

Narrative order remaps time coding subspaces while preserving the geometric structure

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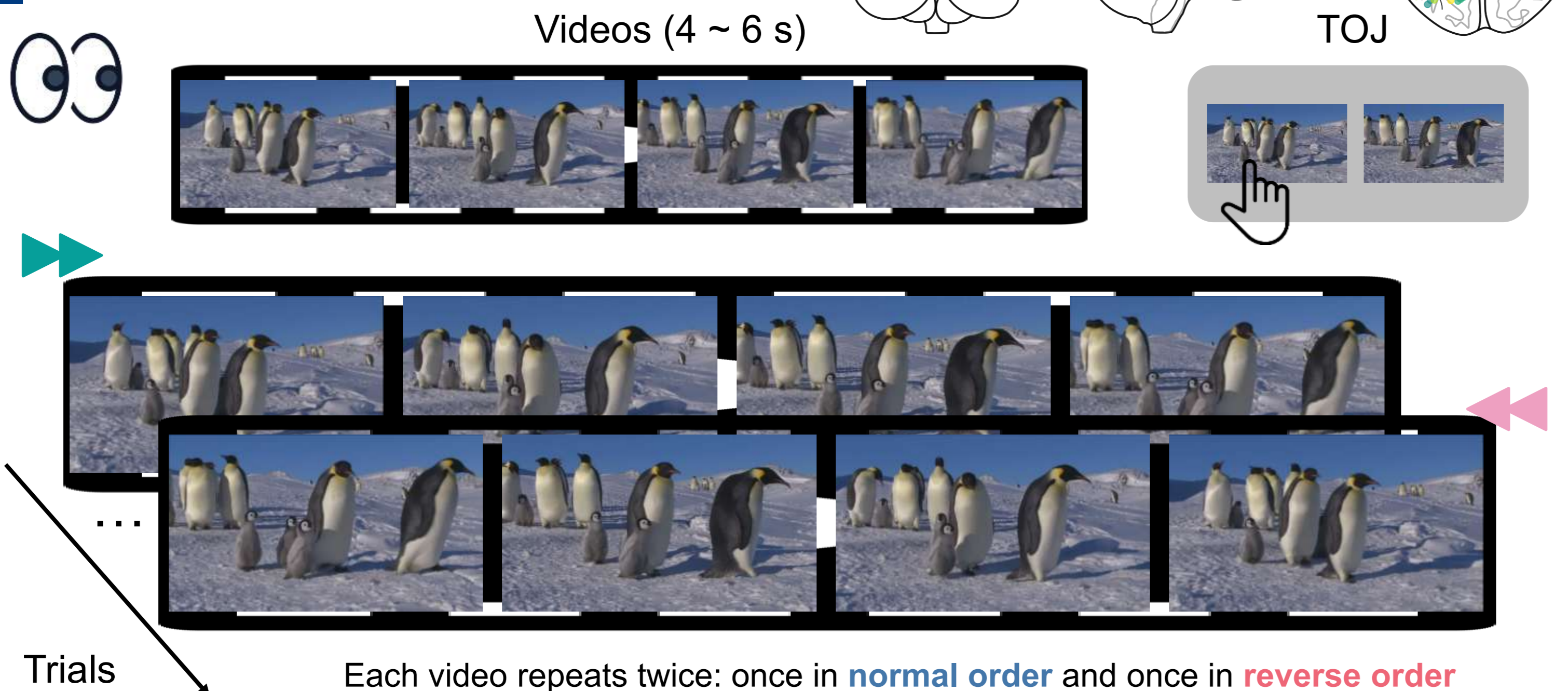
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Introduction

