MRC Cognition and Brain Sciences Unit

UNIVERSITY OF CAMBRIDGE

EEG/MEG Statistics – ROI Analysis and Cluster-Based Permutation Testing

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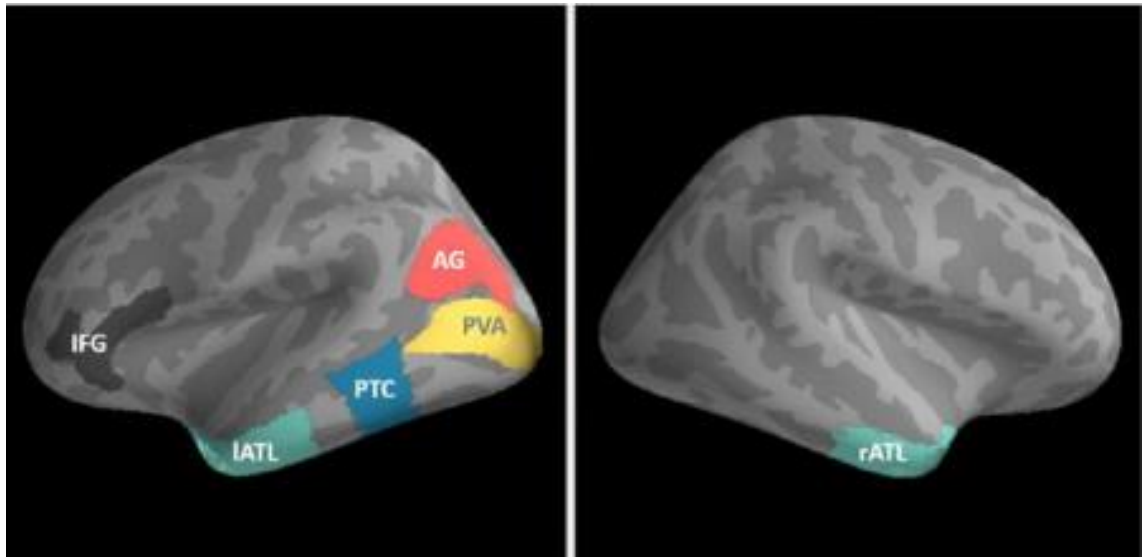
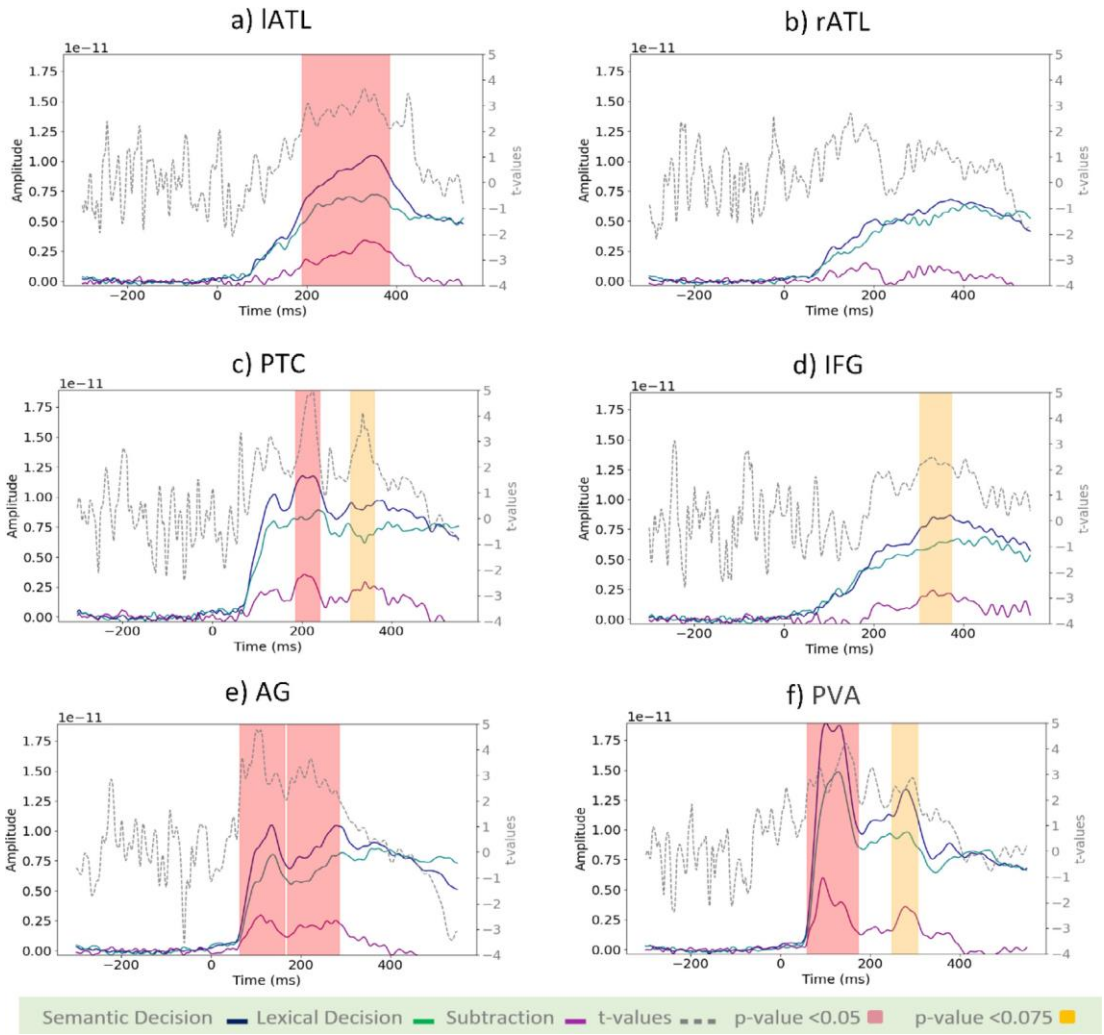
Regions-of-Interest (ROI) Analysis





