

Activation of human cerebellum by median nerve stimulation

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Introduction (1)

- PET and fMRI studies have shown that voluntary movements of the hand activates the intermediate zone of ipsilateral anterior lobe of human cerebellum (Grafton et al., 1993; Ellerman et al., 1994; Nitschke et al., 1996; Sakai et al., 1998; Grodd et al., 2001).
- We studied spatio-temporal response characteristics of the human cerebellum to median nerve stimulation.

Introduction (2)

- Tesche and Karhu (1997, 2000) detected a short-latency transient response (13-19 ms) and sustained oscillatory activity from the human cerebellum to median nerve stimulation, by constraining a priori ECD sources in the cerebellum.
- Except for the reports above, no EEG or MEG observations of human cerebellar activity to somatosensory stimulation appear in the literature.

Two main reasons for the difficulty in the noninvasive physiological detection of the cerebellar activity

1. The macro- and micro-structure of the cerebellar cortex are clearly less than optimal for generating an 'open' electric field.
2. The cerebellum is located fairly deep within the cranium.

Measurements

Stimulus

Electric stimuli (0.2 ms, 4 Hz, 3×threshold)
to the right median nerve in 14 subjects
(age:20-34; male:12,female:2)
the left and right median nerve in 3 subjects

MEG recordings

160-channel whole head system (MEGVISION, Yokogawa)
sampling frequency: 10kHz
on-line filter with a bandwidth of 3-2000Hz
10,000 trials averaged

Spatio-temporal source reconstruction

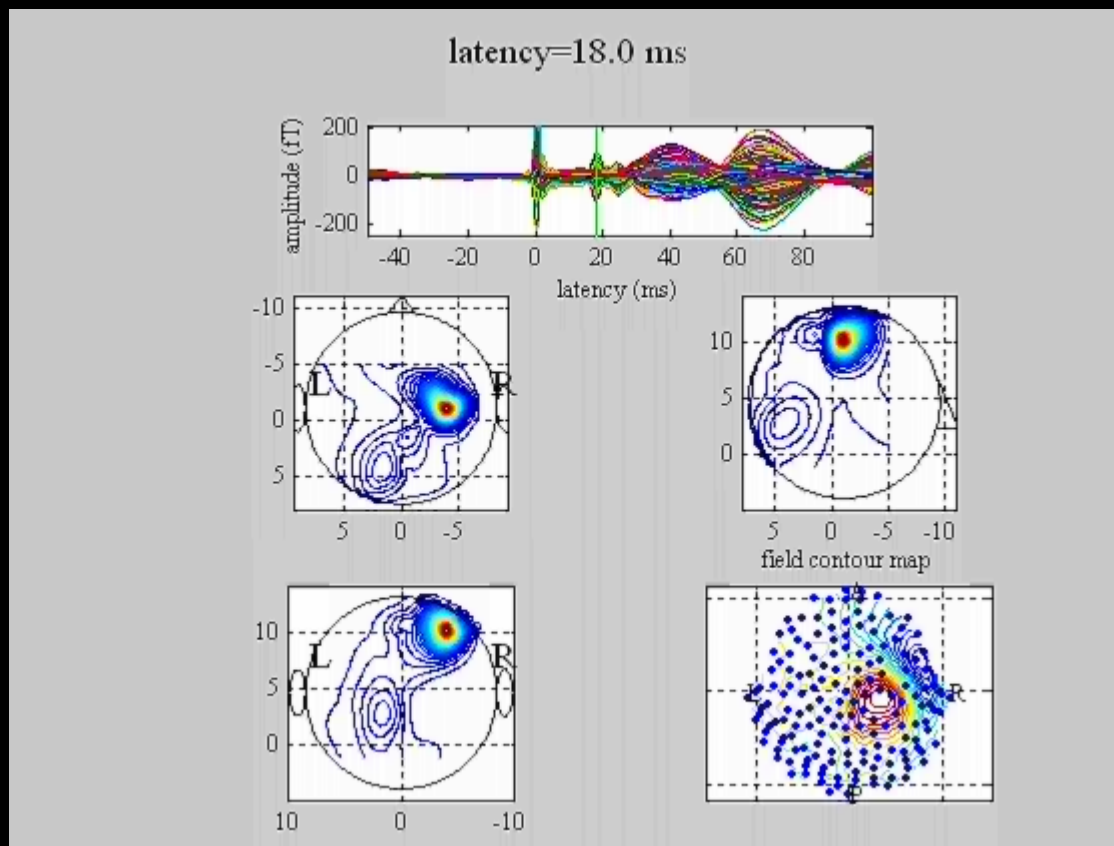
- Adaptive vector beamformer technique
 - 5 mm spatial and 0.1 ms time sampling
 - No channel selection
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Sekihara K, *et al.*, *IEEE Trans Biomed. Eng.*, 48, 760-771, 2001.

