



Binaural Hearing and
Speech Laboratory

Auditory Processing in Down Syndrome: EEG Source Localization Using Individual-Specific MRI-Based Head Models

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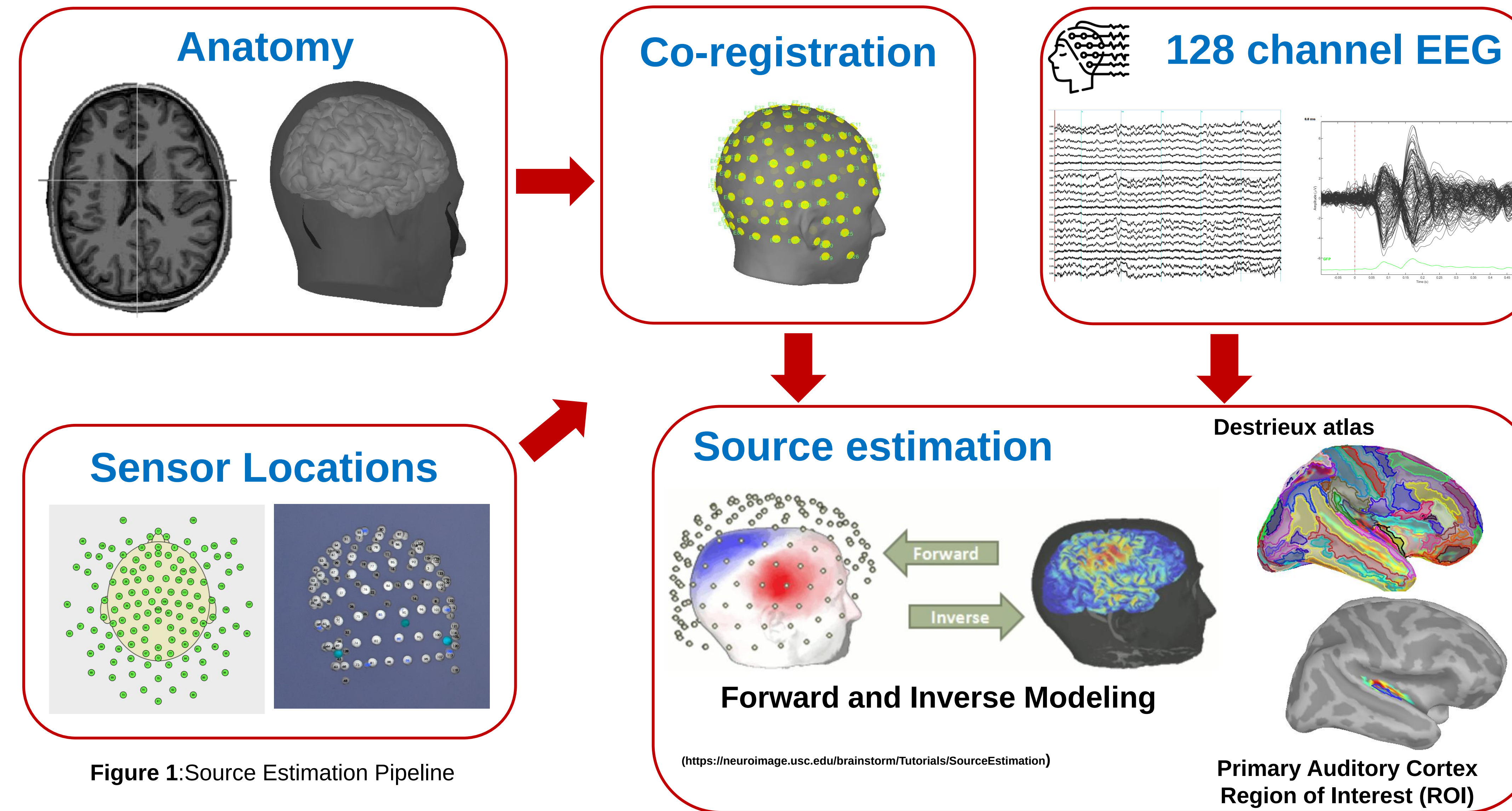
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INTRODUCTION

