A Library of Human Electrocorticographic Data and Analyses

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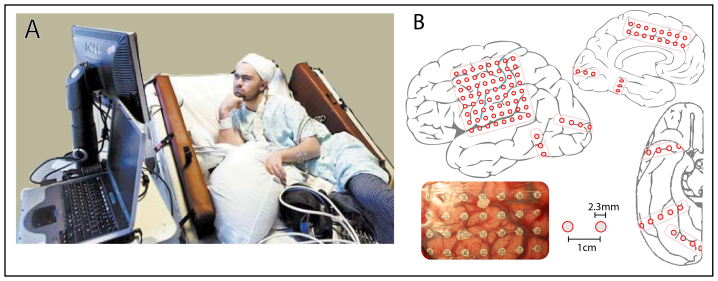
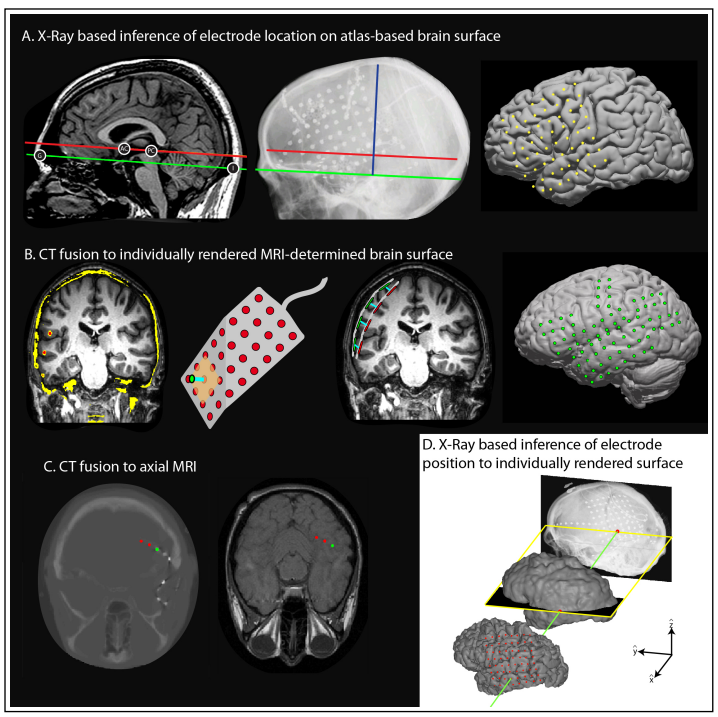
https://purl.stanford.edu/zk881ps0522



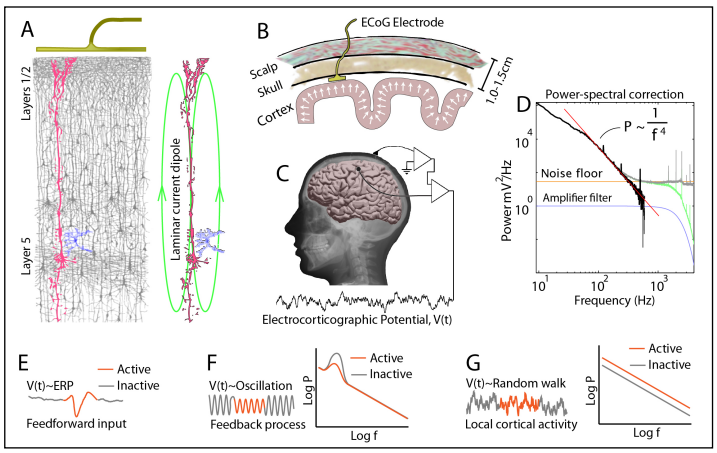
Introduction: Electrophysiological data from implanted electrodes in humans are rare. Most recordings that have been performed are with epilepsy patients who have electrocorticographic (ECoG) electrodes implanted in the course of diagnostic localization of seizure focus prior to surgical resection. Only a small group of physician scientists have had the opportunity to work with these patients, and access to ECoG data has remained somewhat exclusive. It is recorded at only a few institutions around the country, often with different amplification setups, sampling rates, and behavioral variations.

Methods: Therefore, we have compiled a set of 16 benchmark experiments, with over 200 individual datasets made with the same amplifiers, at the same settings, with the same person interacting with the subject and performing the experiment. Depending on where the electrodes were placed for clinical indication, we performed experiments known to be associated with covered brain areas.



Results: All data, anatomic, and analysis files (MATLAB code) are in a common, intuitive file structure. Every study/task has at least 4 subjects with confirmed task-modulated signal change in at least 1 electrode. Our sampling rate and data format were kept uniform, and the anatomic localization was determined rigorously in each case. In the course of analyzing these data, a large number of novel analysis techniques were developed. We have made a publically available code base with the data, in such a way that all figures from published manuscripts describing these data could be directly reproduced. Four of the experiments have not been published.

Conclusions: These data, along with behavioral parameterizations, anatomic localizations, and brain-surface renderings are now available for download worldwide, without restriction on use (other than proper citation), at purl.stanford.edu/zk881ps0522.