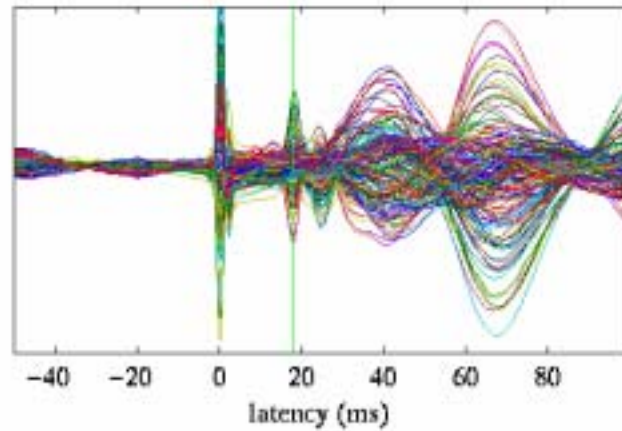
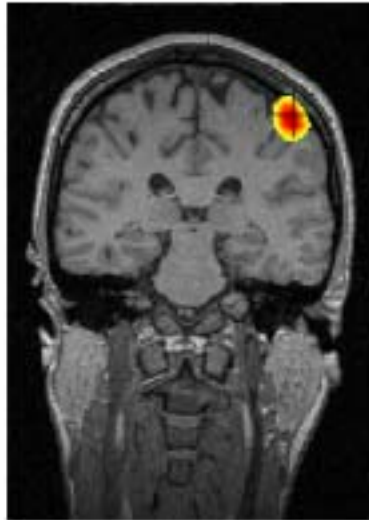
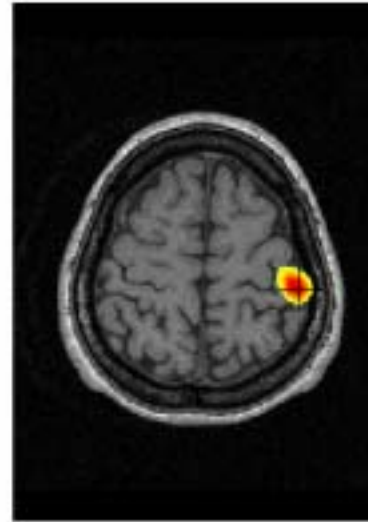
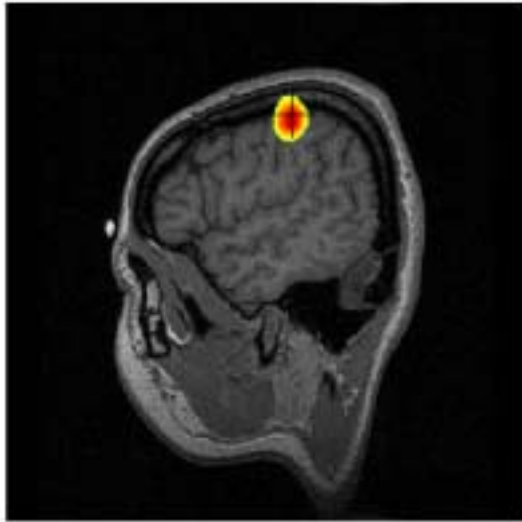
Summary

- The cerebellar activation was observed in 10 out of 14 subjects.
- We were able to extract the time course of the cerebellar activation in 6 subjects.

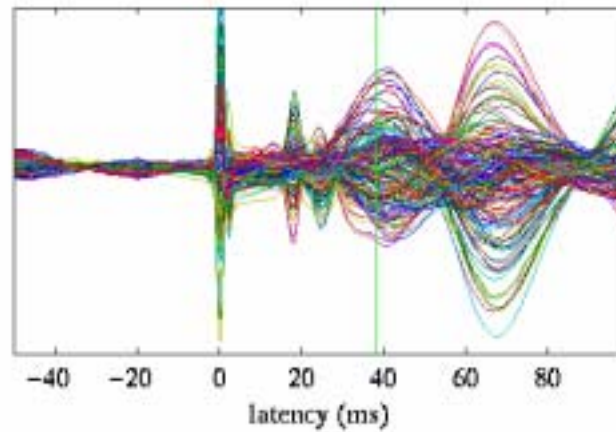
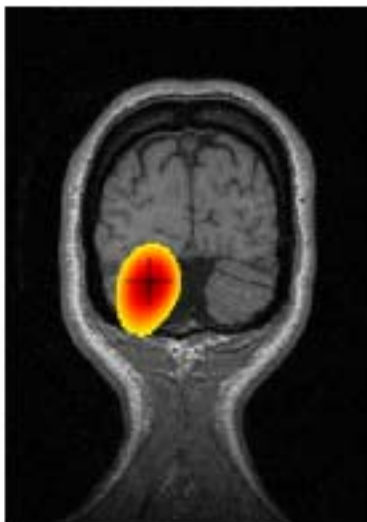
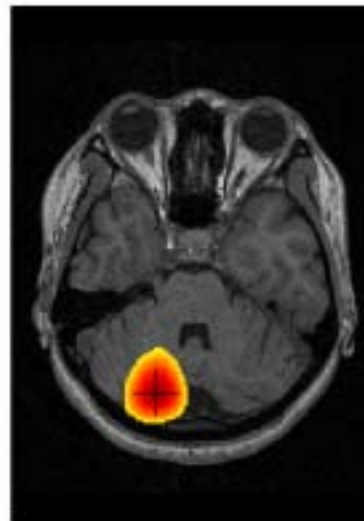
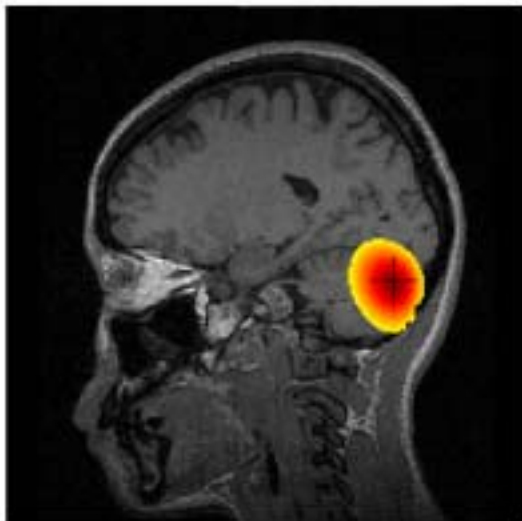
Movie from one representative subject (subject A) (Left median nerve stimulation)



