

Supplementary Information: Event-Triggered Entropy Dynamics in Human EEG

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S1. Replication Across Experimental Regimes

To assess the generality of the observed population-scaling phenomenon, we repeated the full analysis pipeline on two additional datasets beyond the tightly controlled meditation regime shown in the main text: (i) a broader meditation dataset with looser preprocessing criteria, and (ii) an independent resting-state EEG dataset (EEGMIDB).

Across both datasets, we observe qualitatively similar event-triggered entropy responses, stable pair scaling behavior, and smooth convergence with increasing subject count.

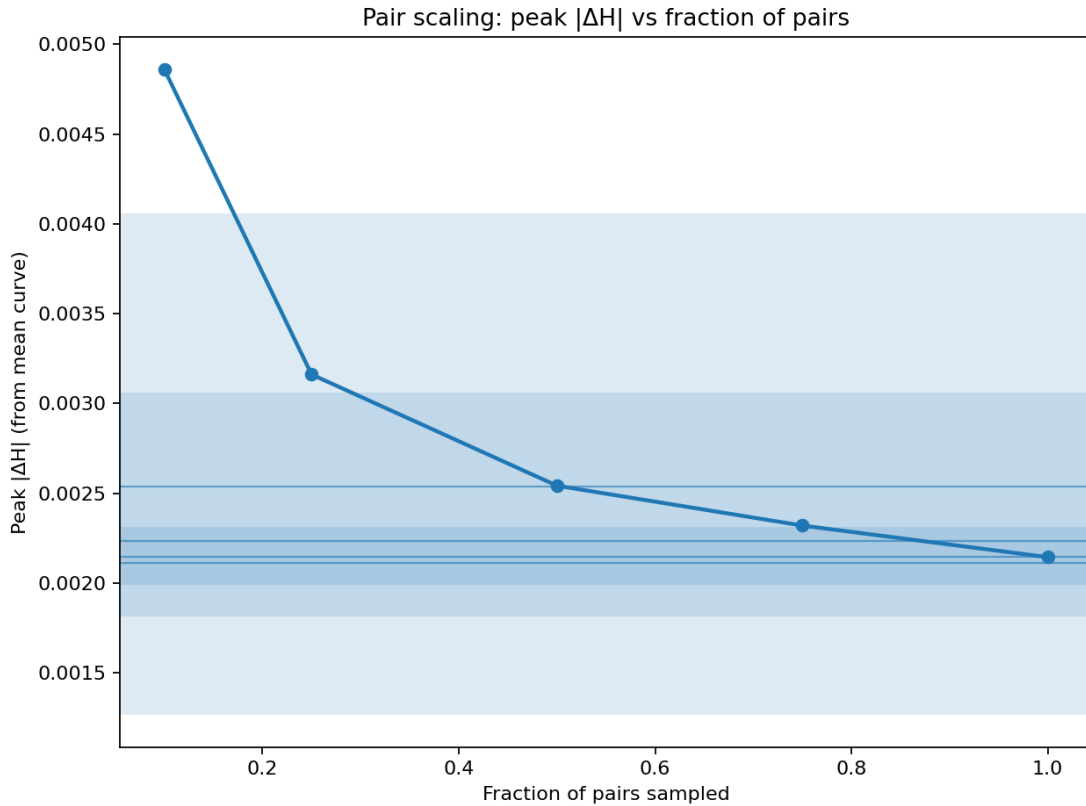


Figure 1: Pair scaling of peak entropy response for the broader meditation dataset. Results closely mirror those observed in the tightly controlled meditation regime.