The ECoG signal. (A) The ~5 square mm of cortical surface beneath each ECoG electrode contains about half a million neurons, each of which receives contributes a current dipole reflecting charge movement across the cellular membrane. **(B)** ECoG electrodes are surgically placed subdurally on the cortical surface. **(C)** ECoG potentials are initially referenced against an external scalp or mastoid reference. **(D)** After re-referencing, the ECoG potential power spectral density (PSD) can be quantified (green), and then corrected for both the built in amplifier filter (blue, intermediate PSD in gray) and intrinsic noise floor (orange, final PSD in black). This final PSD is shown to have a power-law shape, tending to P~1/f4 at high frequencies (fit in red, from folder 'base_HighFreq'). **(E)** Synchronized neuronal activity in response to a timed stimulus can be observed in the event-averaged raw potential (ERP), and is presumed to be due to feedforward input from a different cortical region. **(F)** Synchronized neural activity in response to feedback loops can be observed in narrowband oscillations, which are peaked in the power spectral density. **(G)** Aggregate neural activity from a region is revealed by behaviorally-associated changes in 1/f shape of the PSD.

Folder Name	Description	Anatomy	N	Reference
base_pwrlaw	The **basic baseline fixation task** was performed by the patients staring with their eyes open on an "X", on the wall 3 m away, for 2 to 3 minutes.	Fronto-parietal-temporal grids	16	(Miller et al., 2009b)
mot_t_h	Subjects performed simple, repetitive, **movements of the hand** (synchronous flexion and extension of all fingers) **or tongue** (opening of mouth with protrusion and retraction of the tongue, i.e., sticking the tongue in and out), at ~1-2 Hz.	Fronto-parietal grids	19	(Miller et al., 2007b)
dg	Subjects were cued with a word displayed on a bedside monitor to repetitively **move individual fingers** (contralateral to electrode array placement) during 2s cue periods while finger position was recorded with a dataglove.	Fronto-parietal grids	9	(Miller et al., 2009c; Miller et al., 2012)
JoystickTracking	The patient used a **joystick to track** a counter-clockwise moving target (hand used was contralateral to implanted electrode array).	Fronto-parietal grids	4	(Schalk et al., 2008)
gestures	A series of hand motor tasks were performed where patients performed cued **simple gure movements, cued gestures, or self-generated gestures**, while finger position was recorded with a dataglove (hand used was contralateral to grid).	Fronto-parietal grids	5	Data unpublished
Imagery_t_h	Patients first performed an overt hand and tongue cued movement task. They subsequently performed a task **imagining making identical movements**.	Fronto-parietal grids	8	(Miller et al., 2010a)
Mot_Im_FB	Patients first performed a cue-based movement task, then a **cue-based imagery** task, then **one-dimensional cursor control feedback** task based upon the imagery.	Fronto-parietal grids	4	(Miller et al., 2010a)
rtlang	Patients participated in a **simple verb-generation task**, where nouns were presented on a screen, and the patient would either read the noun or speak a verb that was connected to the noun: for example, if the cue read "ball", the patient might say "kick".	Fronto-parietal-temporal grids	7	(Miller et al., 2011)
nback	After a period of baseline fixation, patients performed an n-back **working memory task** using sequences of house pictures. First they identified when a 'target' house picture appeared (0 back). Second, they identified when a picture had been shown twice in a row (1 back). Finally, they identified when a picture had been repeated with a distracting image in between (2-back).	Right lateral frontal grids	4	Data unpublished
vissearch	In the **visual search task**, pictures were shown of arrays of colored squares. The patient would visually navigate between the squares depending on a cue, and report the color of a targeted square.	Occipital strips, medial & lateral	5	(Miller et al., 2010e)
fhpred	**Simple face/house pictures** were shown in random order for 400 ms each, with 400ms inter-stimulus blank screen.	Subtemporal strips	11	(Miller et al., 2016)
fhnoisy	After performing a simple face and house picture viewing task, patients then performed a face-detection task using **phase-scrambled close-up pictures of faces and houses**.	Subtemporal strips	7	(Miller et al., 2017)
base_PAC	The basic **baseline fixation** task was examined for rhythmic entrainment.	Fronto-parietal-temporal grids	10	(Miller et al., 2012)
base_HighFreq	The basic **baseline fixation** task was performed by the subjects fixating with their eyes open on an "X", on the wall 3 m away, for 2 minutes, while recording at **10kHz**.	Fronto-parietal-temporal grids	4	(Miller et al., 2009b)
MouseTracking	Patients used a **mouse** on a mousepad to track a **counter-clockwise moving target** (hand contralateral to grid).	Fronto-parietal grids	4	Data unpublished
NounVerb_lists	These files form a set **of speech data for lists of nouns** that were first read directly, and then used to produce **associated action verbs**. There were 2 noun lists, and each list was presented 3 times for noun reading, then 3 times for verb production.	Fronto-parietal-temporal grids	4	Data unpublished

List of experiments, with corresponding library folder name for download at library site https://purl.stanford.edu/zk881ps0522. References in rightmost column correspond to the reference in which the relevant experimental data were originally described.