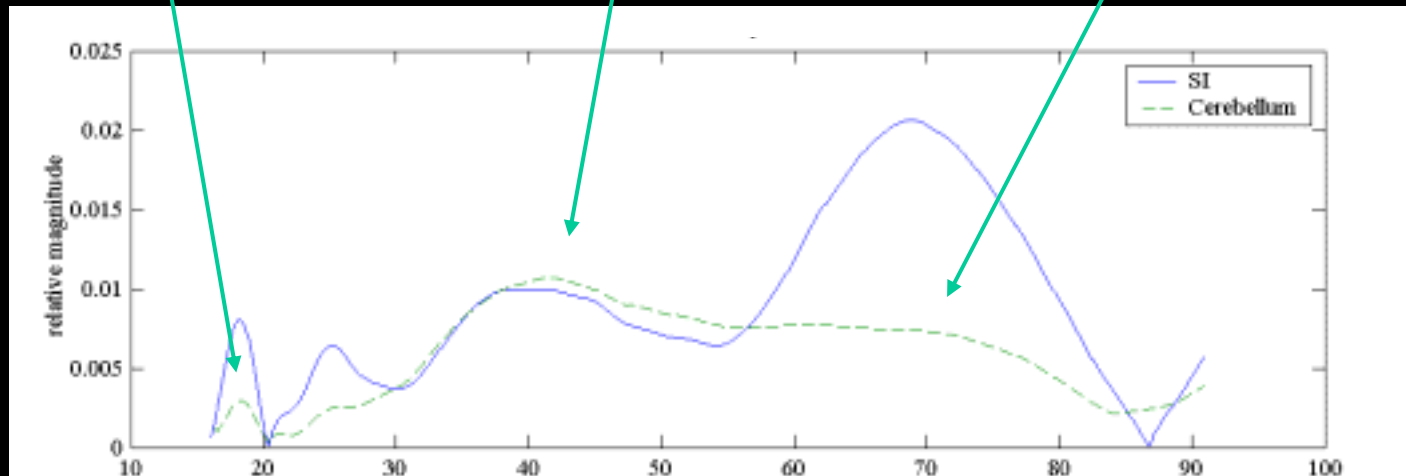
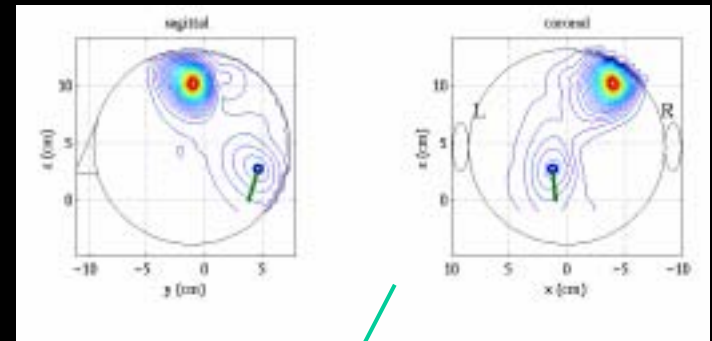
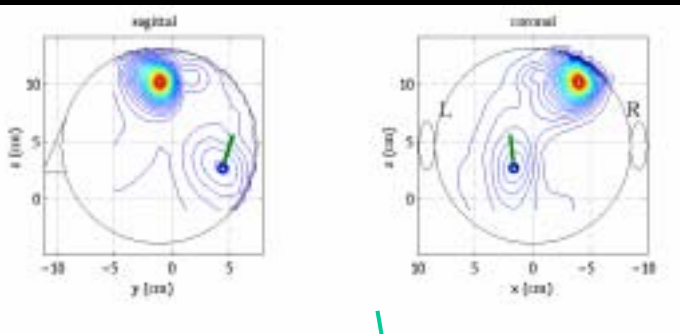
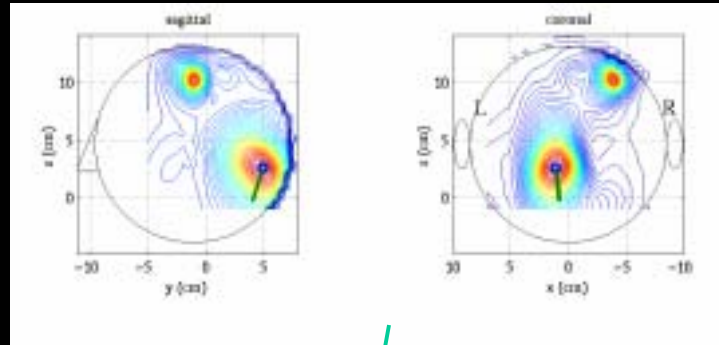
MRI overlay results at 18 ms