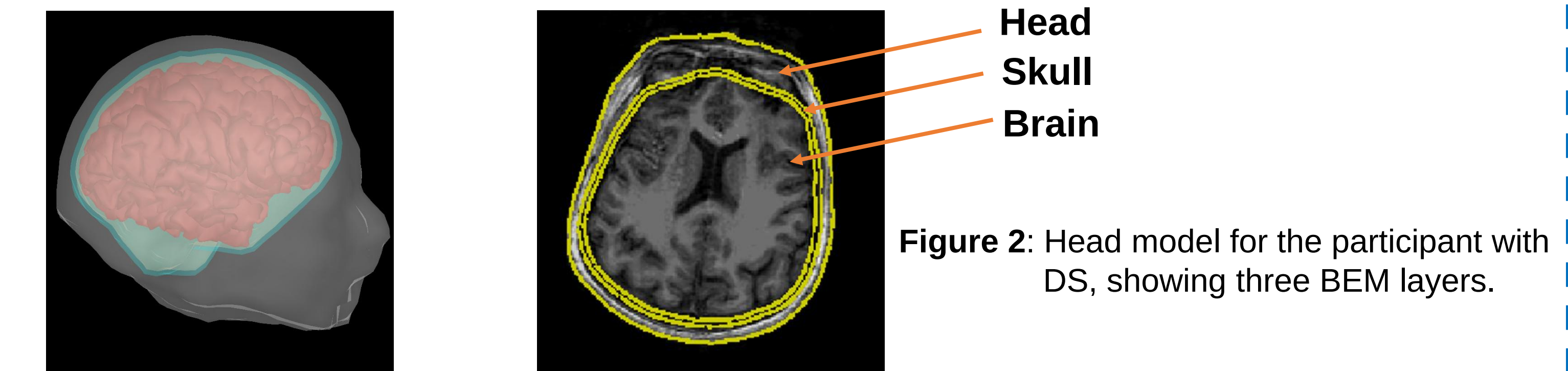
Down Syndrome (DS): A developmental disorder with high prevalence of hearing loss

- Prior EEG studies using cortical auditory evoked potentials (CAEPs such as N1, and P2) demonstrate that individuals with DS exhibit auditory processing deficits, but their neural sources remain unclear.^{1,2}
- EEG source localization analysis estimates the neural sources or brain regions involved in generating scalp-recorded EEG activity.
- Studies using EEG source localization in individuals with DS are limited and have not examined auditory processing.
- The sparse literature relies on generic head models based on average brain anatomy of typically developing (TD) adults.³
- Realistic head models derived from individual subject MRIs improve accuracy of EEG source estimates.^{4,5}
- We evaluated the technical feasibility of using individual-specific head conductivity models for EEG source estimation to explore neural generators linked to altered auditory processing in young adults with DS.

METHODS



- EEG data (128 channel recording with sensor digitization, EGI system) from 8 TD adults and 1 individual with DS were acquired in response to 80ms long /m/ phonemes presented to left ear.
- EEG preprocessing using EEGLAB software to mitigate artifacts and cleaning data.
- High resolution structural MRI scans acquired using 3T scanner (GE MAGNUS).
- Anatomical segmentation using FreeSurfer software.
- Symmetric Boundary Element Method (BEM) for constructing individual-specific forward head models.



- Source estimation using Minimum norm imaging and dynamic statistical parametric mapping (dSPM) in Brainstorm software.

TD Group Results

RESULTS

Individual Examples

SUMMARY

- Consistent with previous literature, the averaged source estimates from TD individuals suggest that the neural generator for the N1 responses is likely located in and around the primary auditory cortex.
- The estimated source time series at the primary auditory cortex ROI closely maps the sensor time series at the vertex electrode Cz, indicating that the Cz activity seen at the scalp is contributed by activity in the primary auditory cortex, and is in accordance with the literature.⁶
- The peak activation ROI did not exactly map onto the Destrieux atlas ROI for the auditory cortex, suggesting limitations in spatial accuracy in EEG source estimation and potential inter-individual differences in structure and functional activation.⁸
- **Construction of subject-specific head models and co-registration needed more manual adjustment for individuals with DS as compared to TD adults, but acceptable outcome was achieved.**
- **Preliminary findings of broader, less focal cortical activation in response to speech stimuli in the participant with DS is suggestive of compensatory neural resource allocation.⁹**

