Cortical Activity Distributions in Cat Area 17/18 Elicited by Short Visual and Electrical Retinal Point Stimuli: Investigations for a Retina–Implant

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Goal

Blind persons with photoreceptor degeneration and intact retinal ganglion cells can perceive phosphenes elicited by intraocular electrical stimulation [1]. However, the development of a retina implant for restoring simple basic vision requires an estimation of the spatio-temporal resolution feasible with electrical retina stimulation. Here we focus on the estimation of the spatial resolution with epi-retinal stimulation.

Methods

① We recorded cortical activities from anaesthetized cats with linear arrays of 7 or 16 μ-electrodes (electrode pitch: 0.5/0.35 mm), while stimulating with trains of biphasic charge-balanced impulses (200 μs/phase) ② directly at the inner limiting membrane. Stimulation by the hexagonally arranged 7 retinal electrodes was at retinotopically corresponding and non-corresponding locations with respect to cortical recording sites. Additional recordings from the retinal stimulation electrodes enabled monitoring of their tip locations at the retinal surface, and by measuring the retinal RFs, their relative positions to the cortical RFs. The spatial distributions of cortical group activities (multiple unit activity MUA and local field potentials LFP, 1-140 Hz) were measured for dynamic multi-focal electrical ③ and visual point stimuli ⑤. Cross correlations between stimulus and response revealed the visual and electrical receptive fields (vRF ⑥, eRF ④), respectively.

Results

The cortical activity distributions of visual and electrical point stimuli are at about the same scale ③ & 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 distributions, activated by short focal electrical stimuli in the retina, provide a coarse estimate for an upper bound of the possible perceptual resolution achievable with retina implants. More confined distributions and hence higher resolutions, may be obtained if cortical single unit activity is used. Since the cortical activity distributions obtained for electrical point stimulation in the retina obey the retinotopic mapping to the cortex, stimulation with a retina-implant for restoring basic vision should be feasible. However, the cats used in our experiments had an intact visual system that might be considerably different to that of a blind with retinitis pigmentosa or macula degeneration.

Humayun MS, et al. (1999) Vis Res 15: 2569-76. *Pattern electrical stimulation of the human retina.*

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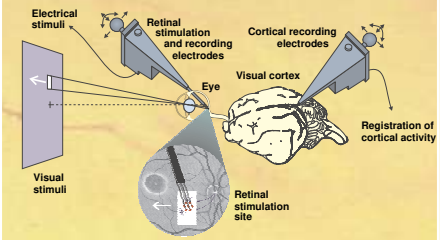
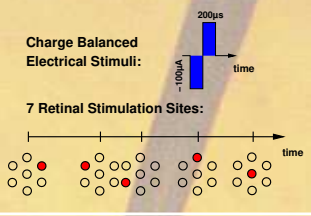
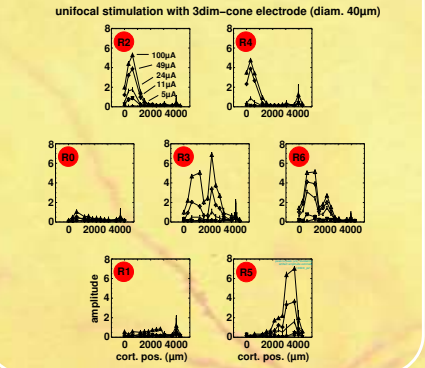
① Setup for Epiretinal Visual and Electrical Stimulation and Intracortical Recording in Cat Visual Cortex



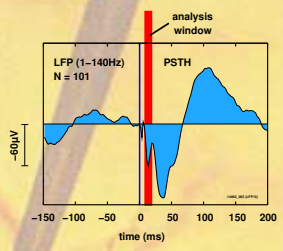
② Assessing Electrical Receptive Fields



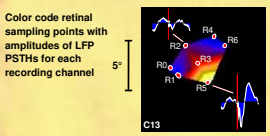
③ Distributions of Cortical Activity (LFP) Electrical Stimulation

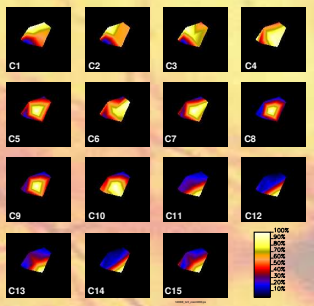


④

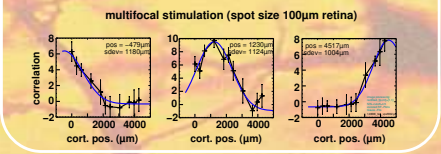


Linear Interpolation of Retinal Sampling Points

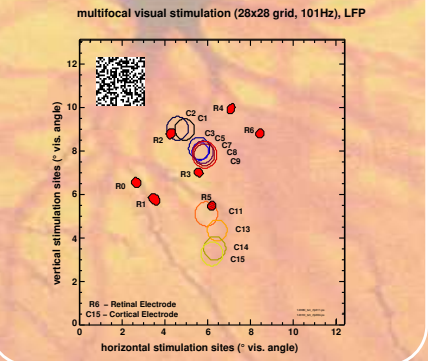
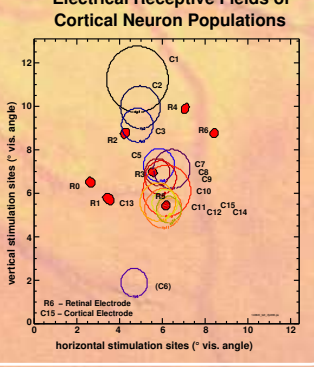




⑤ Distributions of Cortical Activity (LFP) Visual Stimulation



⑥ Visual Receptive Fields of Retinal and Cortical Neuron Populations



Electrical Receptive Fields of Cortical Neuron Populations