

Distributions of Cortical Activities in Cat Area 17/18 in Response to Visual and Electrical Retinal Point Stimuli: Investigations for a Retina-Implant

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Introduction

Blind persons with receptor degeneration and intact retinal ganglion cells can perceive phosphenes with electrical intraocular stimulation (Humayun et al. 1999).

Goal

Estimate the spatial resolution achievable with electrical stimulation at the retinal surface.

Methods

① We made cortical recordings by a linear array of 16 μ -electrodes from anesthetized cats (electrode pitch: 0.305 mm), while stimulating retinotopically corresponding and non-corresponding locations with short charge-balanced impulses ② directly at the inner limiting membrane (7 retinal electrodes, hexagonal arrangement). For comparison, the distribution of cortical activation was measured with dynamic multifocal visual point stimuli ③. The reverse analysis, determination of electrical ④ and visual ⑤ receptive fields of local cortical populations (MUA- and LFP-signals), was also performed. Recordings from stimulation electrodes helped to monitor their tip location relative to the retinal surface and to the cortical RFs.

Results

The cortical activity distributions of visual and electrical point stimuli are at about the same scale, with the electrically evoked distributions ③ being on average slightly larger than their respective visual equivalents ⑤. More confined distributions and hence, higher resolutions, can be obtained if cortical single unit activity is used. Electrical stimulation activates specific cortical neuron populations ③. Electrical receptive fields are retinotopically arranged ④.

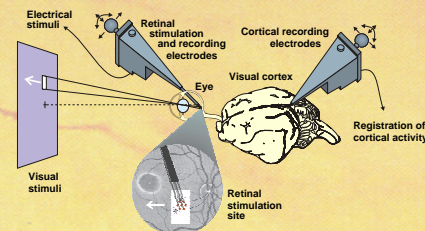
Conclusions

The cortical activity distributions, evoked by focal electrical stimuli in the retina, provide a coarse estimate for an upper bound of the possible perceptual resolution achievable with retina implants. However, the cats had an intact visual system that might be considerably different from that of a blind with retinitis pigmentosa.

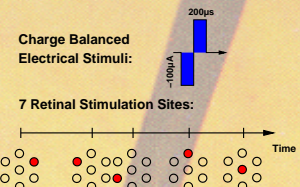
Humayun MS, deJuan E, Weiland JD, Dagnelie G, Katona S, Greenberg RJ, Suzuki S (1999) Pattern electrical stimulation of the human retina. *Vis Res* 15:2569-76

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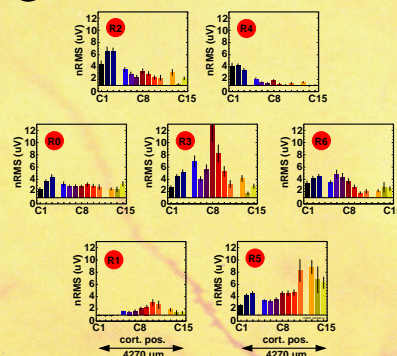
1 Setup for Epiretinal Visual and Electrical Stimulation and Intracortical Recording in Cat Visual Cortex



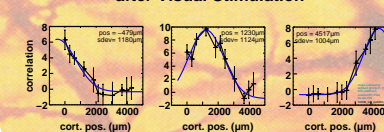
2 Assessing Electrical Receptive Fields



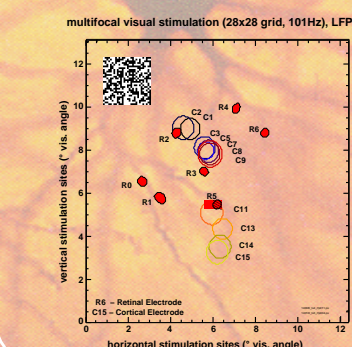
3 Distributions of Cortical Activity after Electrical Stimulation



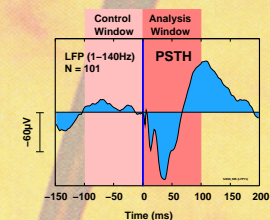
5 Distributions of Cortical Activity after Visual Stimulation



6 Visual Receptive Fields of Retinal and Cortical Neuron Populations



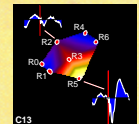
4



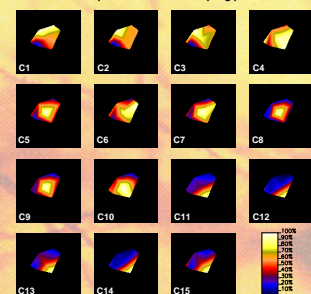
$$RMS = \sqrt{\frac{\sum_{i=1}^N (y_i - \bar{y})^2}{N-1}}$$

$$nRMS = \frac{RMS(Analysis\ Window)}{RMS(Control\ Window)}$$

Color code retinal sampling points with normalized RMS of LFP PSTHs for each recording channel



Linear interpolation of retinal sampling points



Electrical Receptive Fields of Cortical Neuron Populations