from Rahimi et al., NI 2022, https://www.sciencedirect.com/science/article/pii/S1053811921010405

Trade-off between sensitivity and specificity

- **ROI analysis:**
  - High sensitivity (e.g. uncorrected p-values), but:
  - Low specificity (tests only a small subset of regions, latencies, frequencies).
  - Requires a priori selection of vertices/sensors, latencies, frequency.

- **Whole-brain analysis:**
  - High specificity (can locate effects in space, time, frequency), but:
  - Low sensitivity (needs to correct for multiple comparisons).

Cluster-Based Permutation Tests

Defining Clusters:

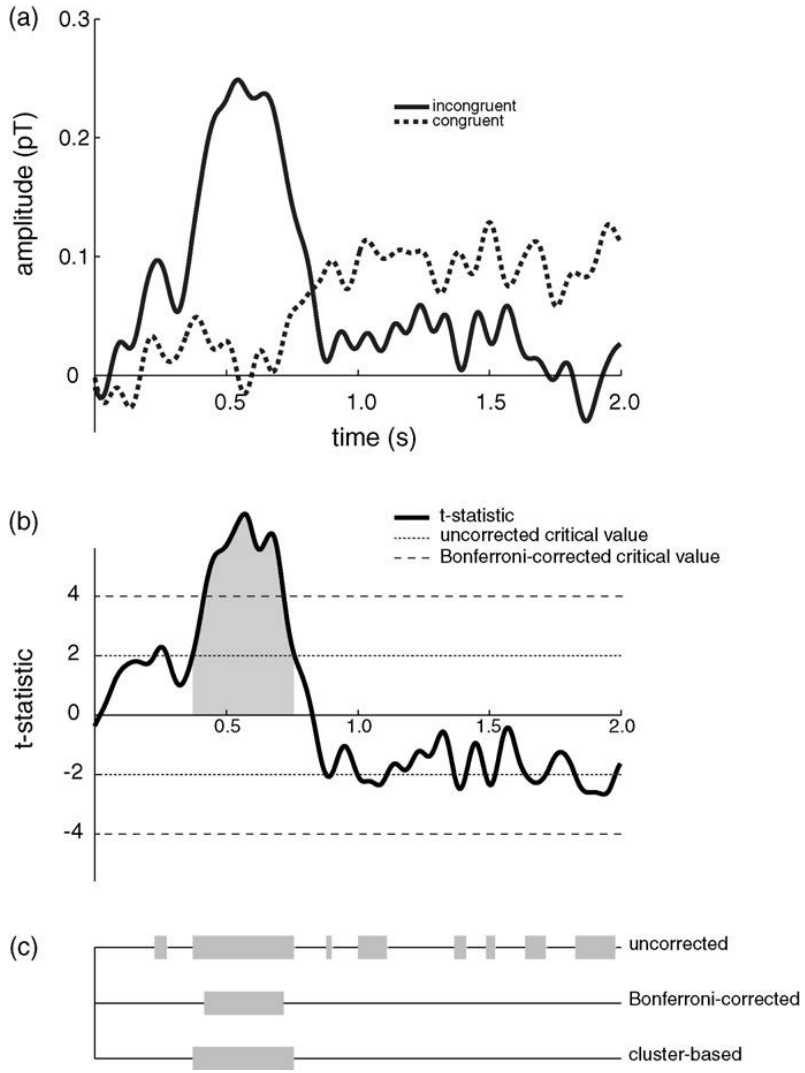
1. For every sample (space/time/frequency) the experimental conditions are compared by means of a t-value (or similar). This t-value is *not* the cluster-based test statistic for which we will calculate the significance probability, it is just an ingredient in the calculation of this cluster-based test statistic.
