

Medial temporal lobe theta oscillations during ongoing experience shape memory organization



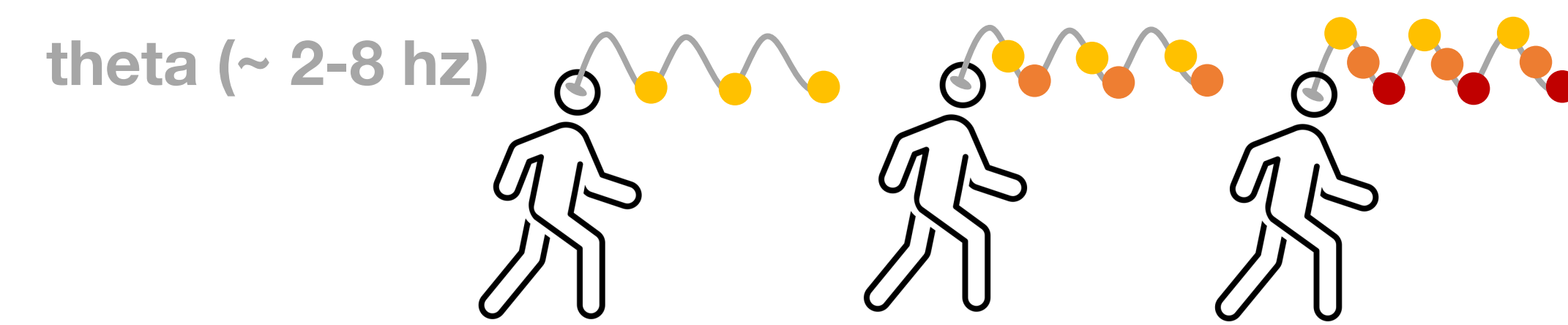
Nicholas B. Diamond & Michael J. Kahana

Time and **space** shape the movement of memory

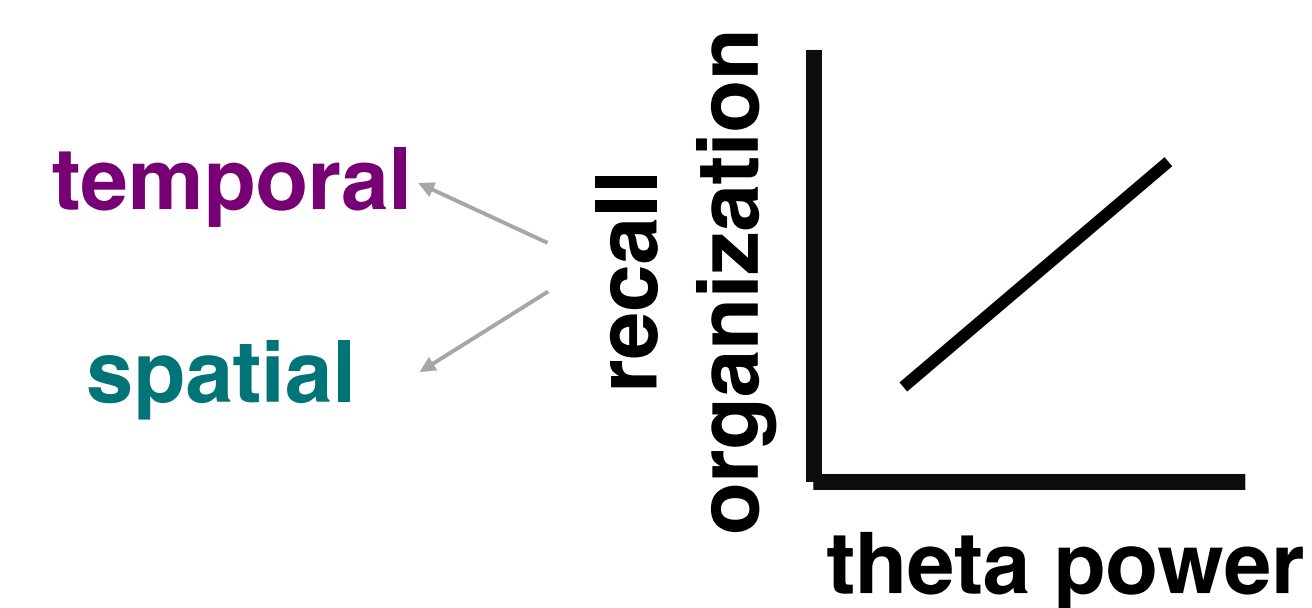


But how do events that are spread out in time and space come to be associated in the first place?

