Time-resolved representational similarity analysis reveals integrated and separated neural patterns of overlapping events

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Time-resolved representational similarity analysis reveals integrated and separated neural patterns of overlapping events

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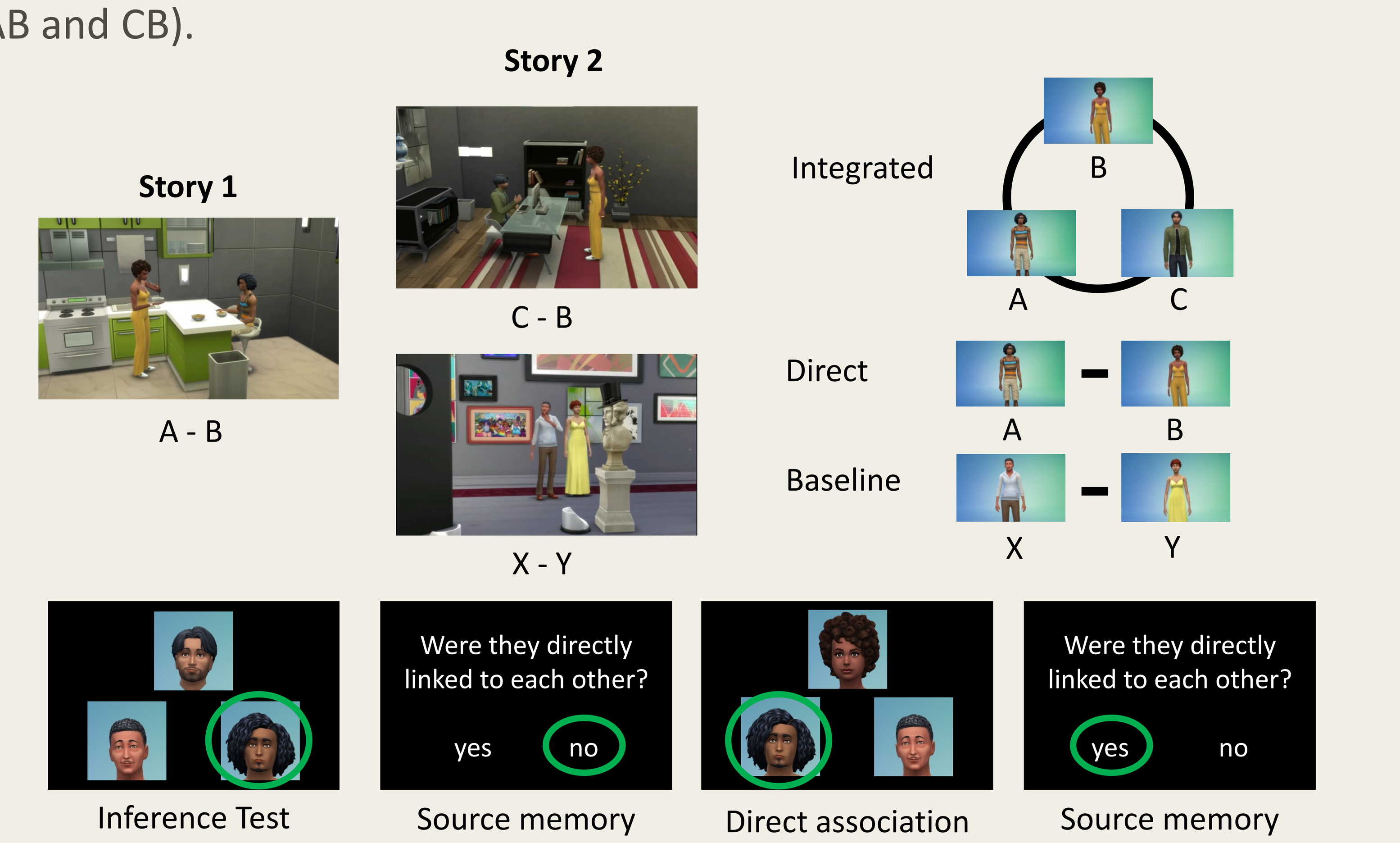
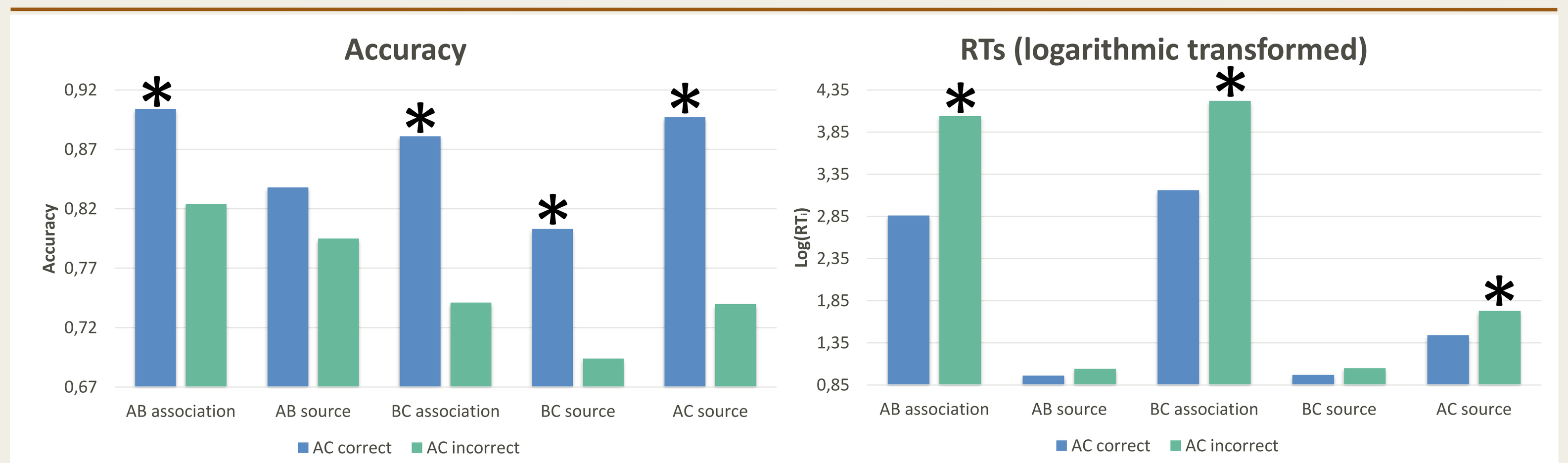
The present study