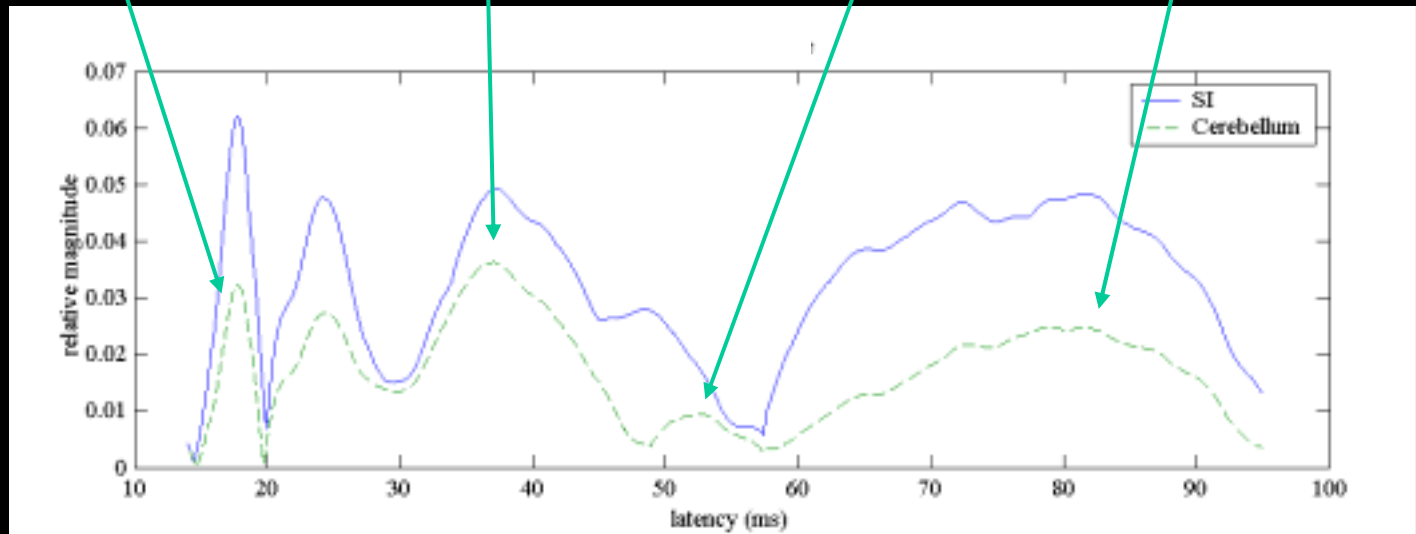
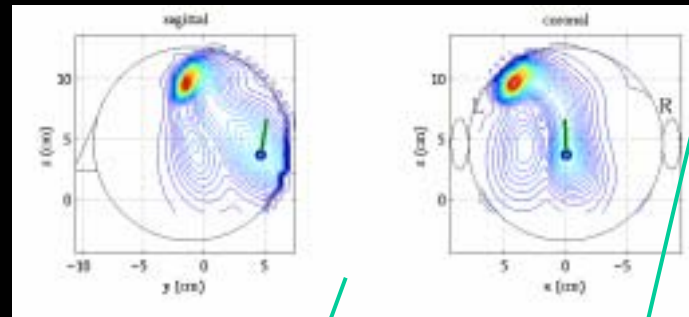
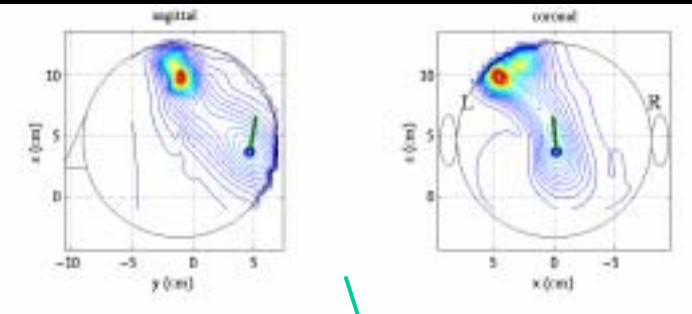
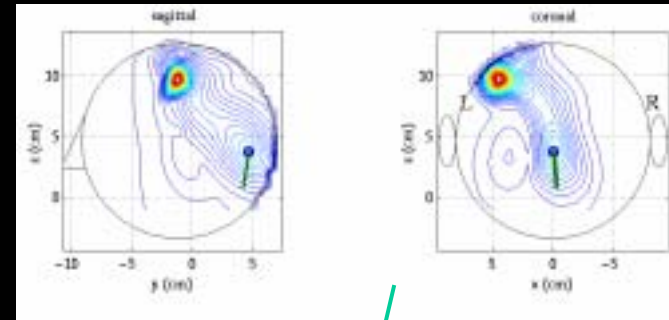
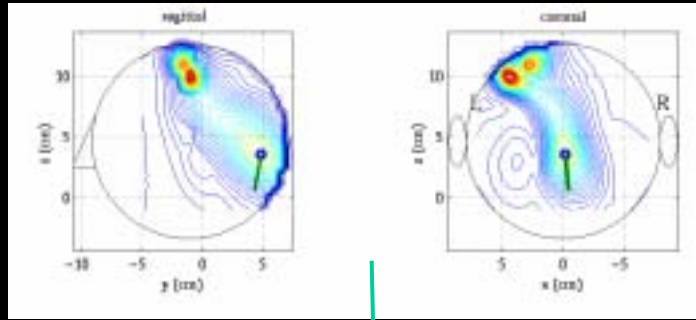
MRI overlay results at 38 ms



