



Electrocorticographic evidence for near-simultaneous early visual response in V1 and posterior parietal cortex in humans

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Introduction

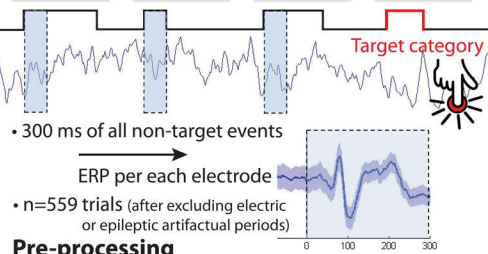
- Measuring the earliest response latencies in distinct cortical areas is important for inferring hierarchical relations. However, such inference is done primarily in monkeys and other mammals [1,6].
- Due to the difficulty in measuring brain activity with both high spatial and temporal resolution in humans, much less is known about the spatio-temporal evolution of visual information processing in the human brain [2].
- We present an estimation of onset latencies of visual responses across the posterior human cortex using electrocorticographical (ECoG) recording in a single patient.
- Our results manifest the temporal progression of responses in the human cortex along the expected visual streams.
- However, we report a very **early and robust visual response in the intra-parietal sulcus (IPS), that happens simultaneously with V1.**

Materials and methods

- A single patient, pre-surgical evaluation period for treatment of intractable epilepsy.
- 112 electrodes (1cm apart), occipital, parietal and temporal cortices of right hemisphere.

Paradigm

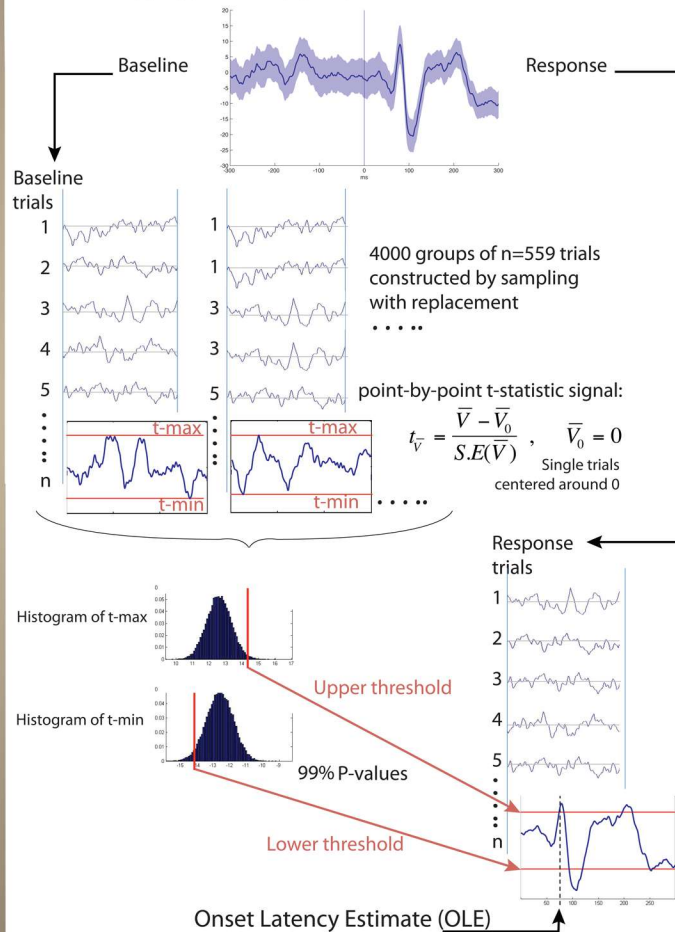
- Stimuli - object images
 - Durations: 300 - 1500 ms, randomly
 - Inter-stimulus interval: 600 - 1500 ms, randomly
 - 4 categories:



- 300 ms of all non-target events
- n=559 trials (after excluding electric or epileptic artifactual periods)
- Pre-processing**
 - Downsampling to 1000 Hz
 - Baseline correction according to 300 ms pre-stimulus
 - Band-pass 0.1-200 Hz • Filter out 60 Hz line-noise
 - Common Average Reference (CAR)

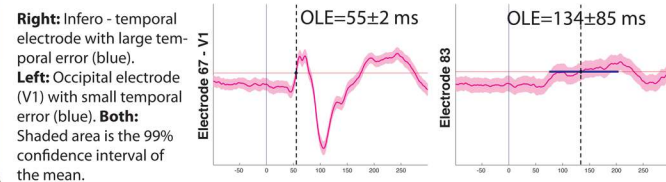
Onset Latencies Estimation

- Calculate threshold from baseline activity - 300 ms pre-stimulus.
- Bootstrapping procedure [3], adapted to onset estimation:



Temporal error estimate for the OLE

- Time that takes for the full 99% confidence interval of the mean signal (calculated point-by-point using the t-statistic) to cross the threshold