This study investigates how overlapping events are coded in the brain to support integrated and separated memory representations. We examined if integrated representations can be formed without losing episodic details for the original events, i.e., information required for source memory judgments. Participants (N = 39) were presented with *Sims* videos simulating real-life events while their electroencephalography was (EEG) recorded. First, they saw videos of two interacting characters (person A and B), which were followed by a new set of videos showing a new character interacting with an old one (person C and B). Participants were asked to integrate the overlapping events to infer the indirect relationship between the characters (i.e., AC) and keep information about the event-specific relationships (i.e., AB and CB).



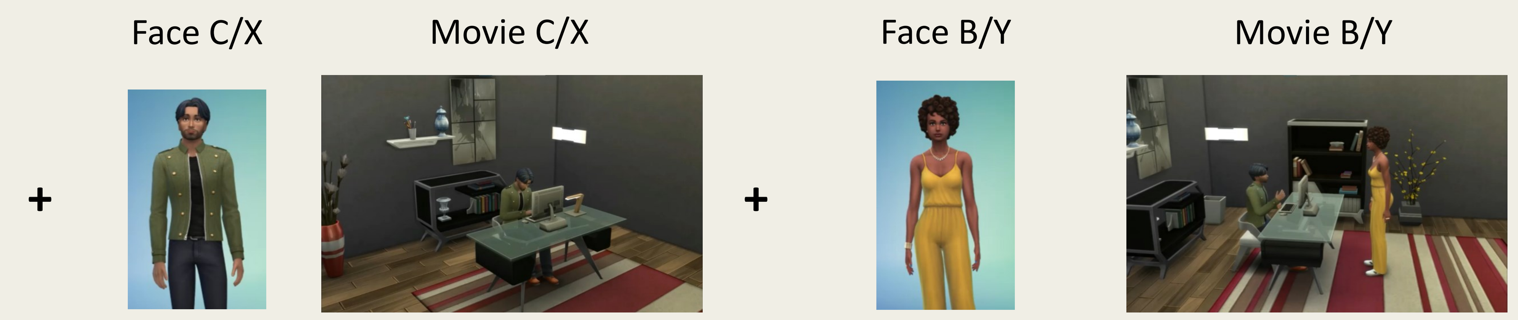
During the test phase, memory for all associations was tested, followed by source memory. For any given ABC triplet, the inference was tested before the direct associations.