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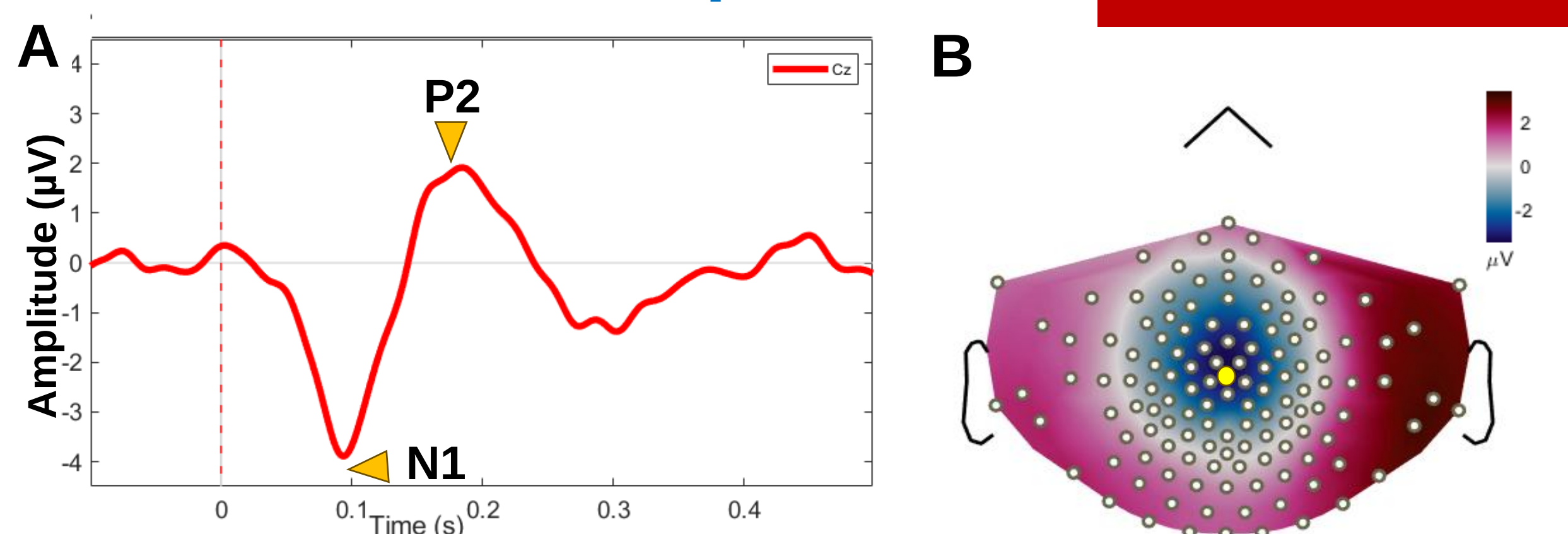


Figure 3: A. Grand average waveform from 8 TD adults showing negative N1 peak at 94 ms and positive P2 peak at 190 ms at Cz. B. Topographic plot showing inhibition at fronto-central sensors at latency of N1 peak. Cz sensor is highlighted in yellow.

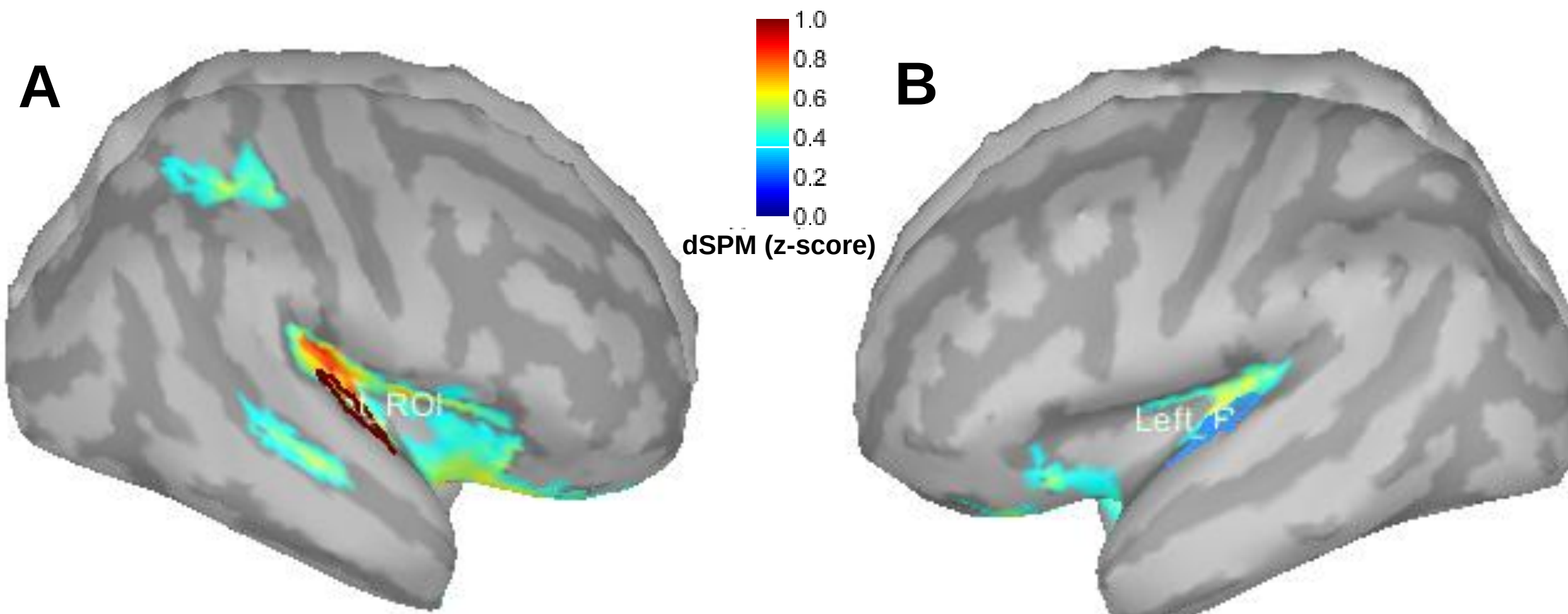


Figure 4: A & B Grand average of estimated source-level activity from 8 typically developing (TD) adults, showing activation at the N1 peak latency in the right and left hemispheres. C. Time series of the estimated source activity in the primary auditory cortex, defined using Destrieux atlas-based ROI.