(Rodent) hippocampal theta oscillations provide an internal reference frame for linking spatiotemporally disparate events¹⁻³

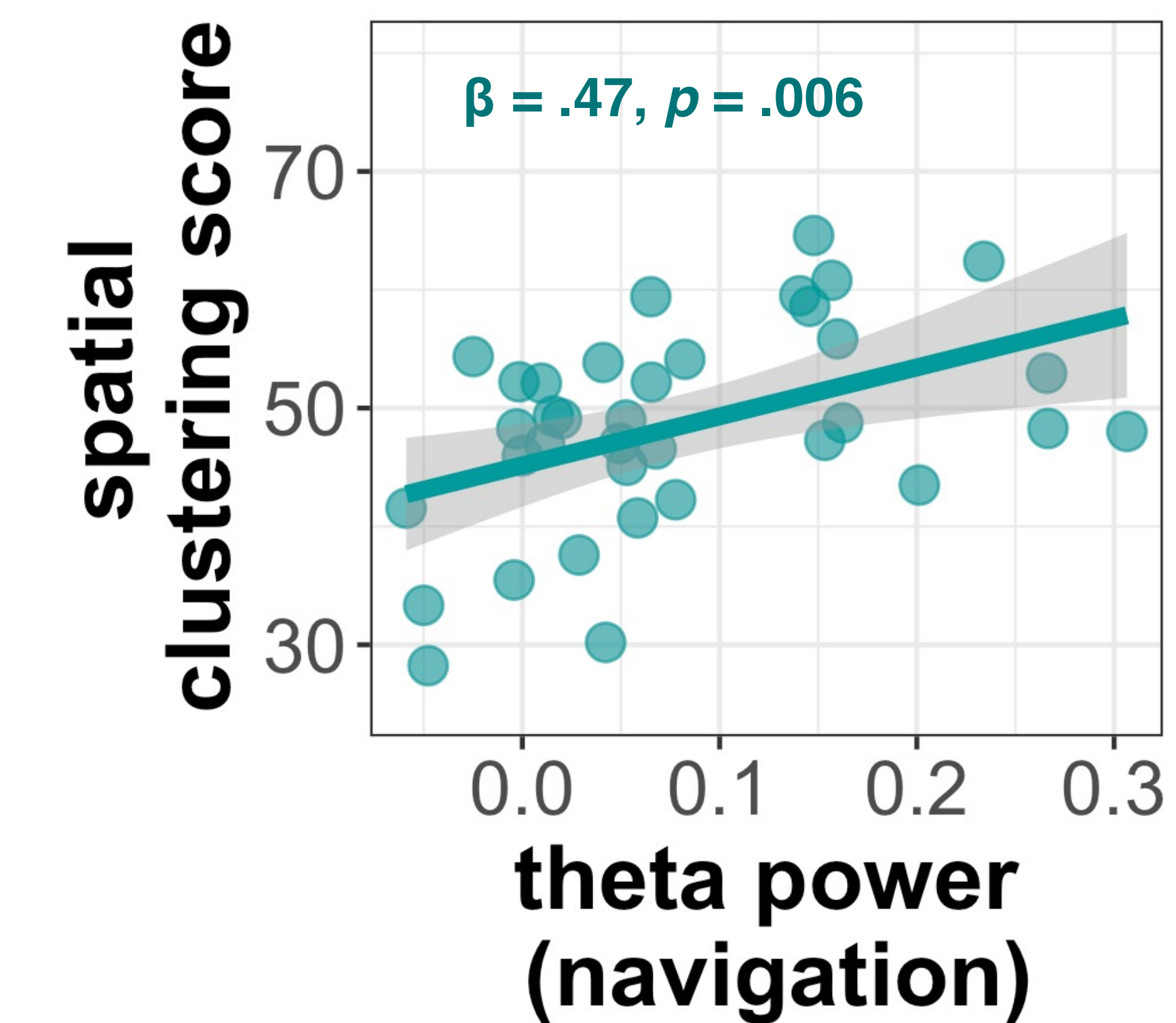
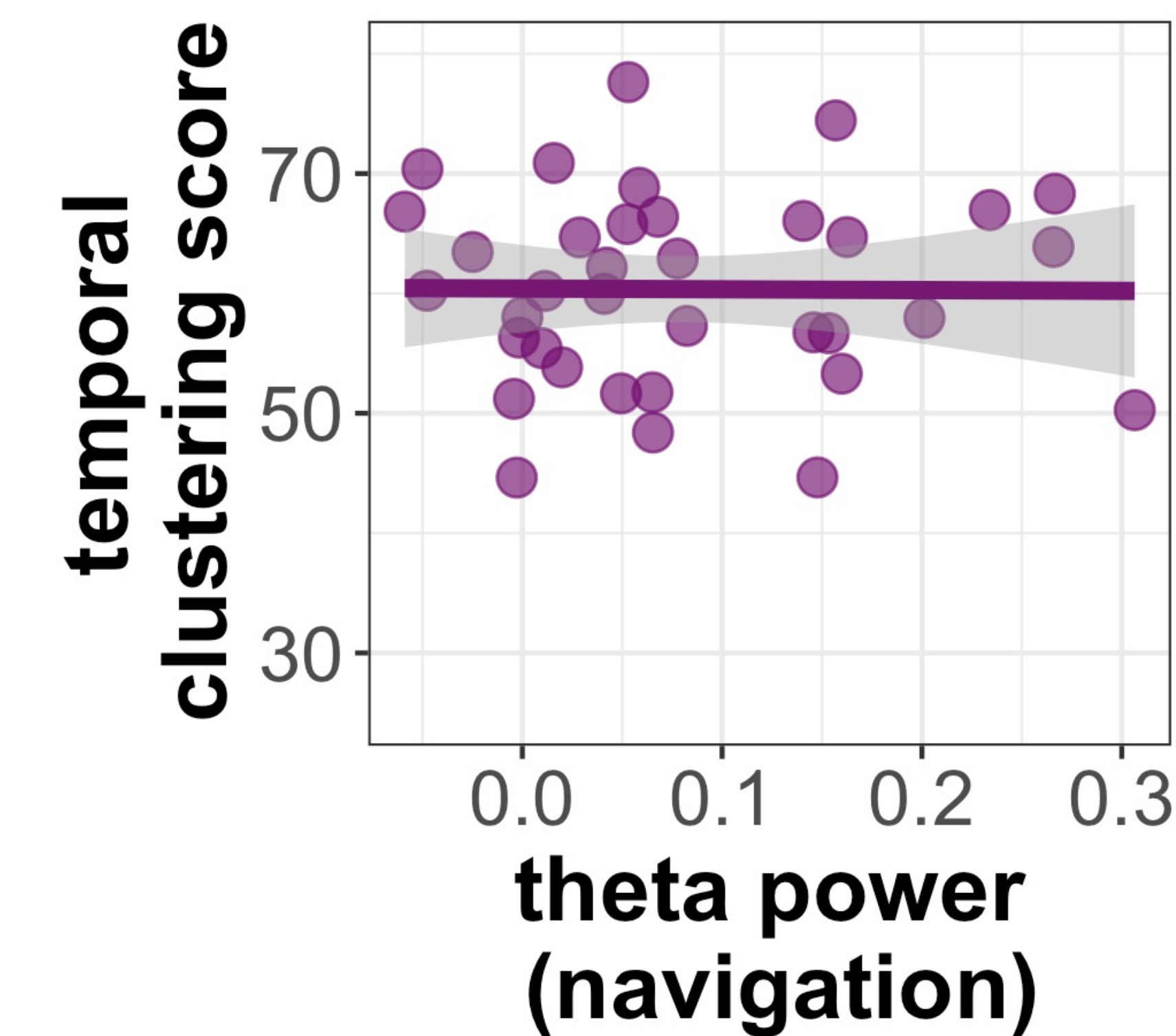
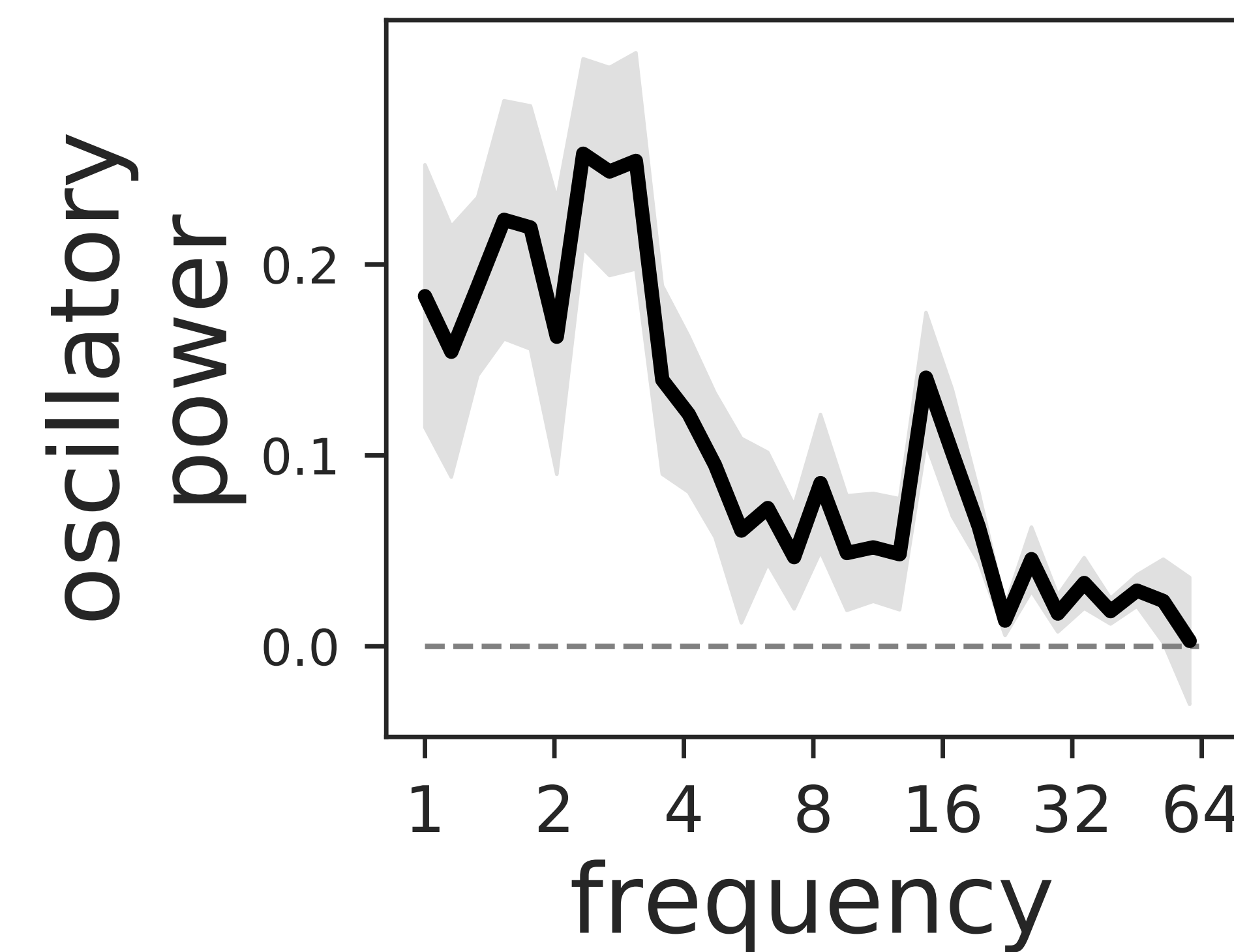