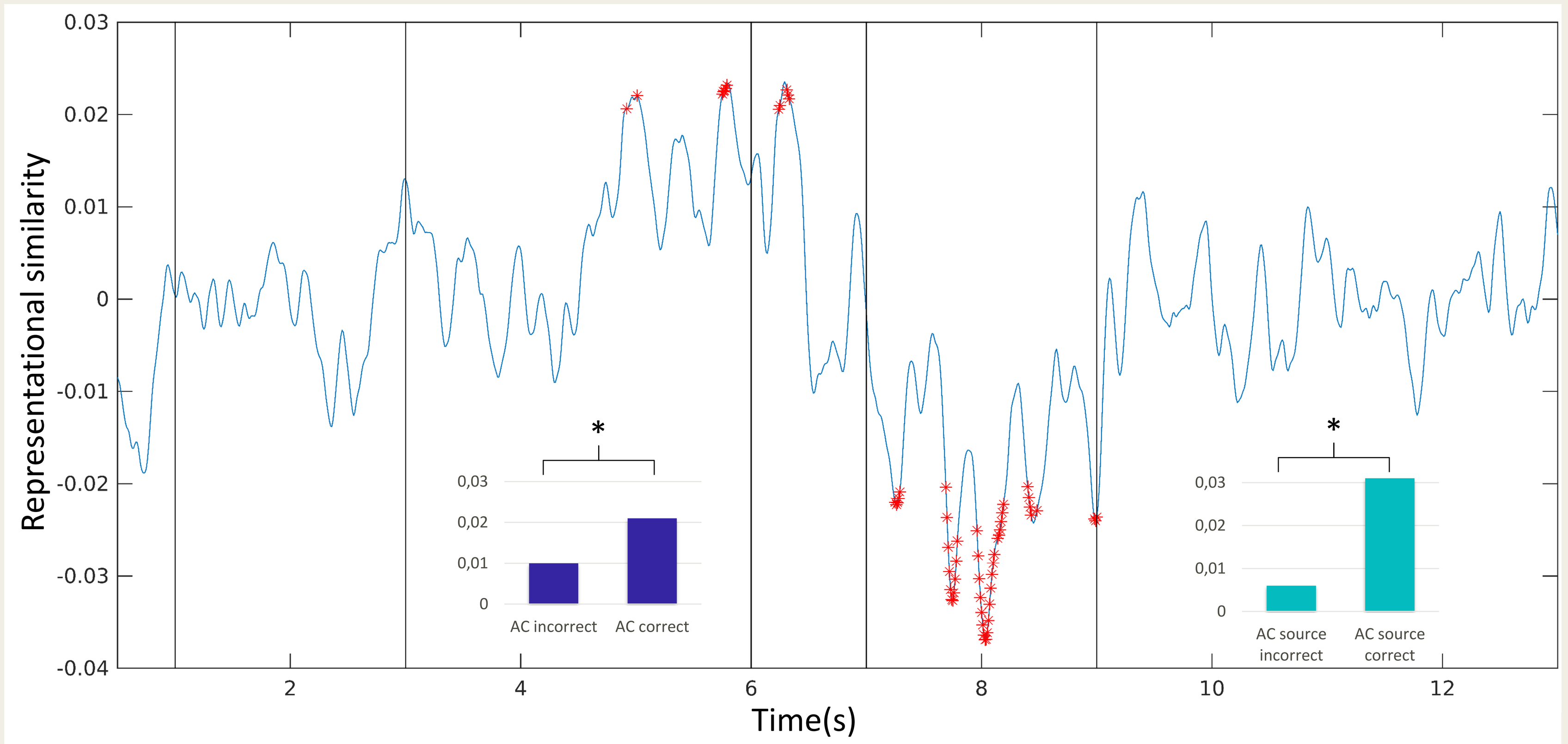
Behavioral analysis



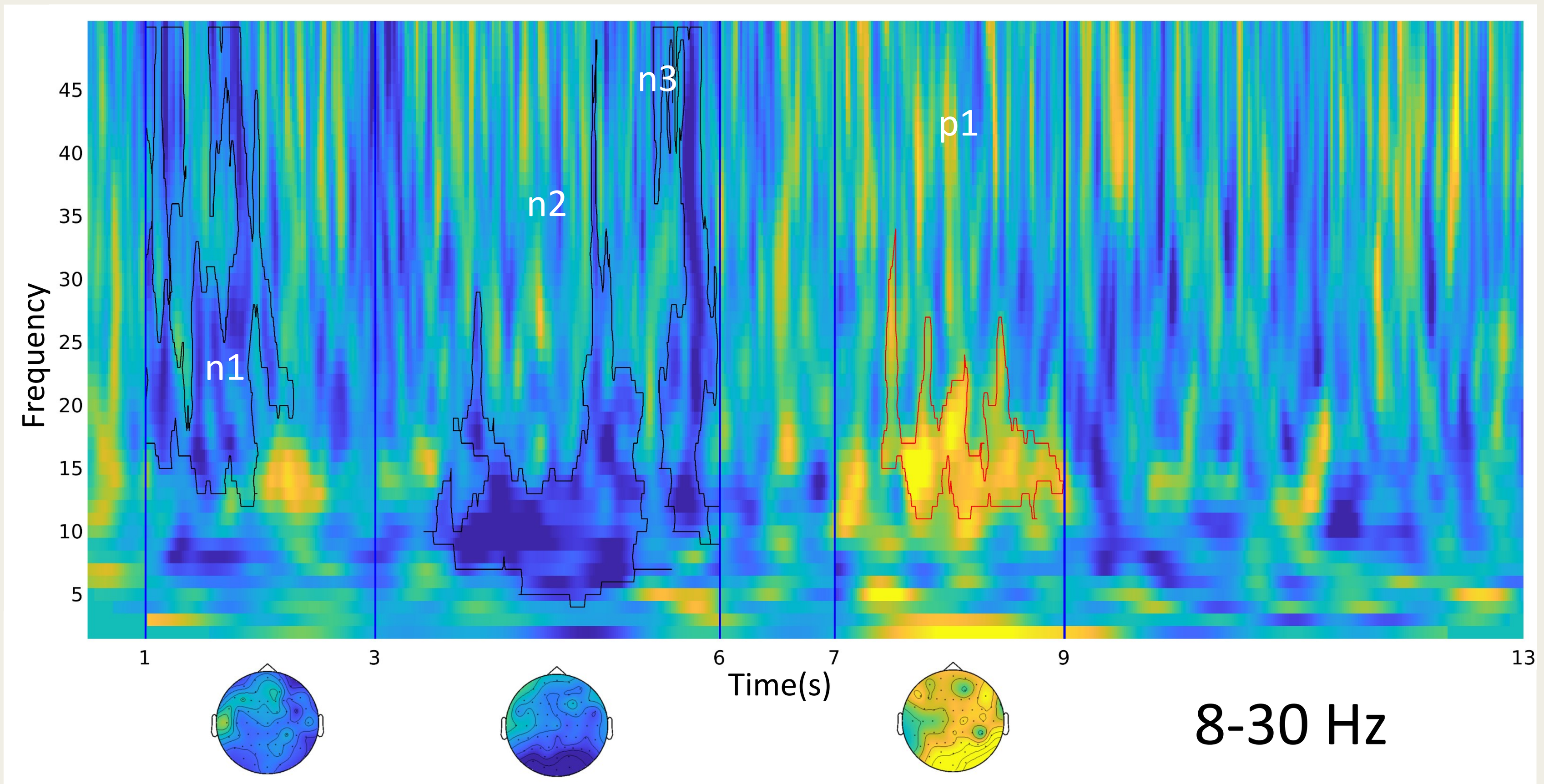
The behavioral data show successful inference is not accomplished at the cost of losing memory for the original events (i.e., leading to erroneous source memory). Rather, good memory for the original event is related to successful memory inference. Statistically significant differences are highlighted (*).

Learning trials. After a 1s fixation, the A/C/X person was displayed for 2s, followed by a 3s movie of the person in a context. After another 1s fixation, the person B/Y was displayed for 2s, followed by a movie of B/Y interacting with the person seen right before. Each video was shown 5 times.





The RSA showed that the neural representation of the AB and CB episodes is characterized by both pattern similarities and dissimilarities.

