CONTRASTING VOLTAGE-SENSITIVE DYES IMAGING WITH DEPTH-RESOLVED NEURONAL ACTIVITY IN RAT SOMATOSENSORY CORTEX

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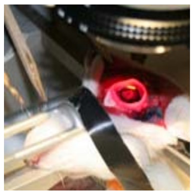
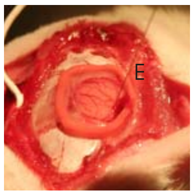
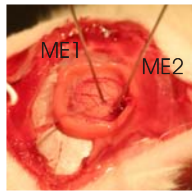
VSD setup



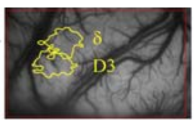
Localizer



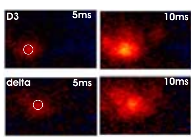
Double ME setup



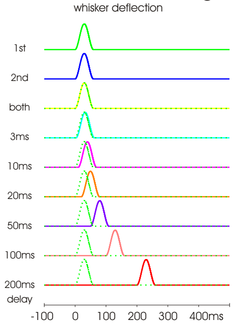
ROI image



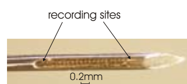
VSD image



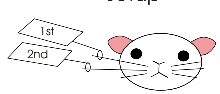
Stimulation paradigm



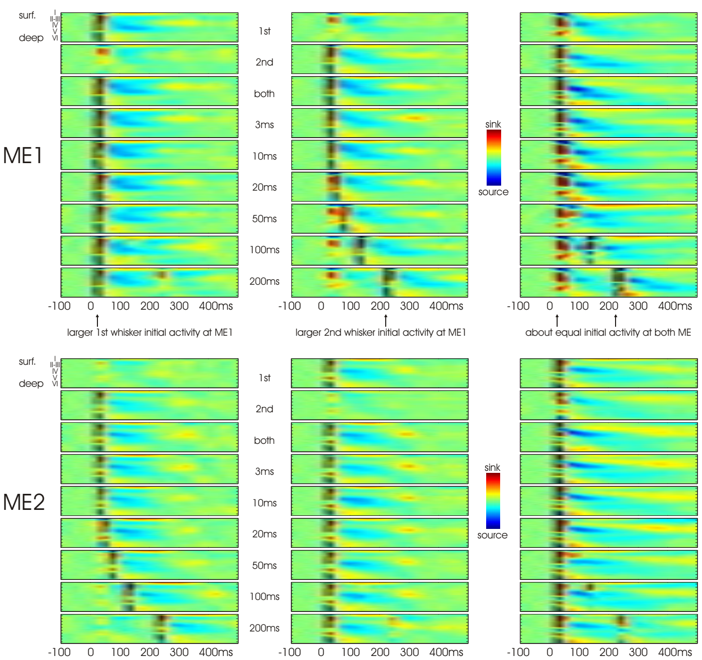
Multielectrode (ME)



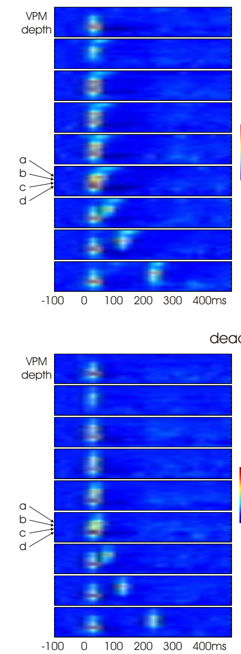
Whisker stimulation setup



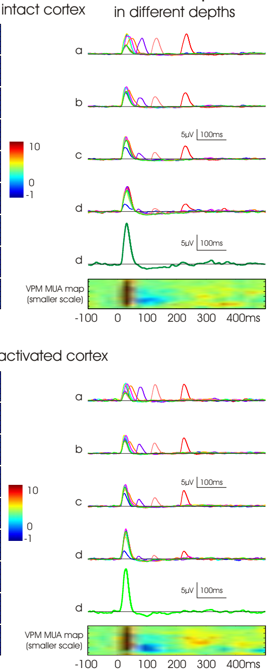
Double ME cortical CSD maps



VPM MUA maps



VPM MUA plots in different depths



INTRODUCTION

To elucidate the correspondence of the spatiotemporal profile of voltage sensitive dye (VSD) signals to the underlying cortical neuronal activity, we performed linear (depth) array multielectrode (ME) recordings and VSD imaging in rat barrel cortex during alpha-chloralose anesthesia. In addition, thalamic recordings were performed from the VPM to relate thalamic relay and cortical activity during cross whisker integration.

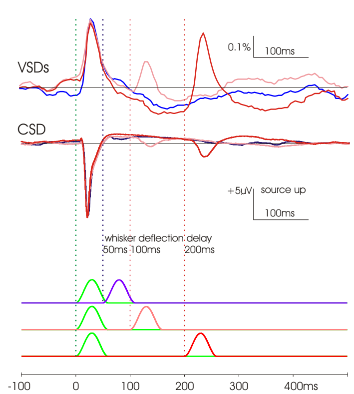
METHODS

Randomized event-related stimulus paradigm was used to deflect two different whiskers with varying interval between them (0, 3, 5, 10, 50, 100, 200ms). Two multielectrode arrays were inserted into the barrel cortex 2-3 barrel columns apart. Current source density (CSD), multiple unit activity (MUA) profiles and event related spectral perturbation (ERSP) were computed from each multielectrode data. Thalamic MUA recordings were also made under two conditions, first the cortex was intact, second the cortex was deactivated by KCl crystals placed on the pial surface. Standard VSD imaging methods were used.

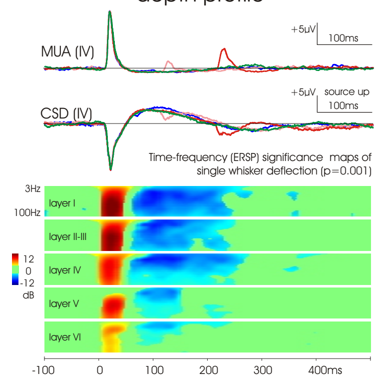
RESULTS

Deflecting only the principle whisker, VSD signal showed the typical depolarization, hyperpolarization, depolarization sequence. CSD and MUA in layer 3/4 was comparable to the local VSD signal. The initial sink was followed by a late source (40-200ms) and a weak rebound sink, MUA faithfully mirrored this sequence. Deflecting only the other whisker, CSD and MUA was smaller and later with a bias towards layer 3.

VSD signal vs. layer IV CSD



CSD wavelet power depth profile



Deflecting first the principal, than the other whisker caused suppression of the other whisker's response, which recovered after 200ms. ERSP data showed large wavelet power decrease in all cortical depths during the late (40-200ms) part of the response. In contrast, only a much smaller suppression was observed for the principle whisker when the other whisker was deflected first.

In the case of the thalamic MUA recordings, single whisker deflection caused an initial MUA burst, followed by decreased firing, regardless if the cortex was intact or deactivated with KCl. Similar late effects were observed in the thalamus in both conditions (intact vs. deactivated cortex) during the two whisker stimulation.

CONCLUSIONS

Our results show that cross whisker integration involves both thalamic and cortical circuits. The initial part of the VSD signal (10-40ms) reflects synaptically driven middle layer excitation, while the later part (40-200ms) is consistent with outward (probably K) currents in the middle layers. During this period, both the cortex and thalamus are relatively silent, suggesting disfacilitatory (synaptic arrest) rather than active inhibitory processes in the cortex. The nature of the late integration is mostly suppressive at the cortical as well as at the thalamic level, even in the absence of the cortex.

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