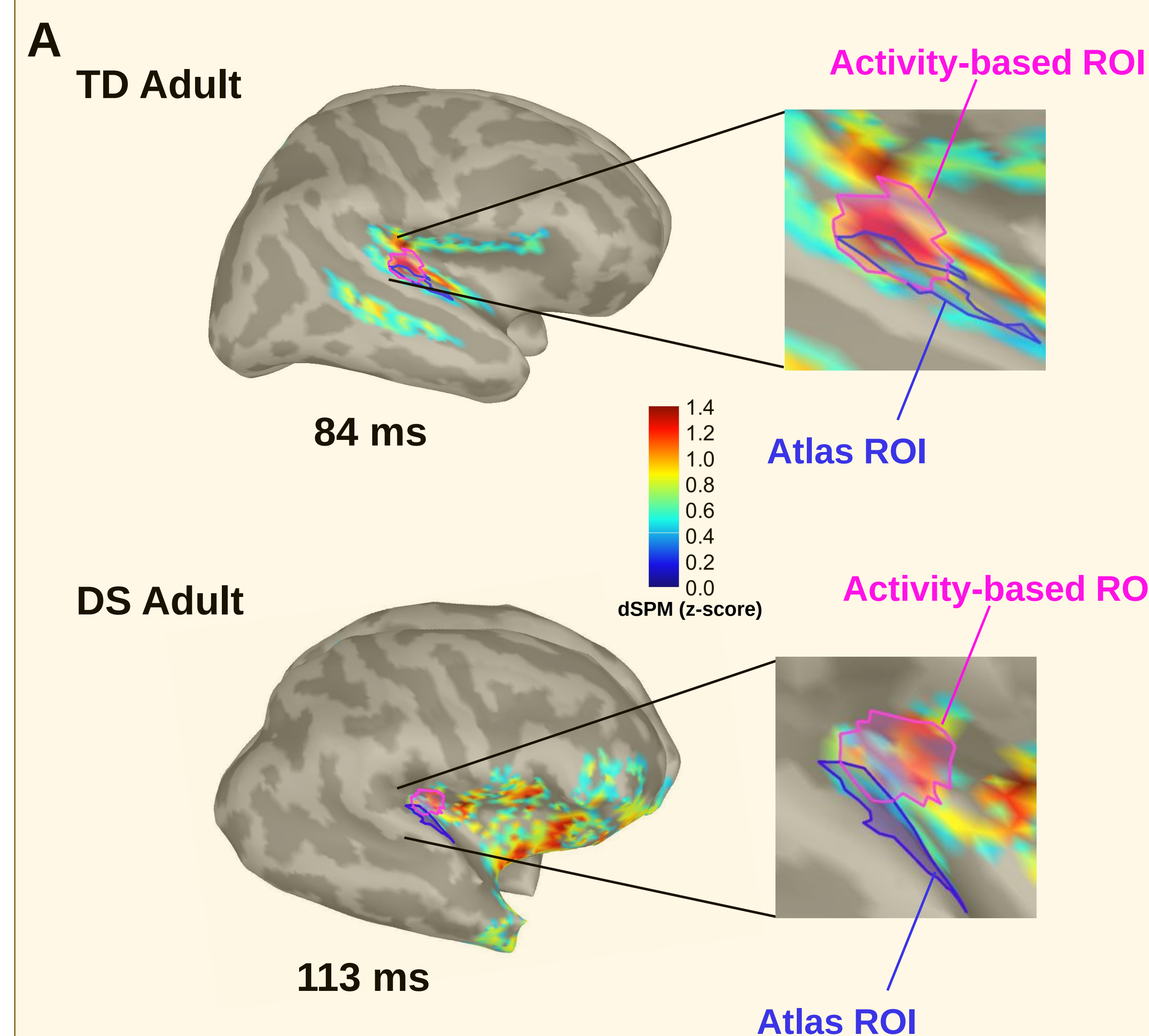


Figure 5: (A) Estimated source-level activity in the right hemisphere at Destrieux atlas-based ROI and an activity-based ROI at the N1 peak latency for one typically developing (TD) adult and one adult with Down syndrome (DS). (B & C) Time series of the estimated source activity at ROIs and activity at the Cz sensor for the TD adult. (D & E) Time series of the estimated source activity at ROIs and the activity at Cz sensor for the adult with DS.