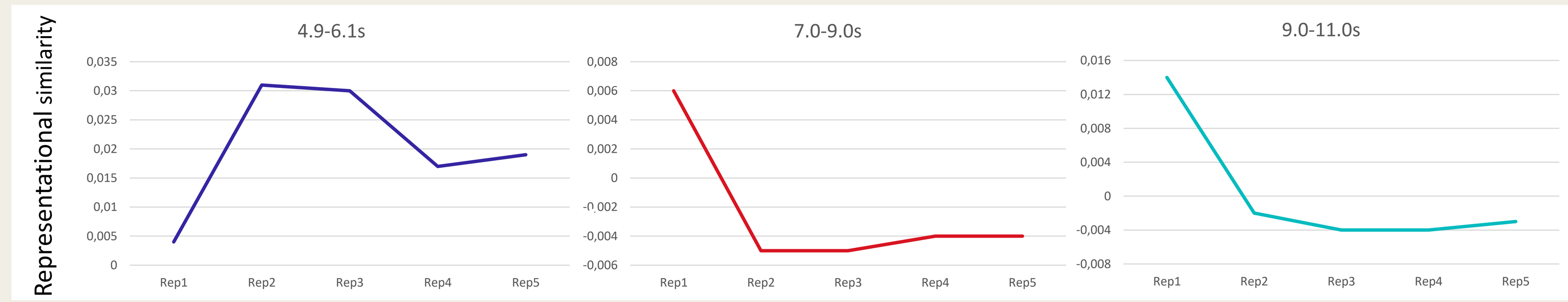


A permutation cluster analysis, contrasting BC-tf and XY-tf, identified significant differences in the alpha, beta and gamma bands. Interestingly, the time window for which power decreases were observed corresponding to the time window where the RSA identified systematic similarities between the neural patterns of AB and BC videos, while the time window for which power increases were detected match to the time window where significant dissimilarities in the RSA were observed.

Representational similarity analysis

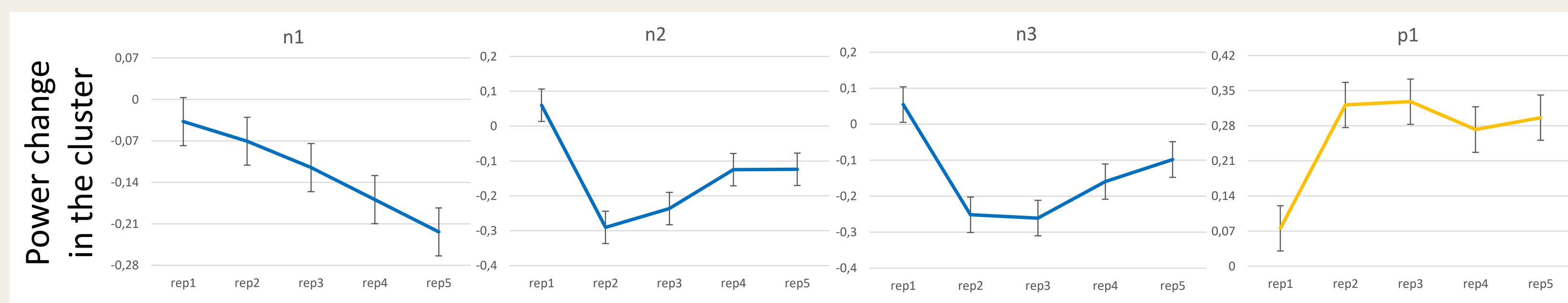
Time frequency (tf) decomposition was applied to extract input features for cosine feature vector angle based representational similarity analysis (RSA). The AB-tf was averaged across repetitions and time to get a stable estimation of the AB neural response. The BC-tf and XY-tf were also averaged across repetitions. The representational similarity between AB-tf and BC-tf was estimated at each time point and contrasted with the representational similarity of AB-tf and XY-tf.

Brain responses to AB and CB episodes were characterized by systematic neural pattern similarities and dissimilarities, which evolved across repeated learning runs (1-5). The results suggest that AB memory reactivation may serve different functions. When encountering C, the reactivation of AB is beneficial for later AC inference, and when watching BC interacting, the reactivation of AB improves source memory, helping to reduce the risk of erroneously thinking that A and C appeared within one story. Importantly, RSA across repetitions shows that the similarities/dissimilarities effects are only present after the second repetition.



Time-frequency analysis

The observed power changes corroborate and extend the RSA results. When C is acting alone, the n2/n3 effects may be related with the reactivation of the previous related AB events. The p1 effect, observed when the overlapping person B is presented, may be related with inhibition triggered by the need to handle the two overlapping associations (i.e., AB and CB). Importantly, the TFR over the 5 repetitions show that these effects occur after the second repetition.



Conclusion

This study provides novel evidence that integrated and separated neural representations may coexist to flexibly support multiple memory functions.

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