Prediction: more theta-rhythmic activity during experience should elicit greater subsequent memory organization



Theta during navigation and encoding predicts subsequent spatial clustering

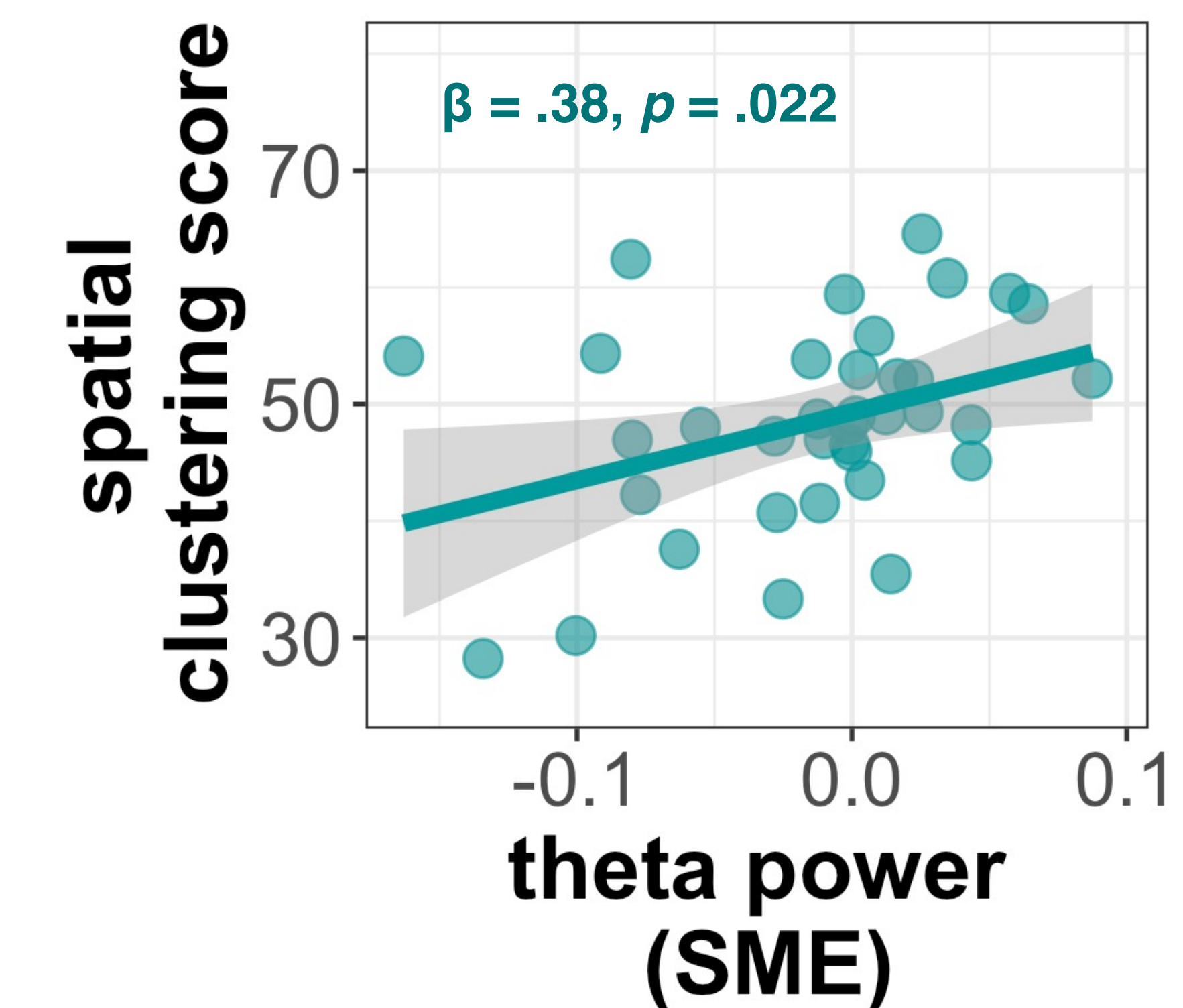