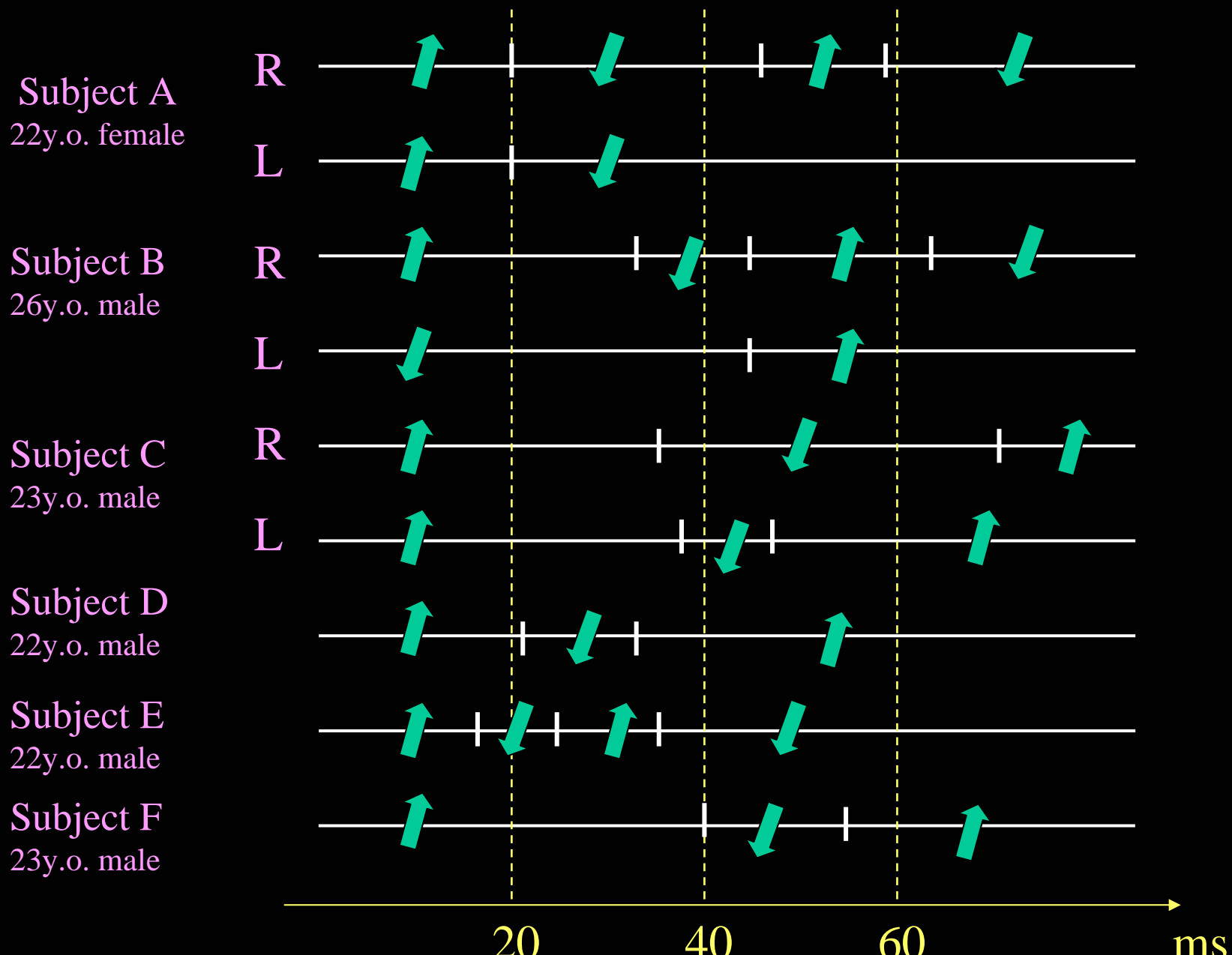
Left median nerve stimulation (Subject A)

