High channel count electrode system to investigate thalamocortical interactions

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Figure 1: Recording tools and setup

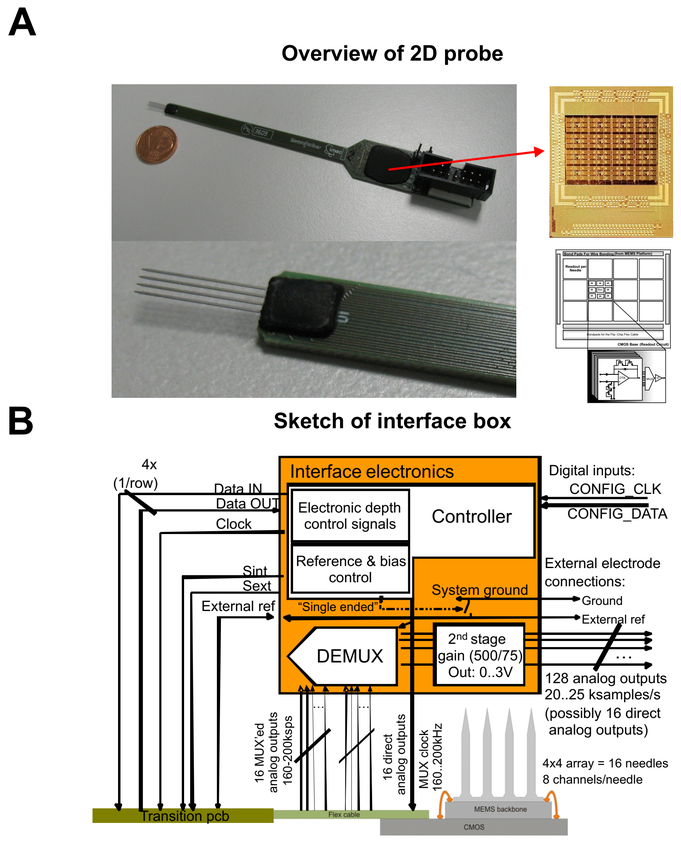
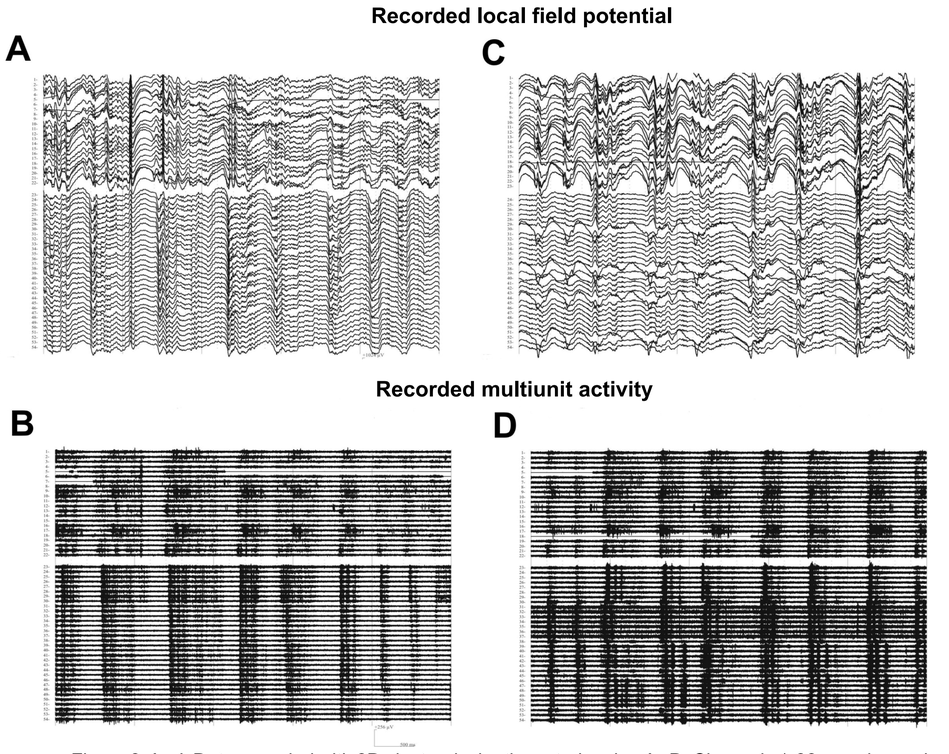


Figure 1: A: Overview of the 2D electrode with analog front-end. Analog front-end structure enlarged on the right. B: Sketch of the interface box containing probe control, providing second stage amplification and analog signal filtering and demultiplexing. C:Optical micrograph of the tip section of a shank, showing its CMOS structure D: Assembled1D probe on PCB and close-up of probe bonded to PCB encapsulated by glob top. E: 1D probe functionality: Electrodes are selected via a shift register; selection is transferred from a host computer via a controller to the microprobe. F: Screenshot of the electrode selection page of the control software.