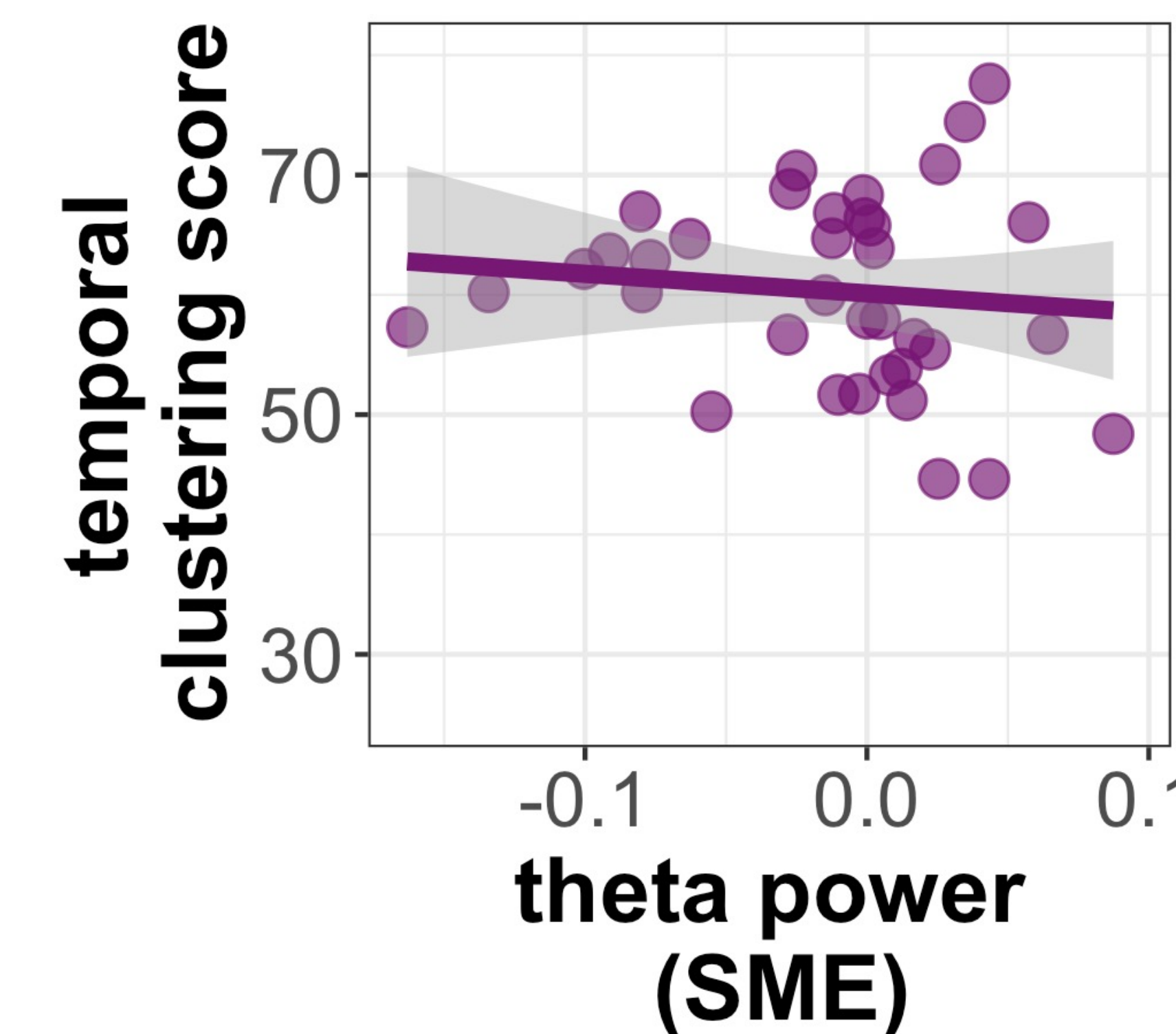
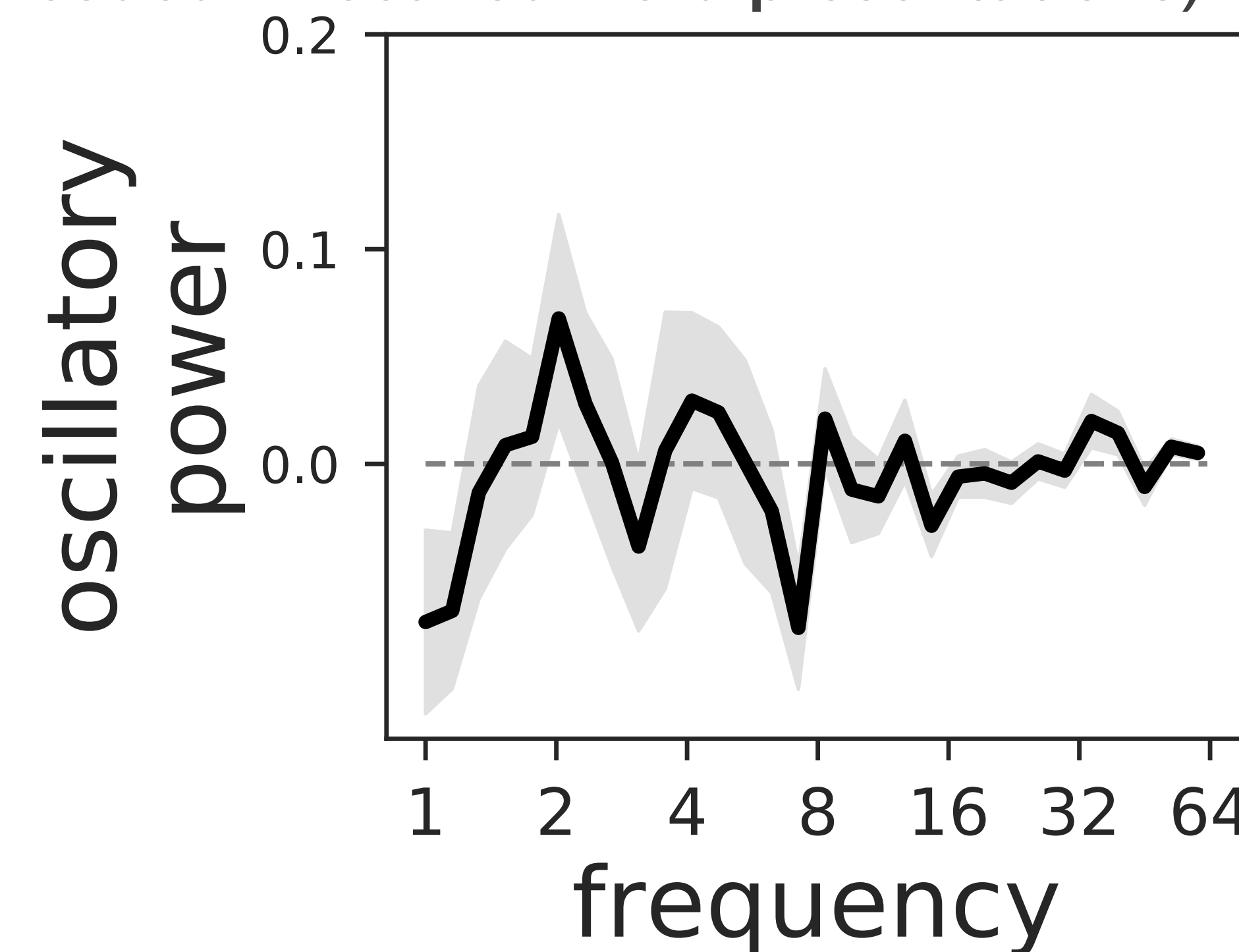
Navigation-related oscillatory activity



