Receptive fields of epiretinally recorded signals in cats: Spatial and temporal aspects

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Goal: In the context of the development of a visual prosthesis, we ask whether epiretinal electrical stimulation can ensure a retinotopic mapping of visual information to a cortical representation that is meaningful to a blind patient. We do that by analyzing retinal visual receptive fields (RFs) of different epiretinally recorded signals assuming that about the same group of retinal neurons can be stimulated by as well as recorded from by an epiretinal microelectrode. **Methods:** Retinal broadband signals from multisite epiretinal microelectrode recordings in anesthetized cats are separated into local electroretinograms (LERG, 1-140 Hz) and single unit spike trains. We characterize the RFs of these signals using multifocal visual stimulation combined with stimulus-response cross-correlation. **Results:** We analyzed RFs of 44 recording positions in four cats. Retinal LERG exhibit spatially unimodal RFs that are always centered at the actual location of the retinal recording electrode (N=34). Retinal spikes from the same electrode have distinct RF center locations that are aligned along the fiber bundles at the recording location. We found an average of 1.8 spike-RFs per retinal recording position. Spike-RF positions are either congruent with LERG-RFs (*local RFs*, N=26/61) or shifted distally (*distal RFs*, N=35/61) but never proximally with respect to the optic disk. This indicates that displaced spike-RFs result from the recording of spikes that originate from more distal locations of the fibers passing the recording electrode *en route* to the optic disk. Comparisons of congruent *local* LERG-RFs and spike-RFs calculated from simultaneously recorded signals from the same electrode show that LERG-RFs temporally precede *local* spike-RFs by 5.38 ms ± 3.64 ms. Furthermore, the measured OFF-center spike latencies (time to 70% of peak amplitude) are shorter than ON-center spike latencies. We found congruent ON-center and OFF-center spike RFs in four recordings with OFF being 2.40 ms ± 0.83 ms faster than ON. **Discussion:** Our results indicate that epiretinal electrical stimuli might evoke phosphenes that are not confined to the electrode location but dispersed distally from the electrode position with respect to the optic disk and can therefore yield multiple visual percepts. Epiretinal implants should use precisely controlled stimulation strengths and the geometry of the stimulation fields such that erroneous phosphenes are kept subthreshold. E.g., small conical electrodes can bypass the fiber layer with their tips in the ganglion or bipolar cell layer. (Support by BMFT grant 01 IN 501 F and KP 0006 to R.E. greatly acknowledged.)

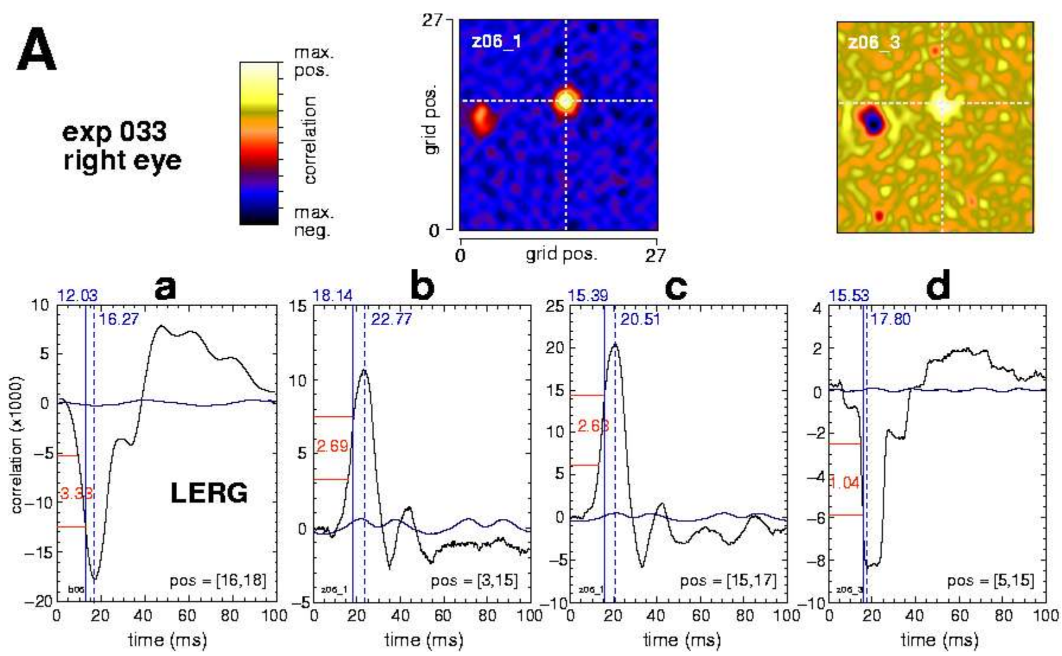

Figure: Two RF maps that were calculated from spike trains derived from the same broadband recording in a right cat eye. Note the ON- and OFF-center RFs that are shifted distally from the projected electrode position (crosshair). **a-d:** Time courses of the retinal responses to stimulation with the optimal stimulus (i.e., in the center of the particular RF): LERG (**a**), left RF of first spike train (**b**), right RF of first spike train (**c**), left RF of second spike train (**d**). Response rise times from 30%-70% of the peak amplitude (red), latency (blue), and peak time (dashed blue) are indicated. The baseline (dark blue) is calculated from the average correlation strength between the retinal signal and all pixel luminance time courses.