2. All samples are selected whose t-value is larger than some threshold. This threshold does *not* affect the false alarm rate of the statistical test, it only sets a threshold for considering a sample as a candidate member of some cluster of samples.
3. Selected samples are clustered in connected sets on the basis of temporal, spatial and spectral adjacency.
4. Cluster-level statistics are calculated by taking the sum of the t-values within every cluster.

Significance Test:

1. Randomly draw trials from your data and assign them to subset 1 and subset 2, respectively. The result of this procedure is called a *random partition*.
2. Calculate the test statistic (the above maximum of the cluster-level summed t-values) on this random partition.
3. Repeat steps 1 and 2 many times and construct a histogram of the test statistics.
4. Calculate the proportion of random partitions that resulted in a larger test statistic than the observed one. This proportion is the Monte Carlo significance probability, which is also called a *p-value*.

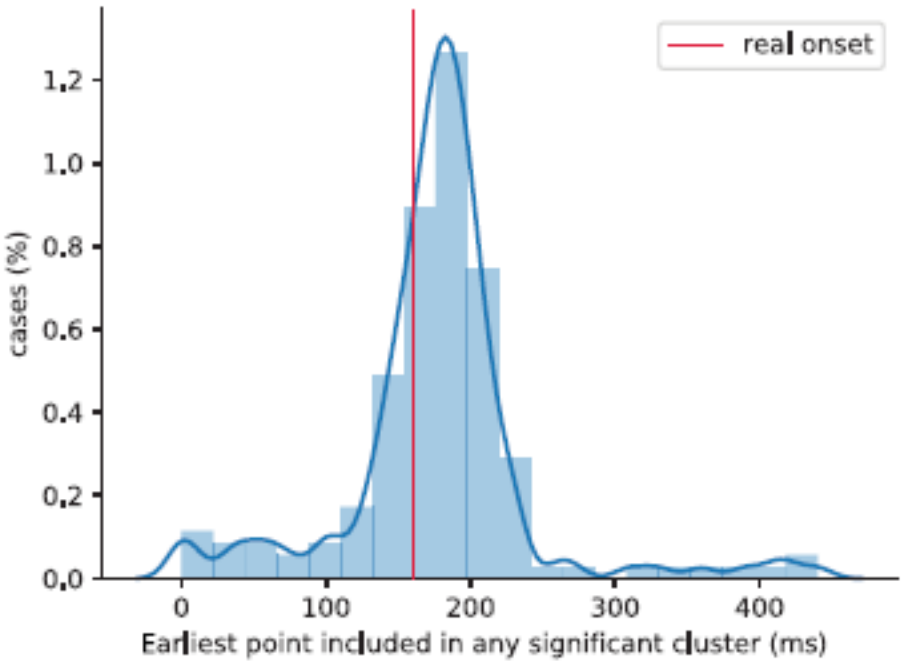
Modified from https://www.fieldtriptoolbox.org/tutorial/cluster_permutation_timelock/