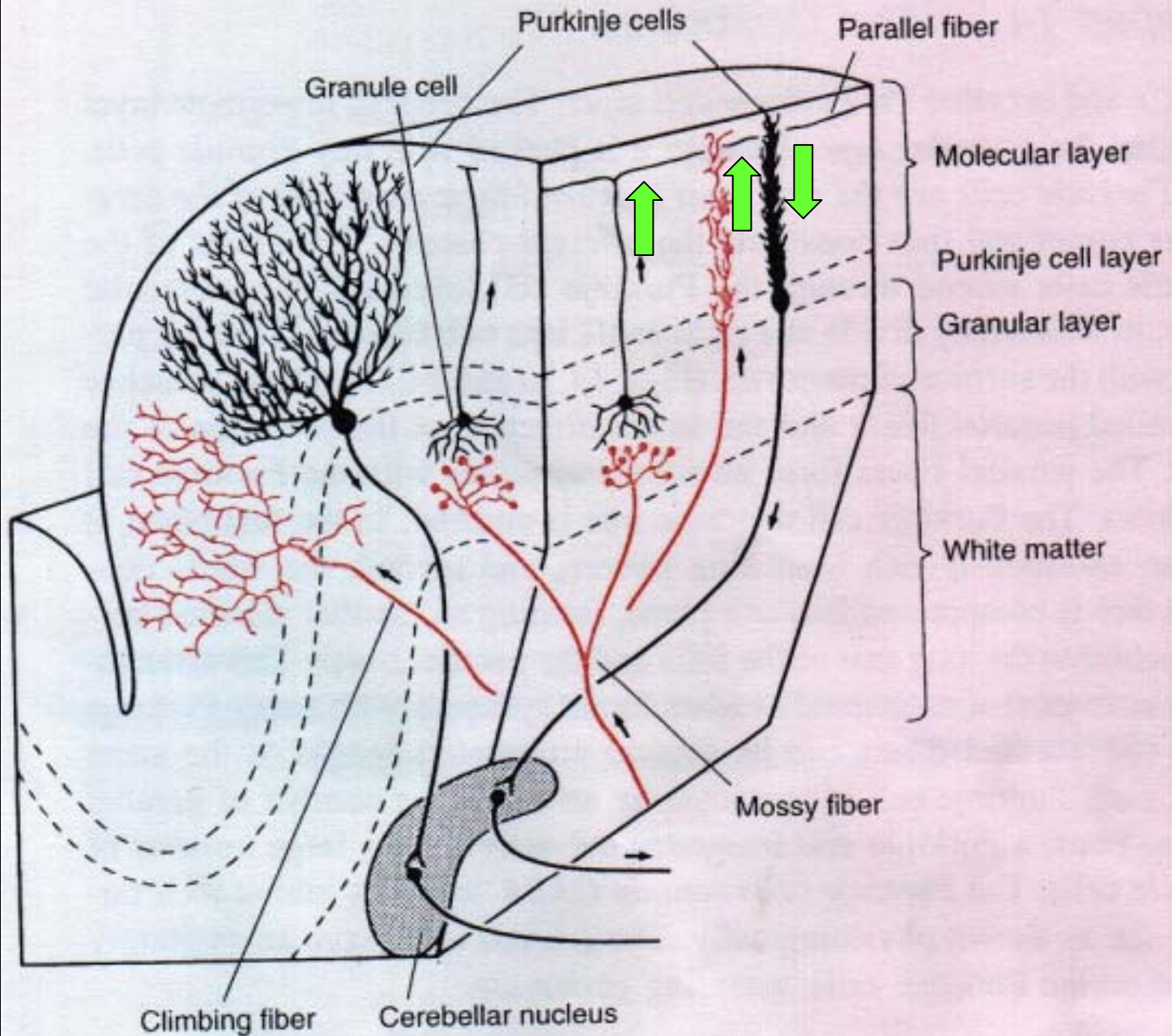


Right median nerve stimulation (Subject A)