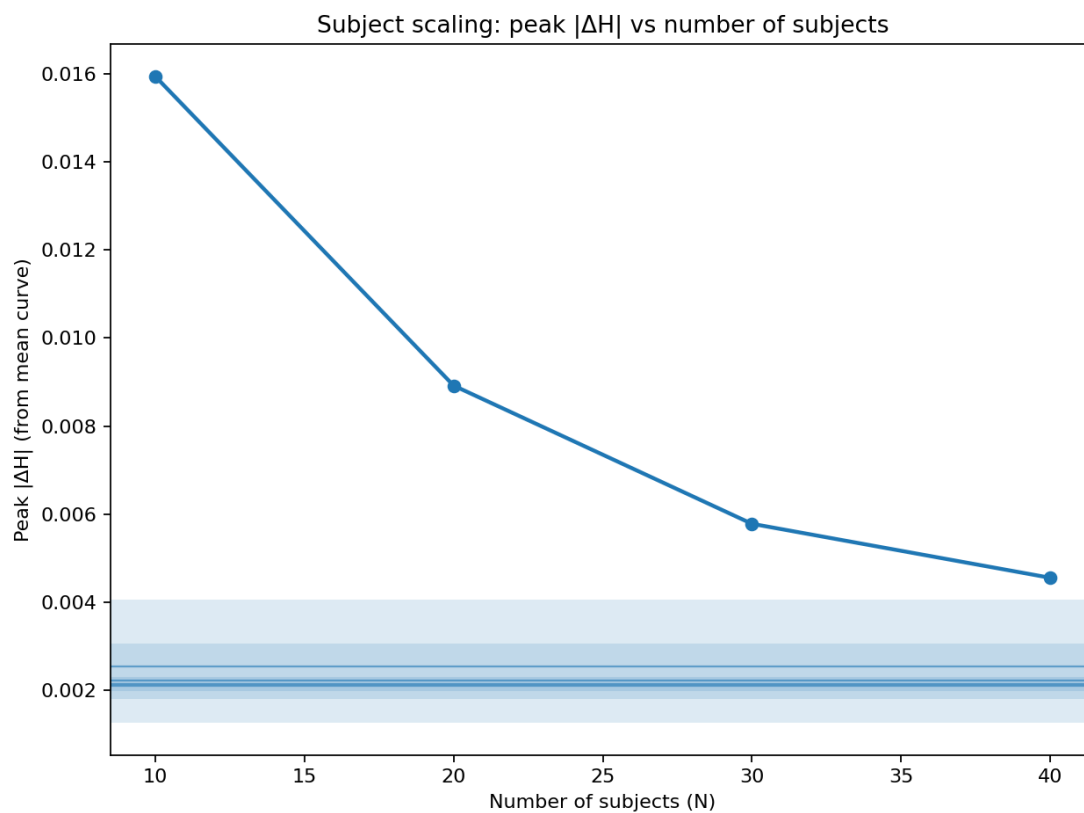


Figure 2: Subject scaling of peak entropy response for the broader meditation dataset.

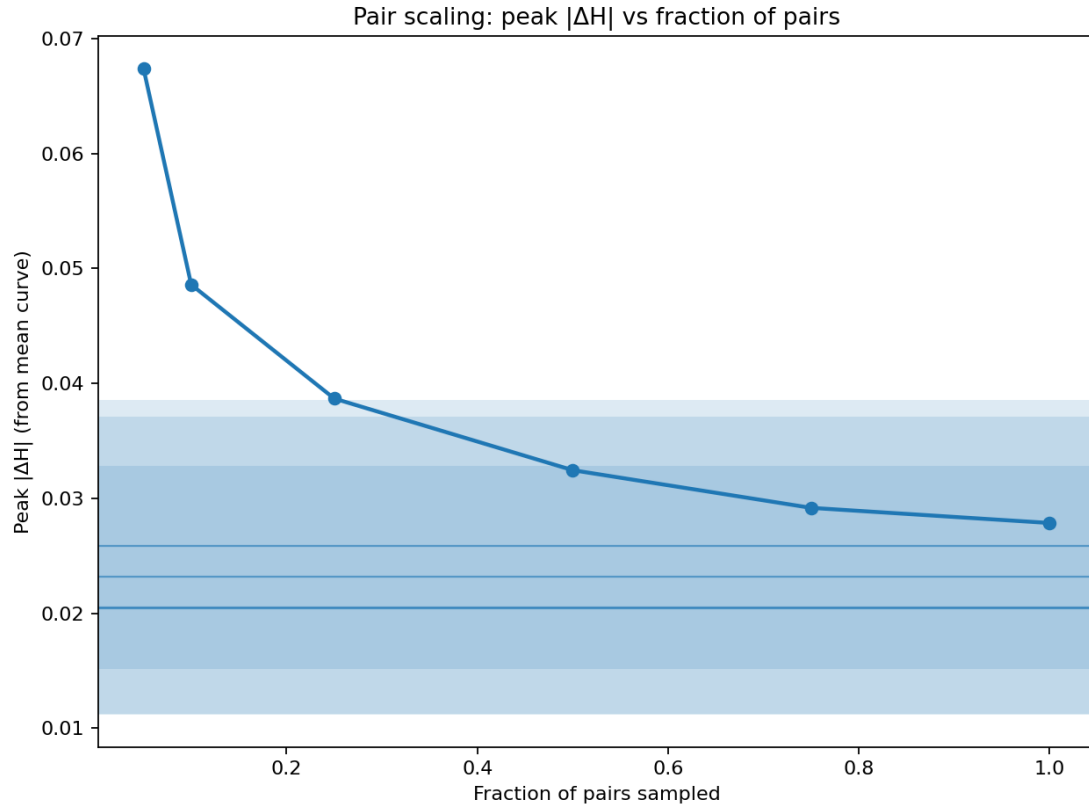


Figure 3: Pair scaling results for resting-state EEG (EEGMMIDB). While weaker in magnitude, the entropy response remains statistically separable from null models.

