Human statistical learning dynamically shapes the hippocampal processing of temporal associations

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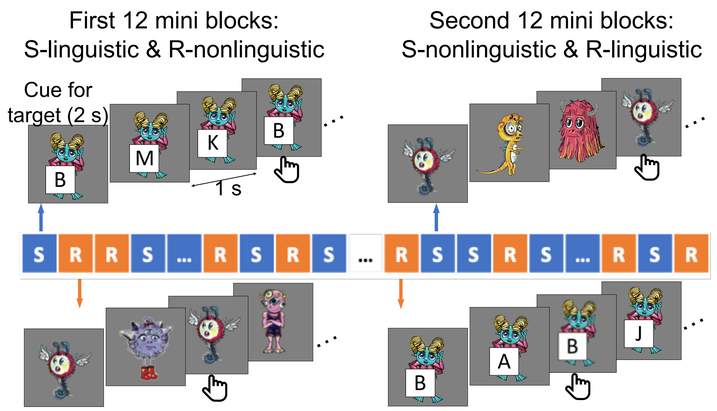
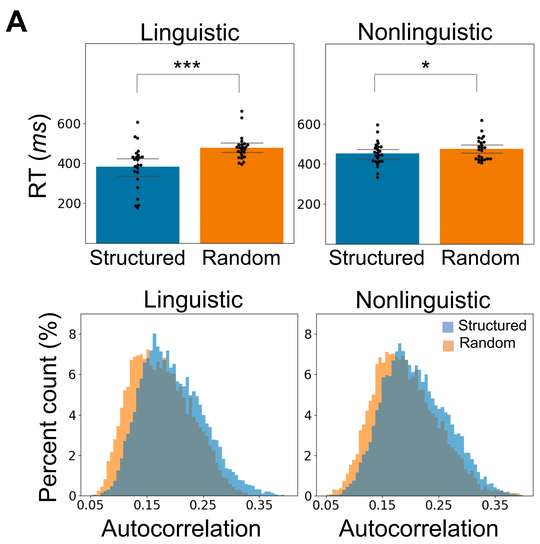
1. Introduction

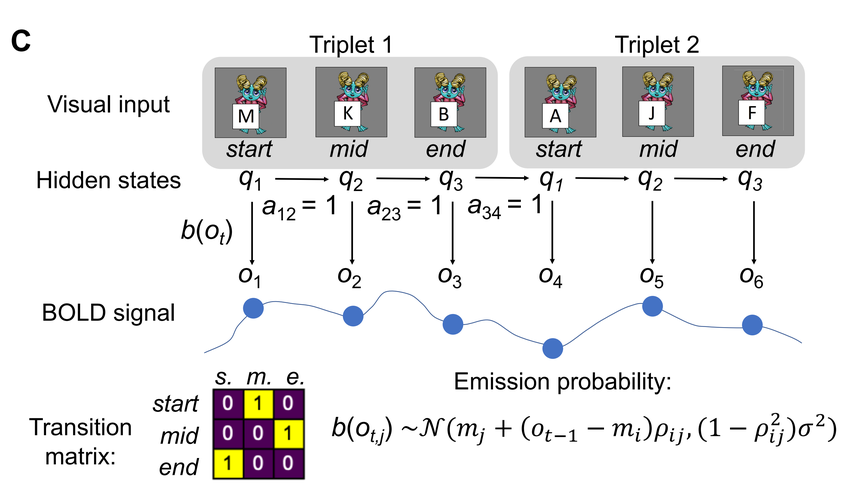
The human hippocampus becomes sensitive to temporal associative patterns during statistical learning (SL) [1-4]. And yet, whether such sensitivity reflects the outcome of passive exposure to structured information or an active process to encode such information, or a mixture of both, remains unclear. We investigated this question in human adults performing a visual SL task, in which the transitional probability (TP) among stimuli alternated between a triplet and a random structure. We asked whether the hippocampal activity would be sensitive to the TP difference between structured and random sequences, reorganize to reflect the TP change, and correlate with behavioral SL effects. Moreover, we used a Hidden Markov Model (HMM) to decode stimulus transition patterns from the hippocampal activity. By examining the decoding efficacy, we explored how the sensitivity to TP unfolded over time.

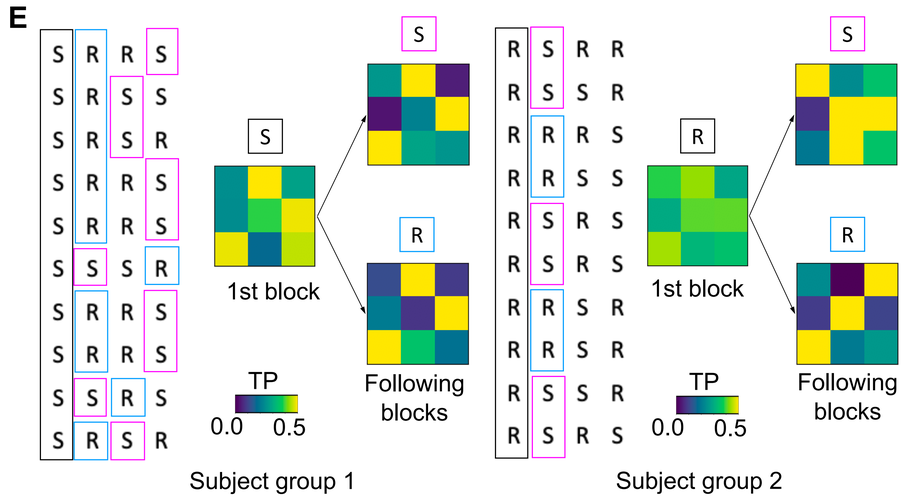
2. Methods



1) Blood-oxygenation-level-dependent (BOLD) data were acquired from 20 subjects performing a visual SL task (see schematic above).
2) The task was composed of structured and random stimuli presented in interleaved mini blocks.
3) Autocorrelation of the hippocampal BOLD signal was computed for each mini block.
4) A conditional-Gaussian HMM was developed to decode transition patterns from the BOLD signal.







3. Results

A. For both linguistic and non-linguistic stimuli: Reaction time (RT) was significantly lower in structured than in random blocks; Autocorrelation of the BOLD signal from the hippocampus was greater in structured than in random blocks.
B. The S-R difference of RT and that of the BOLD autocorrelation were linearly correlated across mini blocks.
C. Schematic for the conditional-Gaussian HMM method and the TP matrix of a triplet transition pattern.
D. HMM decoding error varied across mini blocks.
E. HMM-decoded transition matrix "predicted" a triplet pattern, even for R-blocks, after initial exposure to S-blocks.

4. Conclusion

Hippocampal activity is sensitive to the temporal structures in the visual inputs, adaptive to the changes of these structures, and shows predictive processing as reflected by a mere-exposure effect. Overall, these results suggest that the hippocampus is not a passive storage for learning outcomes but plays an active role in the learning process.

5. References

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