retrieval in representing the temporal relative positions of episodic memories.

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