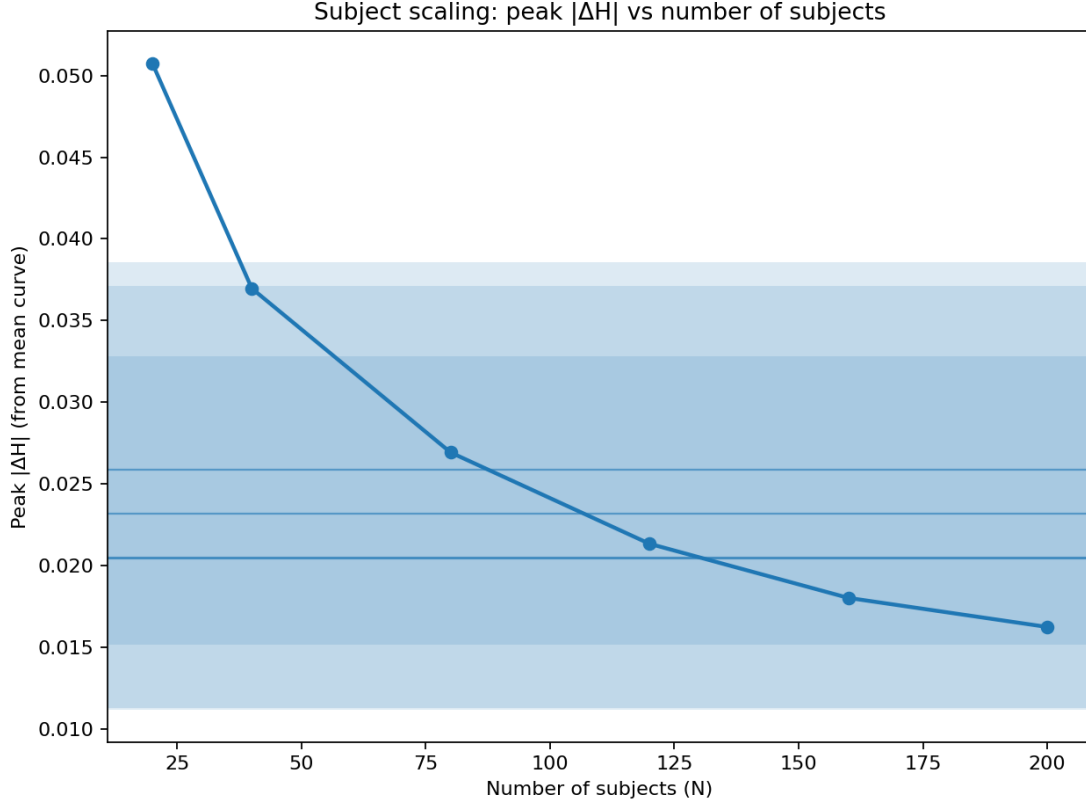


Figure 4: Subject scaling results for EEGMMIDB. The response converges with increasing population size.

S2. Additional Null Models

We evaluated several null models to test whether the observed scaling behavior could arise from trivial statistical structure:

- Time-shuffled entropy series
- Phase-randomized surrogates
- Randomized event timings
- Time-reversed entropy trajectories

Across all null models, the real data consistently shows increasing separation with aggregation.