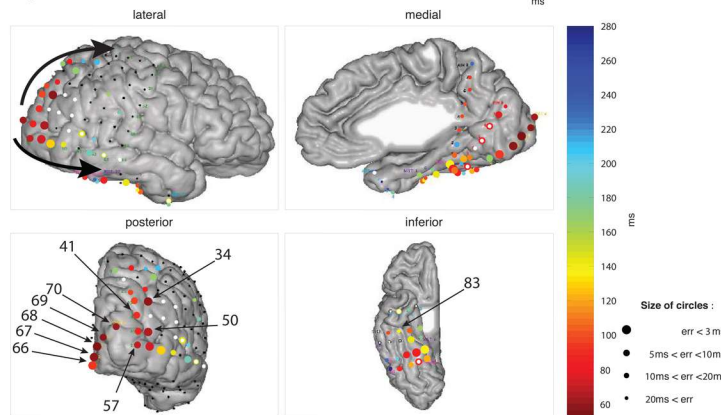
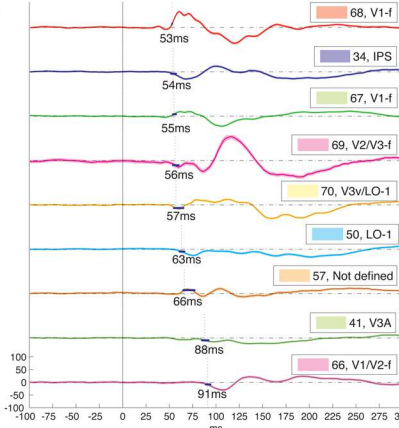
Results

1. Spatio-temporal progression of onset latencies along the visual stream of processing

- Electrode labels according to retinotopical mapping done on the patient previously and independently [4].
- Earliest responses in occipital electrodes
- Progression along ventral and dorsal streams.

Right: ERP waveforms of earliest responding electrodes, ordered by onset latencies. Blue - temporal error estimate.

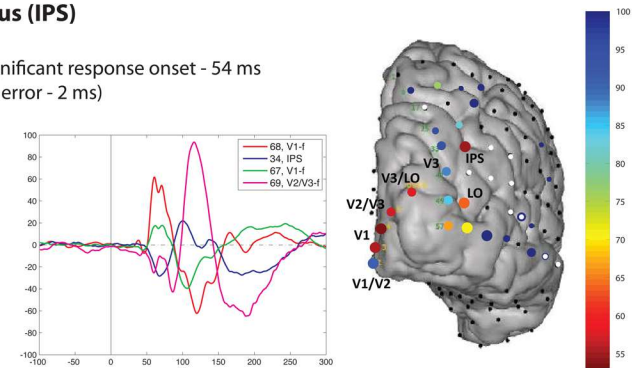
Bottom: Color of circles - onset latencies. Larger circles - smaller temporal error. White dots - electrode excluded from analysis due to artifacts. Black dots - no significant onset detected.



2. Very early response the ventral bank of posterior intra-parietal sulcus (IPS)

- Robust and significant response onset - 54 ms (small temporal error - 2 ms)

- V1 - 53-55 ms (small temporal errors - 1 ms)



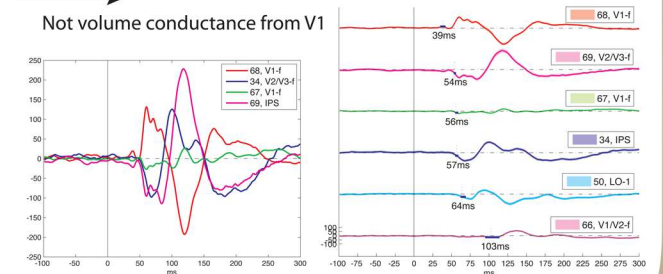
Current Source Density Estimation

- Simultaneous onset of early responding electrodes (V1 and IPS) raise the possibility of **volume conduction**.
- Current Source Density (CSD) computes **localized responses**.
- Can be estimated by a local reference [5, 6]:

$$CSD_{i,j} \approx V_{i,j} - \frac{V_{i+1,j} + V_{i-1,j} + V_{i,j+1} + V_{i,j-1}}{4}$$

$$CSD_i \approx V_i - \frac{V_{i+1} + V_{i-1}}{2}$$

- Early response in the IPS detected with CSD estimation - 57 ms.



Conclusions

- Direct evidence for the upper bound of visual onset latencies in localized areas across occipital, parietal and temporal human cortices.
- Early and robust visual response in IPS - 54 ms, not reported before in humans. In the monkey, early visual response onset in intraparietal areas reported - 33 ms [6] (consistent with conduction delay differences).
- Early response in the IPS supports the notion of fast processing in the dorsal stream, possibly preparing the ventral stream for processing at a given location [6]. It is also in line with recent evidence for visual information bypassing V1 [7]. The latter may explain preserved visual abilities after loss of V1, as in the neuropathological condition called 'blindsight'.

References

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