Orientation measurements





Conclusions

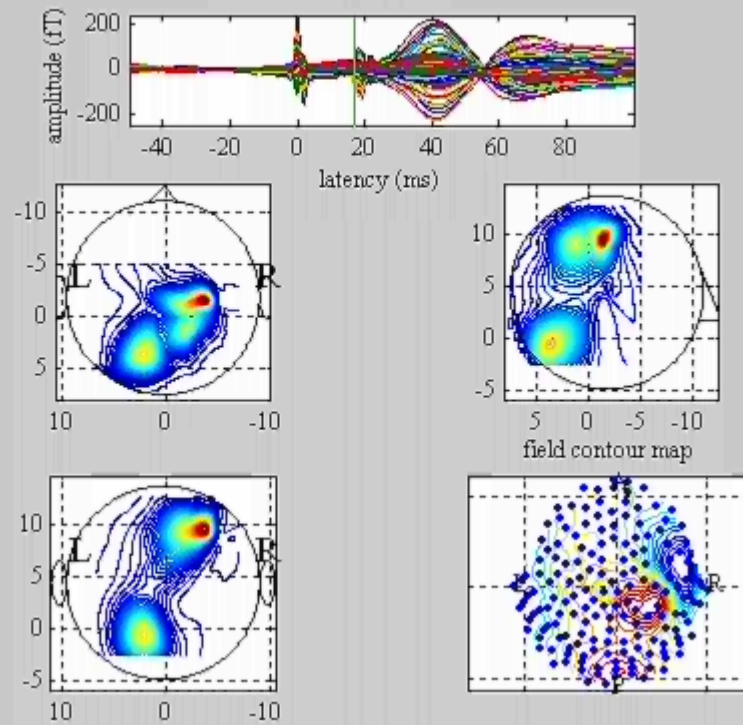
From the timing and the direction of intracellular currents for the 3 human cerebellar responses (intermediate zone), we hypothesize that

1. The first response (15-20 ms) may reflect action currents in the ascending fibers of granule cells at the branch points into parallel fibers.
2. The second response (20-40 ms) is Purkinje cell EPSPs at the distal dendrites driven by the parallel fiber system.
3. The third response (40-60 ms) is Purkinje cell EPSPs mediated by the climbing fiber system.

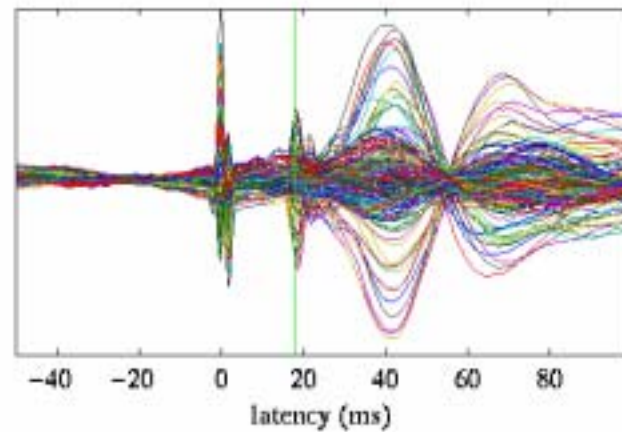
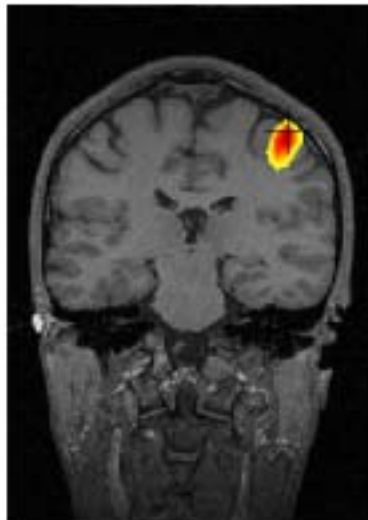
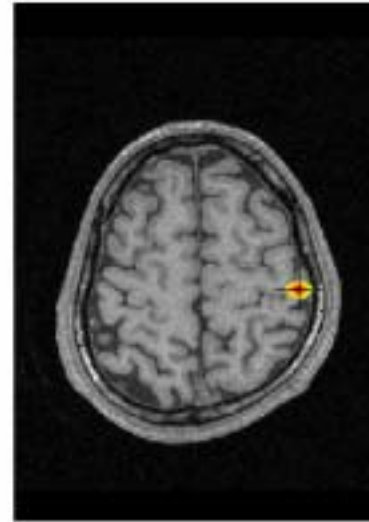
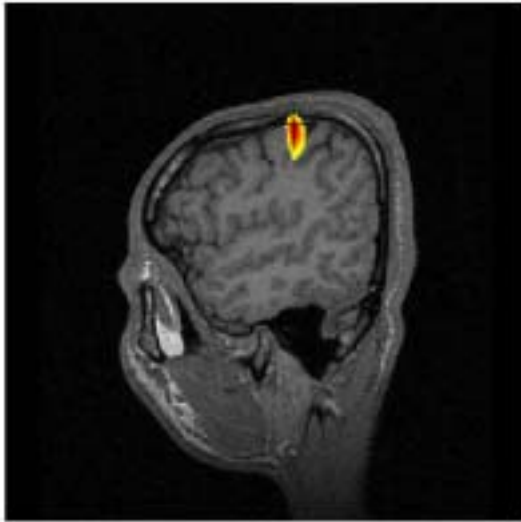
However, it should be remembered that the cerebellum is complex machinery, which may not allow such simplistic conclusions

Movie from subject B (Left median nerve stimulation)