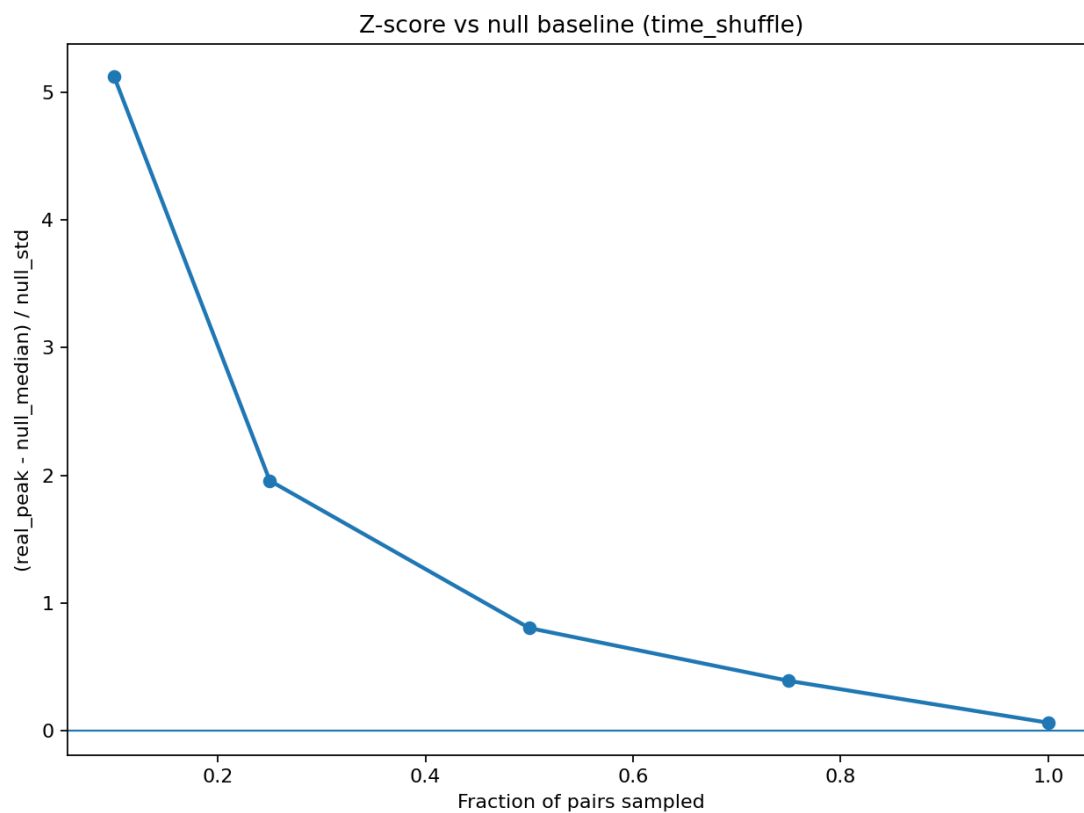


Figure 5: Z-score separation between real pair scaling and null models across all datasets.

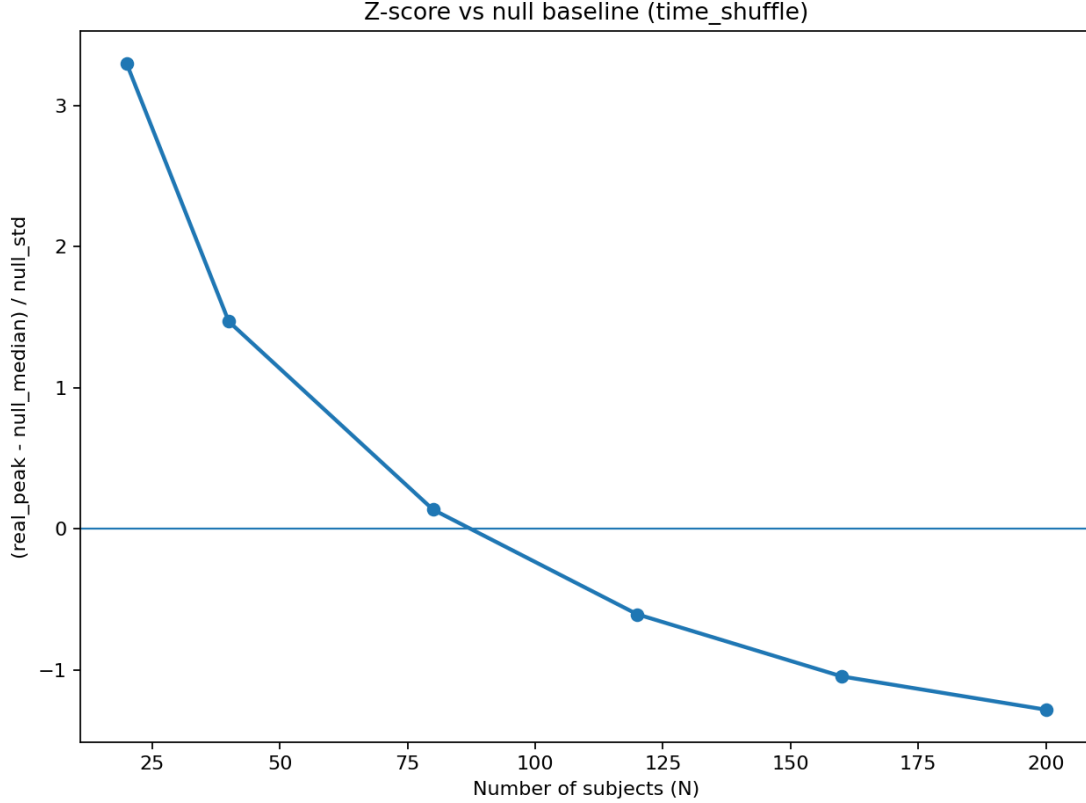


Figure 6: Z-score separation for subject scaling relative to null distributions.

S3. Implementation Details

- EEG signals were segmented into fixed-length epochs.
- Band-power fractions were computed for theta, alpha, beta, and gamma bands.
- Shannon entropy was computed per epoch using normalized band-power fractions.
- Emission events were detected using thresholded entropy changes and state transitions.
- Pairwise entropy responses were aggregated across ordered subject pairs.
- Scaling analyses were performed via repeated random subsampling of pairs and subjects.

All analyses were implemented using custom Python pipelines and repeated with multiple random seeds to ensure robustness.