High theta (but not low theta) power during navigation predicts subsequent spatial (but not temporal) memory organization.

Neither navigation efficiency nor recall quantity explained significant variance).

Subsequent memory effect (SME; encoded – recalled word presentations)



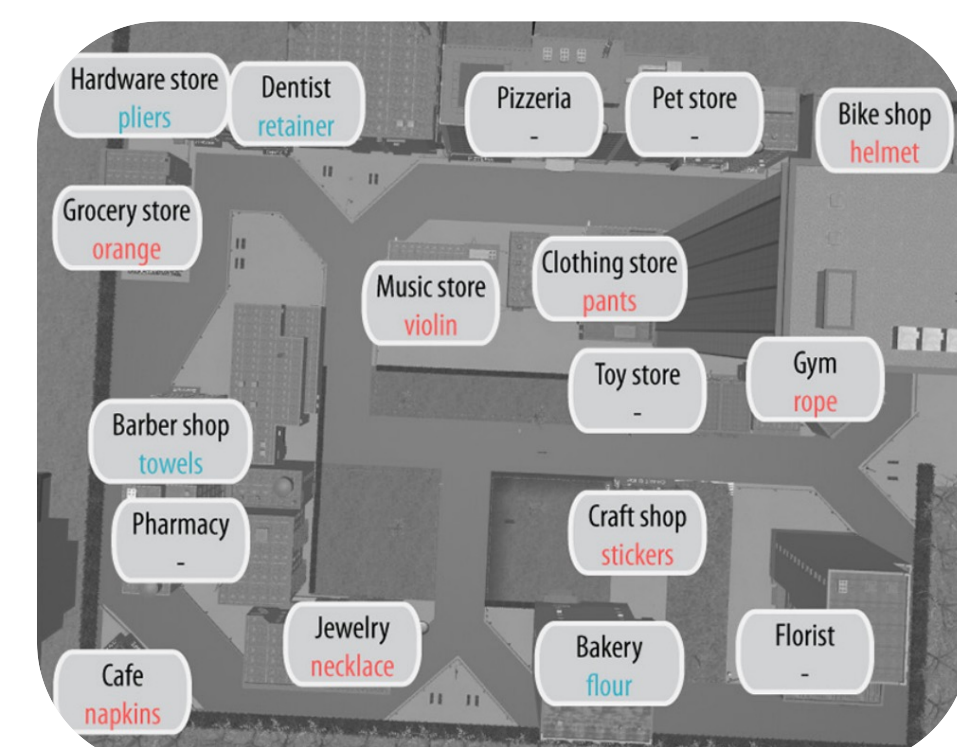
Same as above, but with successful (vs. unsuccessful) word encoding events.

Navigation- & SME-related theta are correlated ($r = .55$) but explain unique variance in spatial clustering.

VR navigation and memory task



Subjects play the role of a bike courier, **delivering different items to different locations** in a virtual city⁴