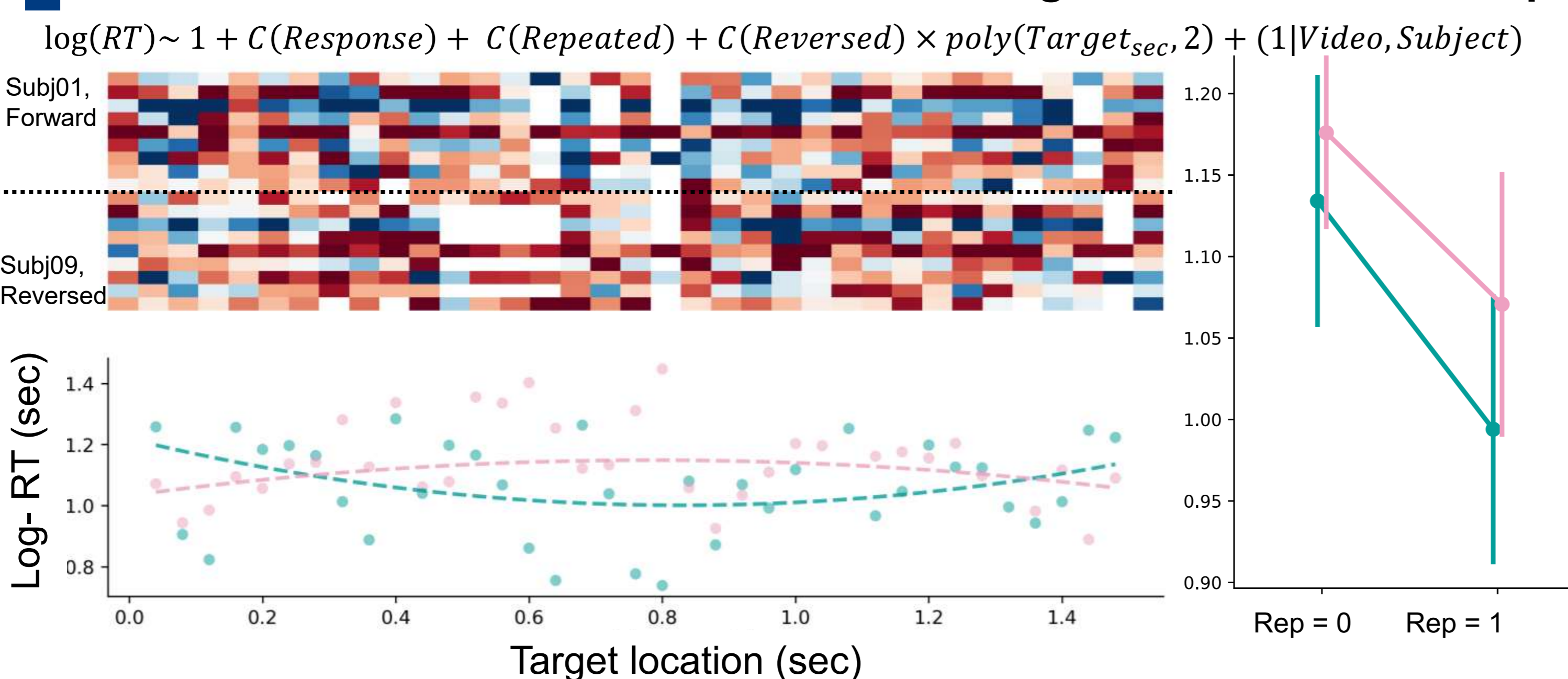
Episodic memory relies on the brain's ability to represent the temporal structure of continuous experience. However, how disruption in the natural flow of events affects temporal encoding and retrieval remains unclear. We recorded intracranial EEG from 9 patients performing a temporal-order judgement task: 4–6 s video clips were presented twice — once in their original (Forward) order and once Reversed — and participants judged which of two still frames occurred earlier. Here we analyze encoding-period population activity to test whether (1) time forms a low-dimensional coding axis, (2) presentation direction alters population geometry, and (3) any direction differences reflect linear transforms of a shared temporal manifold.