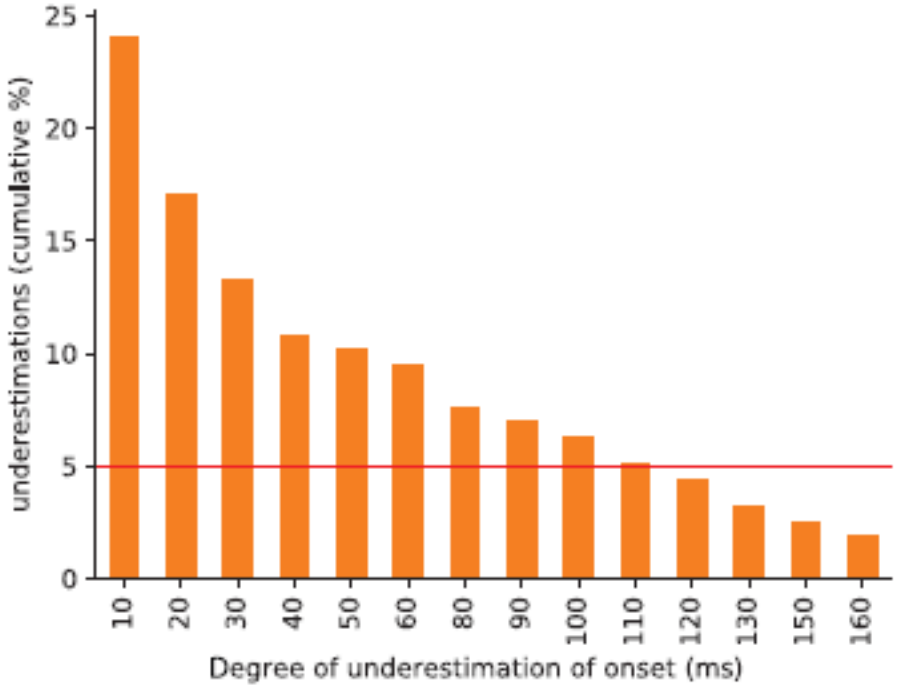
Cluster-Based Permutation Tests



Maris & Oostenveld, J Neurosc Meth 2007, https://pubmed.ncbi.nlm.nih.gov/17517438/