Figure 2: Experimental results



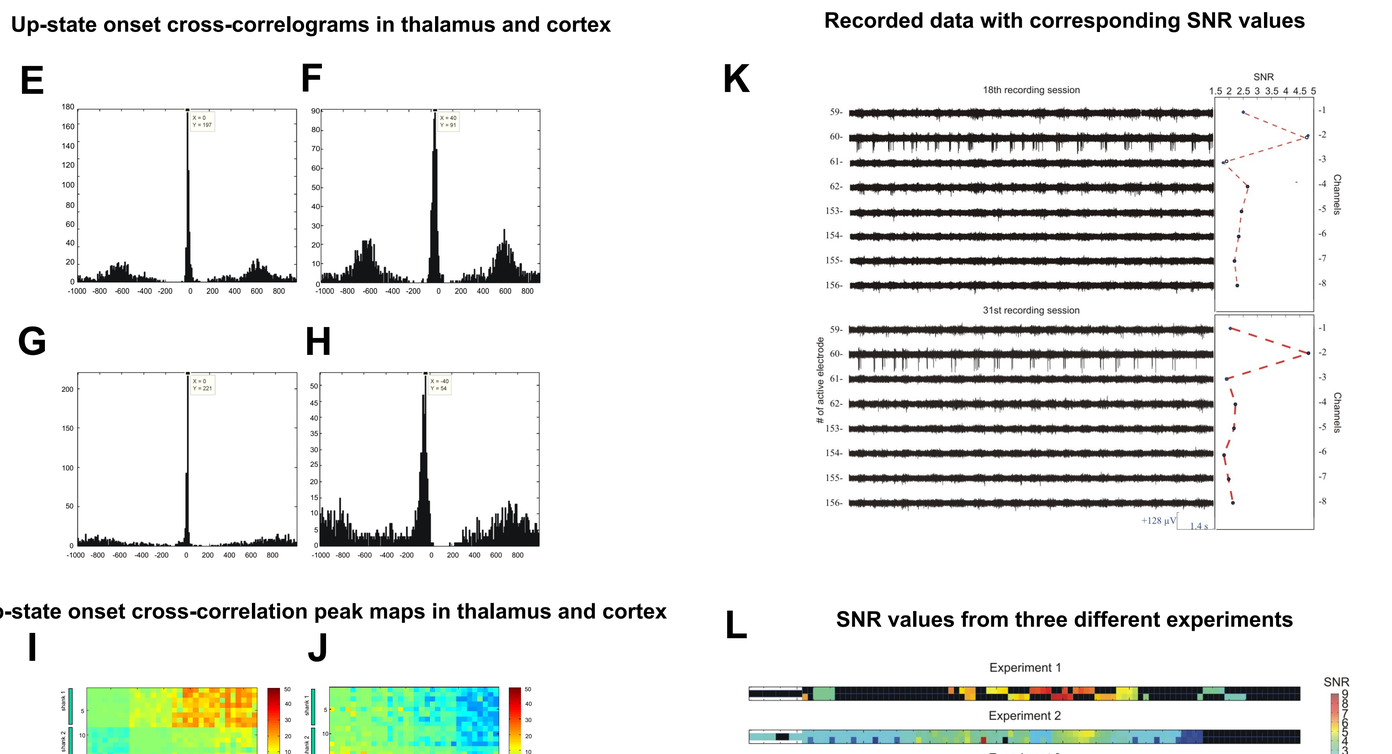


Figure 2: A - J: Data recorded with 2D electronic depth control probe. A - D: Channels 1-22: passive probe (PP), channels 23-54: 2D electronic depth control probe (EDC). A: Local field potential activity recorded from the motor (PP) and the sensory (EDC) cortex. B: Multiunit activity (MUA) recorded from the motor (PP) and the sensory (EDC) cortex. C: Local field potential recorded from the motor cortex (PP) and the thalamus (EDC). D: MUA recorded from the motor cortex (PP) and the thalamus (EDC). E: Cross correlogram of up-state onsets from the same shank and different channels located in the cortex. F: Cross correlogram of up-state onsets from two different shanks both located in the cortex. G: Cross correlogram of up-state onsets from the same shank and different channels located in the thalamus. H: Cross correlogram of up-state onsets from two different shanks. One shank was located in the cortex and the other one in the thalamus. Note the thalamic onsets leading by 40 ms. I: Cross correlation peak map of up-state onsets in the cortex. J: Cross correlation peak map of up-state onsets in the thalamus. K - Q: Data recorded with 1D electronic depth control probe. K - L: SNR analyses. K: Two different recording sessions with the same electrode configuration and corresponding SNR values (right side). Note: approximately 1 hour elapsed between the two sessions. L: SNR values of 3 different experiments. 