Paradigm



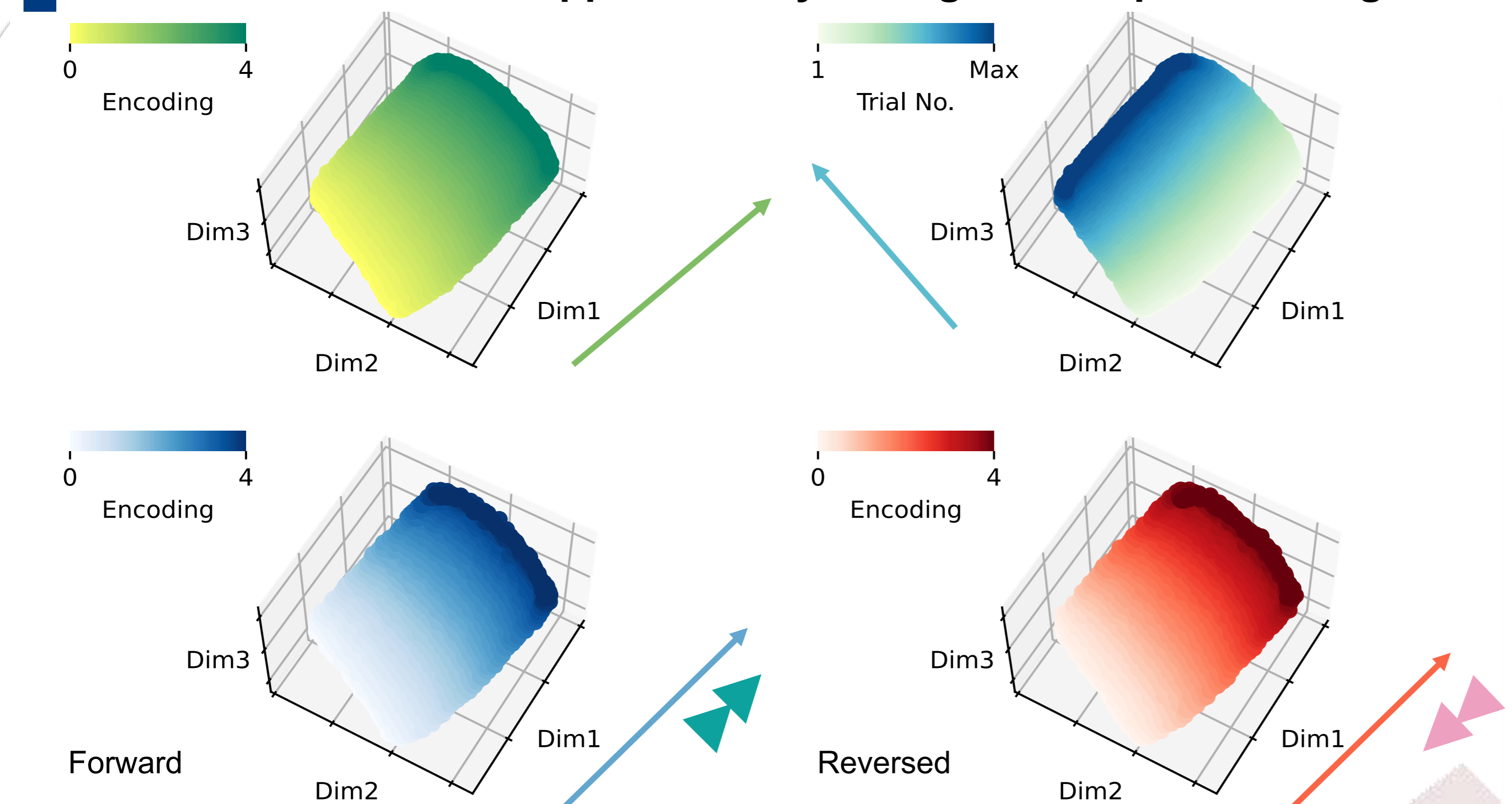
Behavioral results

Reversed RT-target location relationship

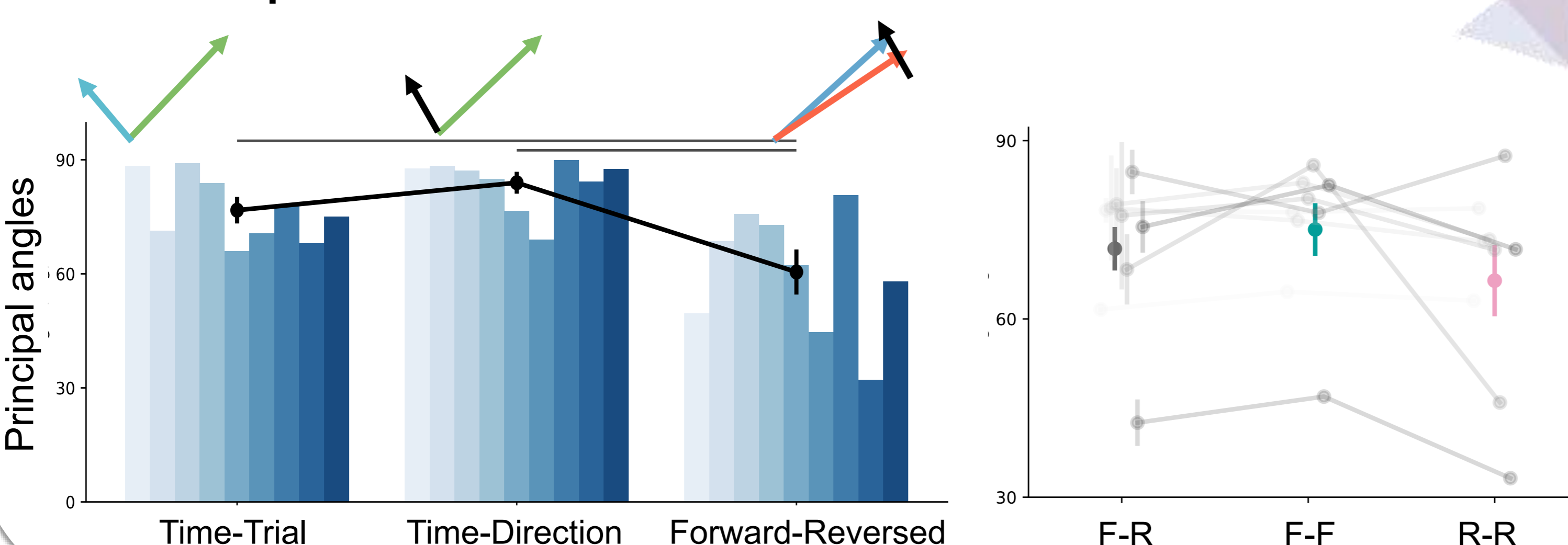


Neural manifold

Approximately orthogonal temporal coding axes

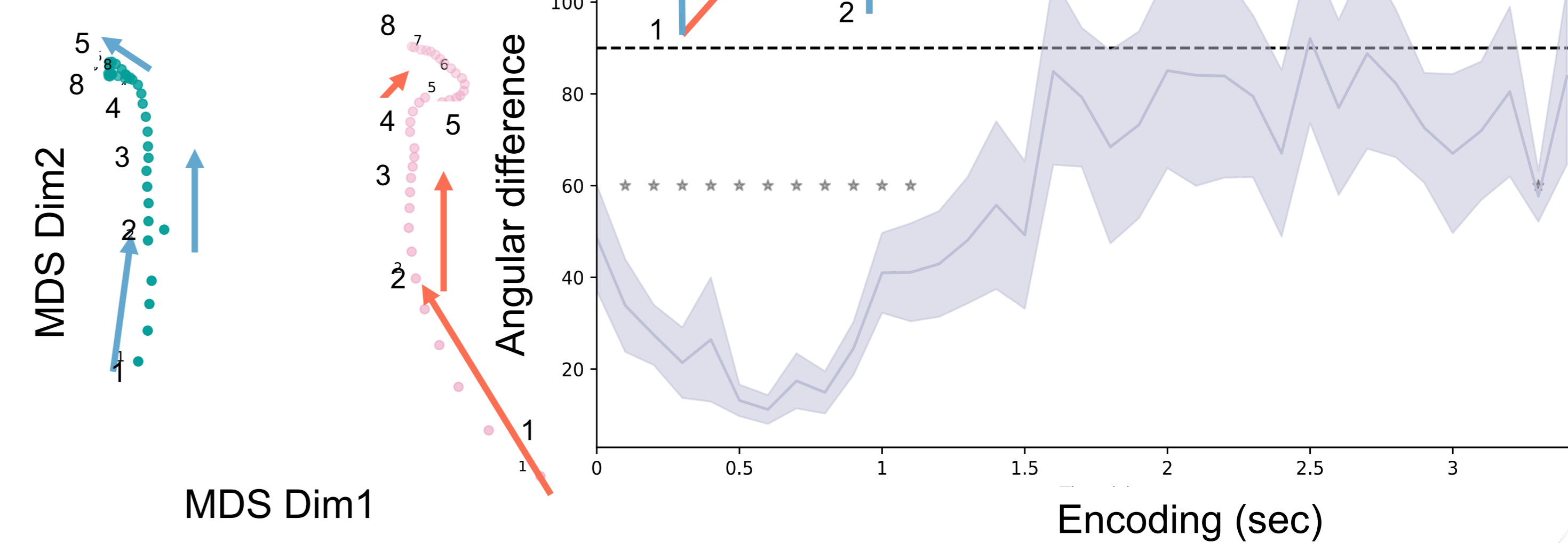