Cluster-Based Permutation Tests



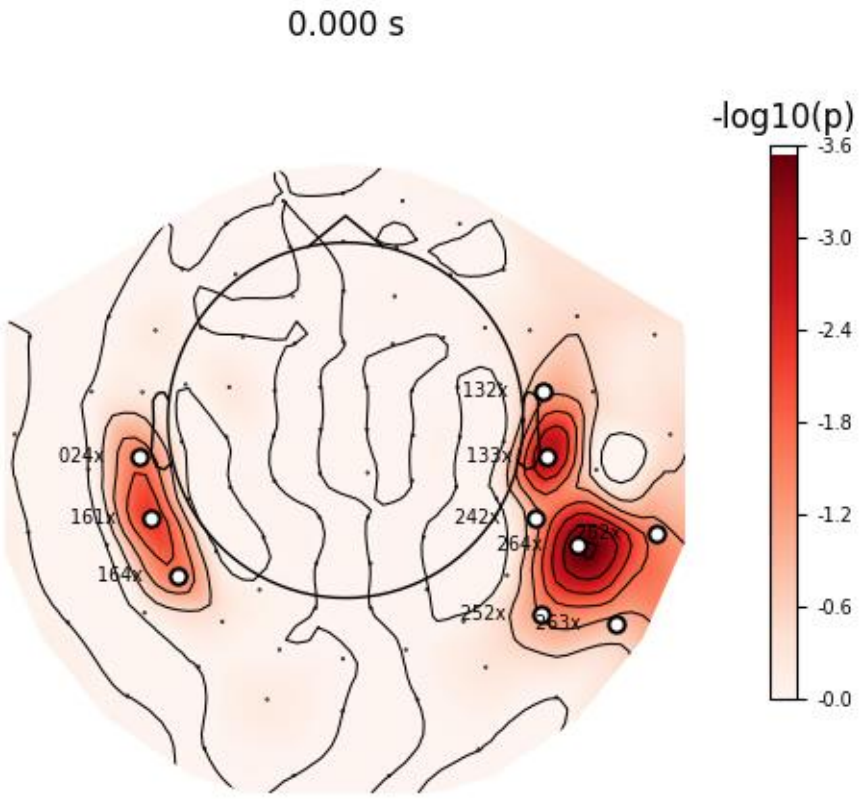


Cluster-based permutation tests of MEG/EEG data do not establish significance of effect latency or location

Sassenhagen & Draschkow, Psychophysiol 2018, https://pubmed.ncbi.nlm.nih.gov/28893608/

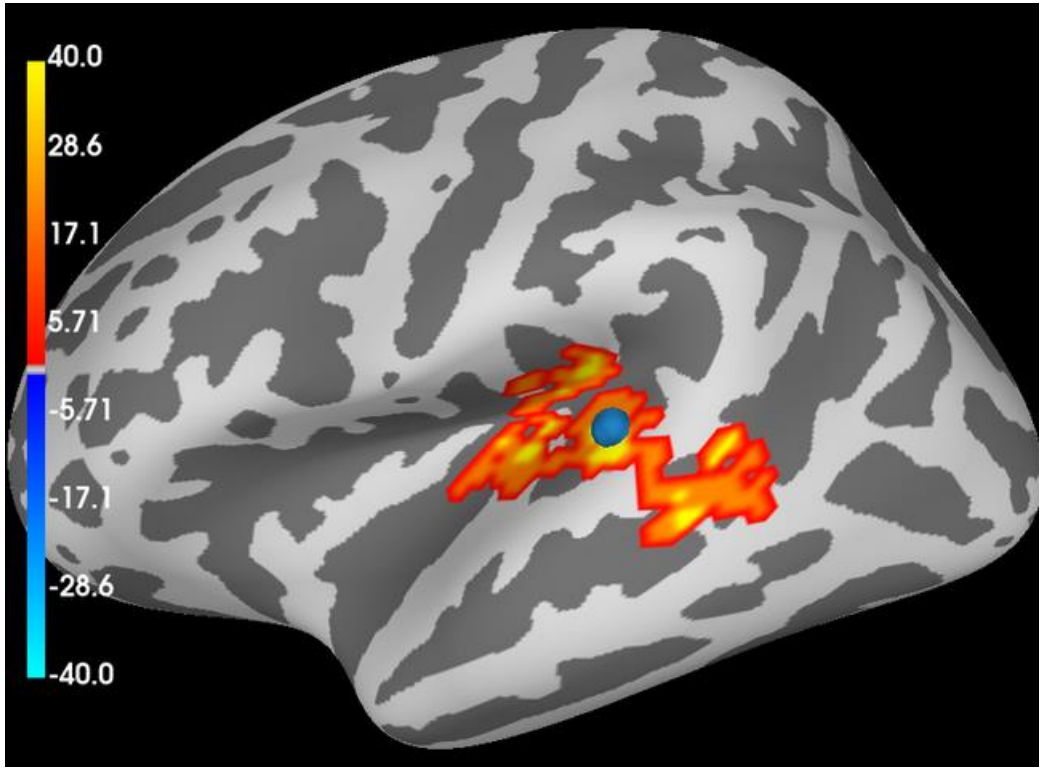
Cluster-Based Permutation Tests

Sensor Space



https://mne.tools/stable/auto_examples/stats/sensor_permutation_test.html

Source Space



https://mne.tools/stable/auto_tutorials/stats-source-space/20_cluster_1samp_spatiotemporal.html#sphx-glr-auto-tutorials-stats-source-space-20-cluster-1samp-spatiotemporal-py

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Thank you