0 µm in depth represents the tip of the microprobe. M - P: Spike sorting. M: Original sample of recorded MUA activity. N: Two different spike activities (grey and blue) on a three dimensional view of clusters, sorted from (M). O: Results of sorted clusters (grey and blue) with different shapes. P: Corresponding autocorrelograms (upper: blue cluster, lower: grey cluster). No firing found within the 2 ms refractory period.

A novel silicon-based microelectrode array with one and two-dimensional variants was developed in the framework of the EU-funded research project NeuroProbes. The electrode array comprises CMOS-based (complementary-metal-oxide-semiconductor) integrated circuitry to implement the concept of electronic depth control which is used to select up to 32 recording sites from more than 1000 possible electrode channels integrated on four slender probe shafts. The electrode array was tested in acute experiments performed simultaneously in cortex and thalamus of the rat's brain. In both brain regions good quality local field potential and multiunit activity was recorded during the tests.

Figure 3: Experimental approach

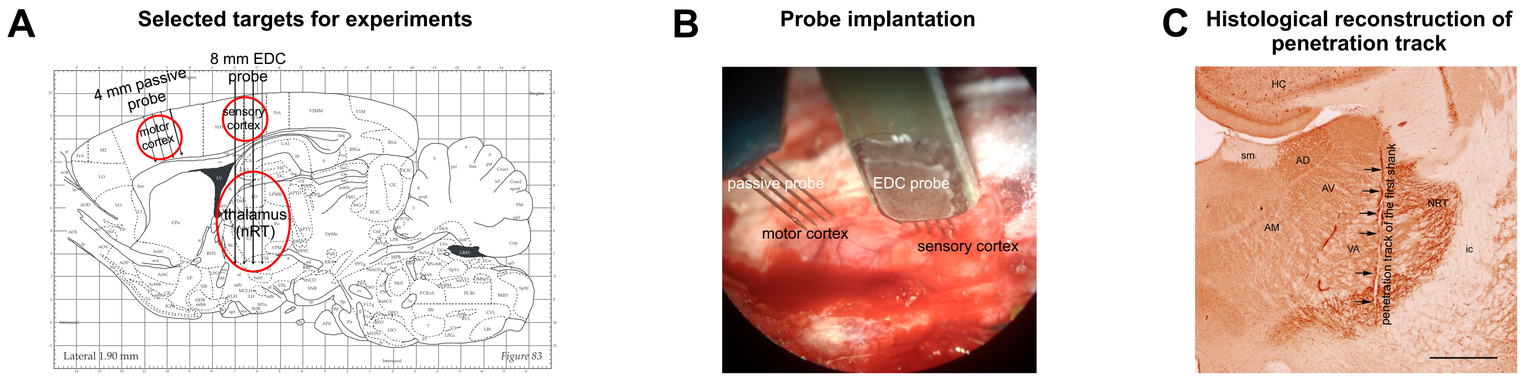


Figure 5: A: Selected targets for experiments on rat brain atlas section. A 4mm passive probe was also implanted for comparison. The 8mm electronic depth control (EDC) probe was implanted into the primary somatosensory cortex and the underlying different thalamic nuclei. The passive probe was implanted into the primary motor cortex. B: Implantation of the probes. C: Histological reconstruction of the probe penetration track.

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