Shared temporal manifold

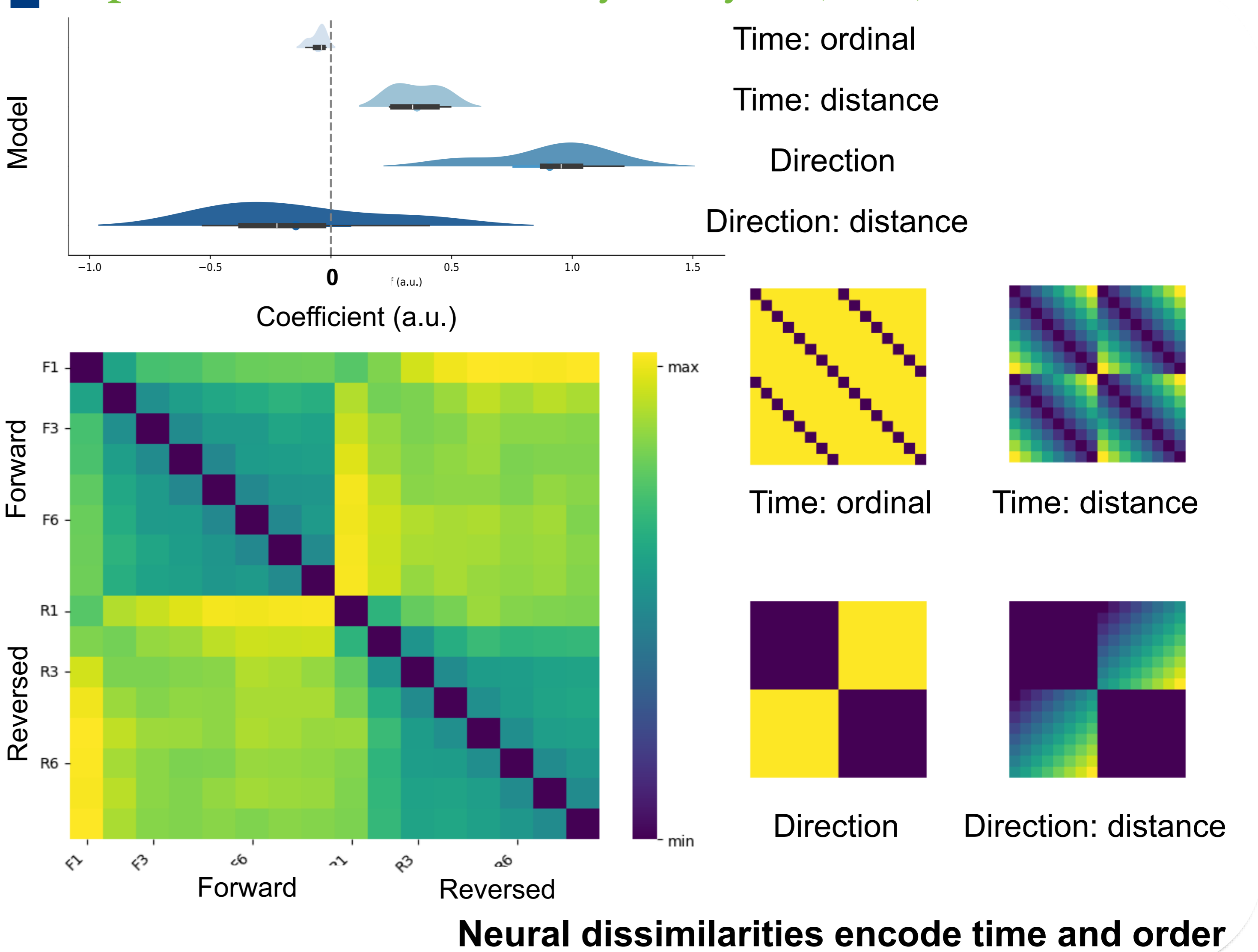


Time-coding direction

Early alignment, then divergence

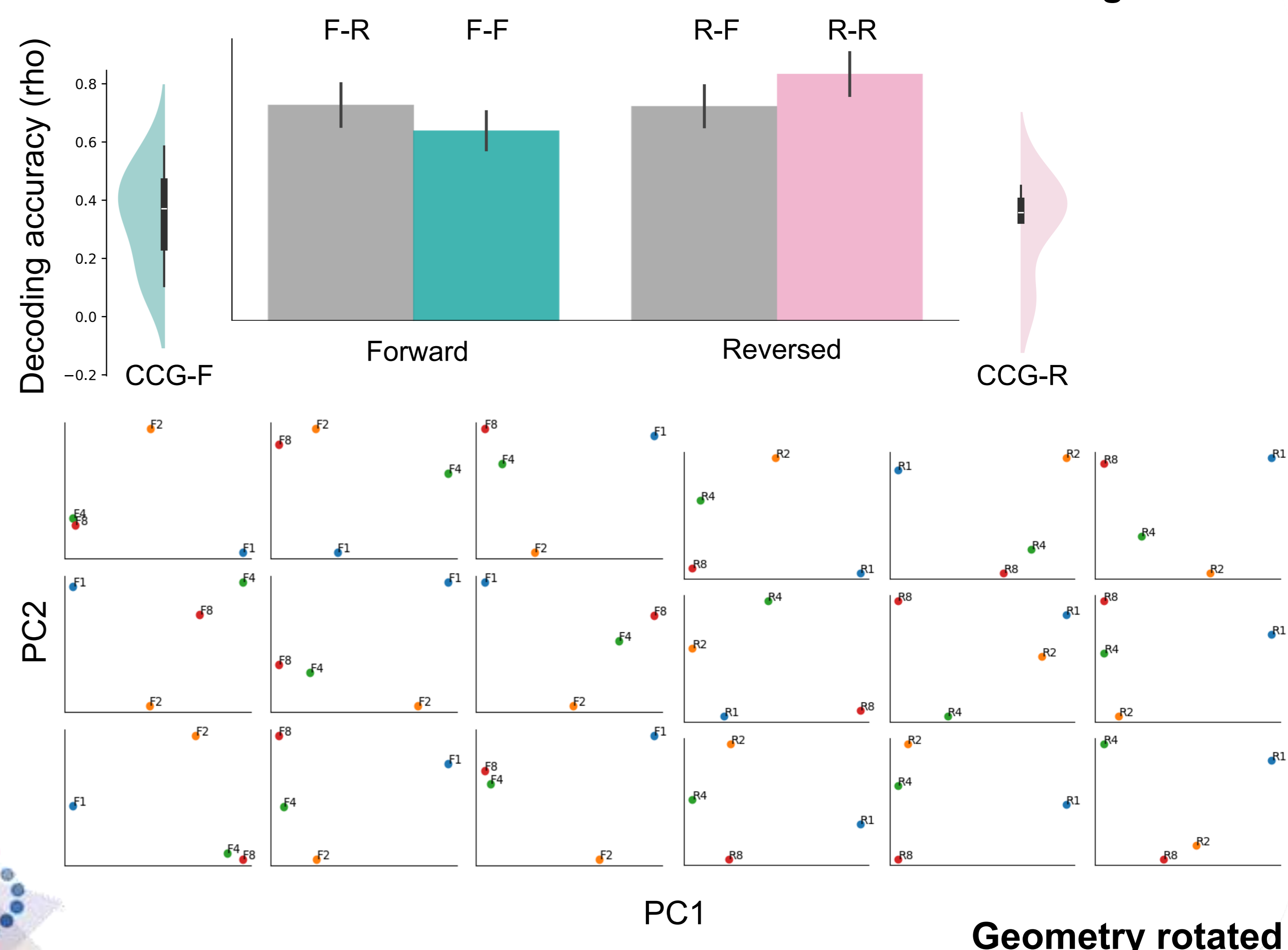


Representational similarity analysis (RSA)



Cross-condition generalization

Cross-direction decoders generalize



Conclusion

- Reversed presentation slows decisions and qualitatively remaps RT-time relationship.
- Population activity encodes elapsed time as a low-dimensional manifold that is largely preserved across presentation direction.
- Early encoding stages are direction-invariant (step-vector alignment $< 90^\circ$), after which direction-specific deviations accumulate.
- A direction-invariant temporal axis combined with modest, direction-specific linear transformations, which might explain behavioral costs under reversal.