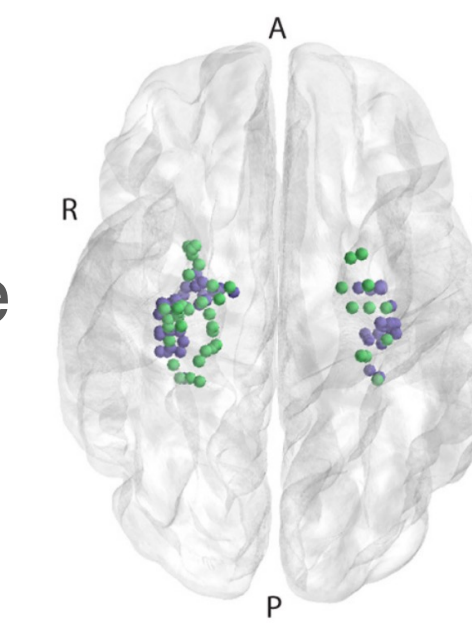


Temporal and spatial distances are decorrelated by design

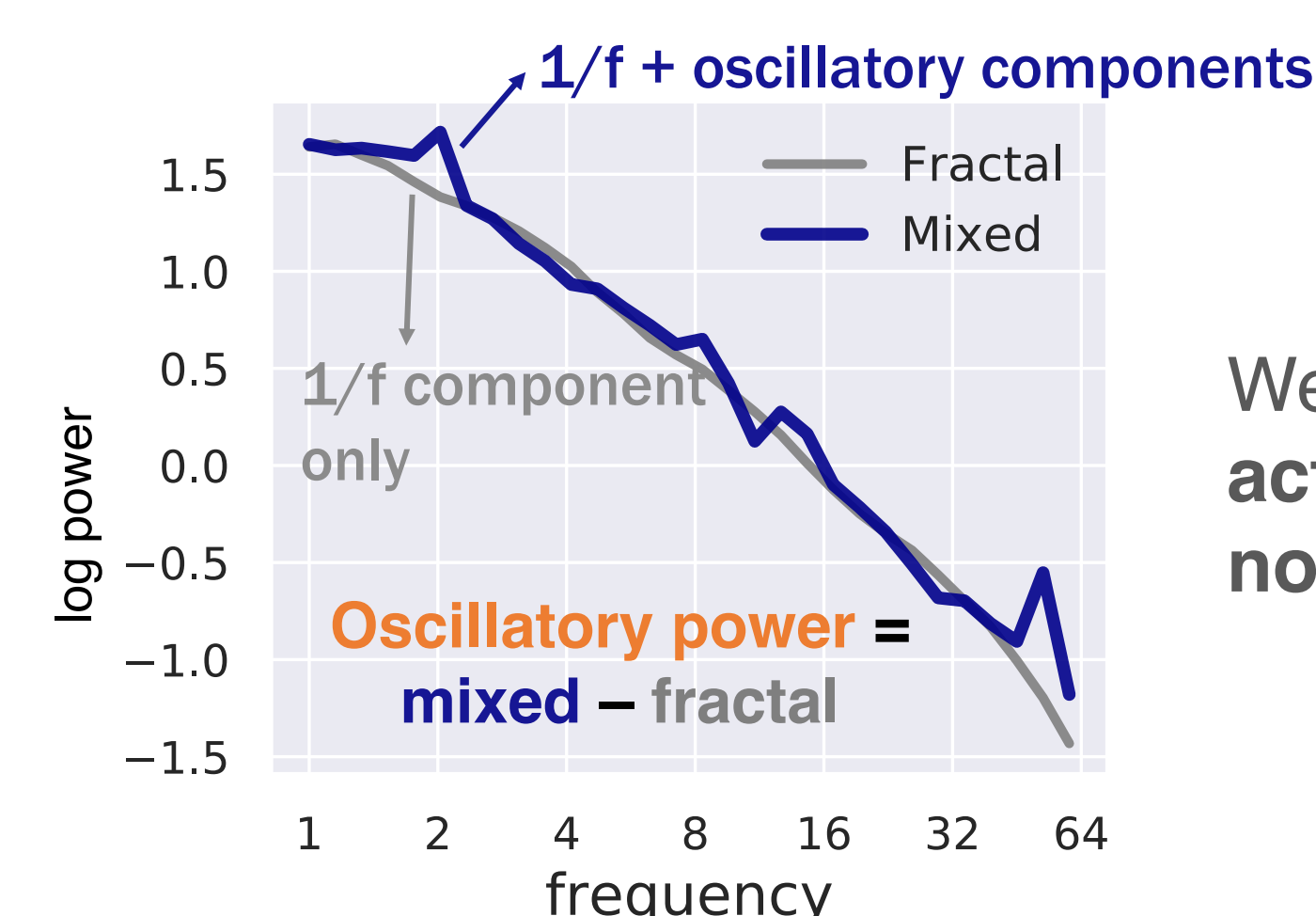
After 12 deliveries (one 'delivery day'), they **verbally recall** items

IEEG Spectral Decomposition

LFP recordings from intracranial electrodes in the medial temporal lobe (MTL; $N = 37$ subjects)



Two epochs: final navigation trajectory (*navigation-related theta*) & word encoding events (*encoding-related theta*)



We isolated **oscillatory activity (vs. aperiodic 1/f noise)** using IRASA⁵.

Linking theta to recall organization

We analyzed temporal & spatial organization in recall trajectories using **temporal⁶** & **spatial⁴** clustering scores

We took an **individual differences** approach

We predicted temporal *or* spatial clustering from low (1-4hz) and high (4-8hz) theta power⁷, & regressors of no interest.

spatial *or* temporal clustering ~
high theta + low theta + navigation efficiency + recall quantity

Conclusions & Questions

- Human MTL theta oscillations may facilitate associations among items encoded close in space even if far in time, giving rise to spatial organization in memory search
➢ *Anatomical specificity (hippocampus) within the MTL?*
- Why does theta predict spatial but not temporal clustering (consistent with previous work⁴)?
➢ *Theta-mediated compression and reactivation of nearby stores/locations may facilitate spatial associations, 'stitching together' items encoded at nearby locations*
- Do patterns of covert item reactivation during navigation & encoding exhibit sequential organization that predicts verbal recall? Is reactivation clocked by theta?

References

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