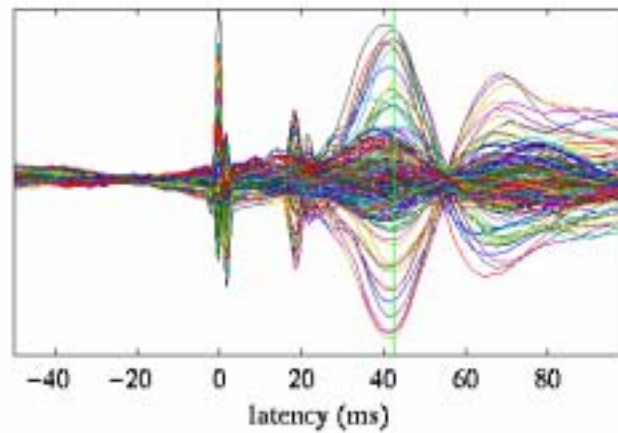
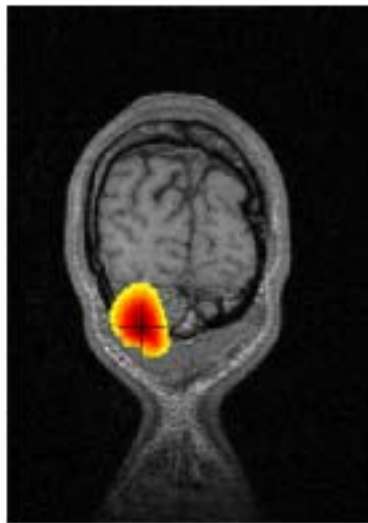
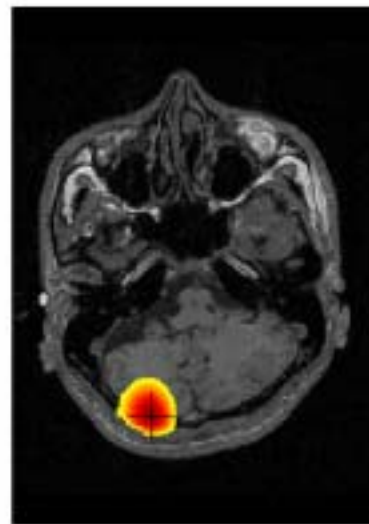
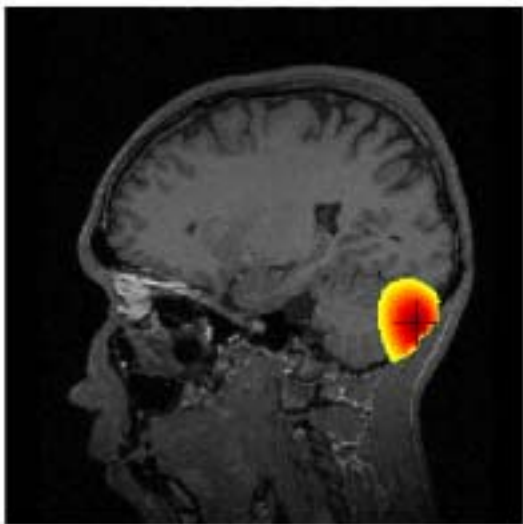
latency=17.0 ms



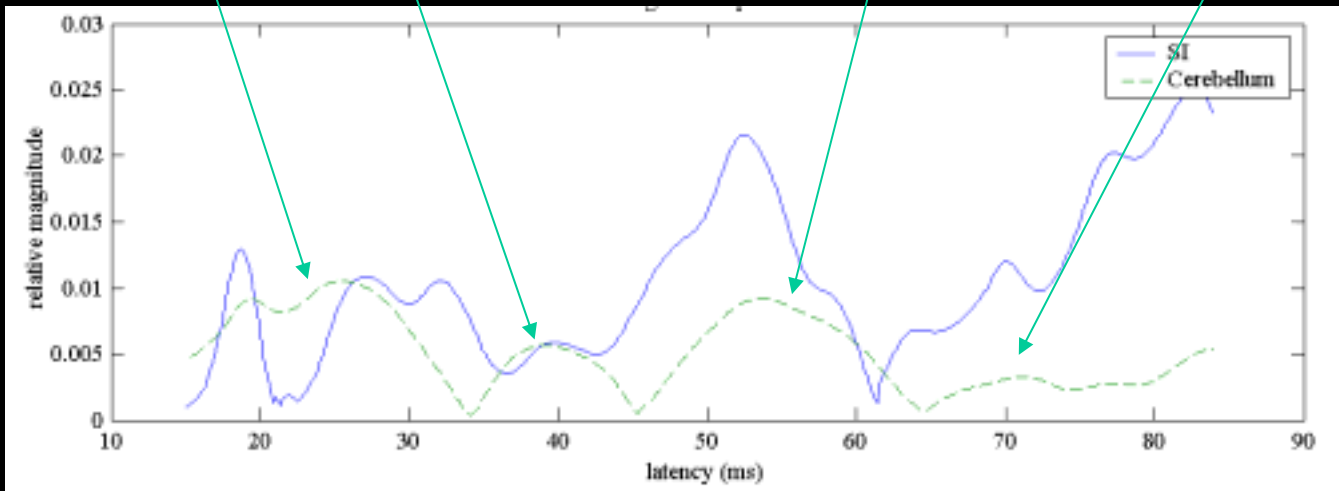
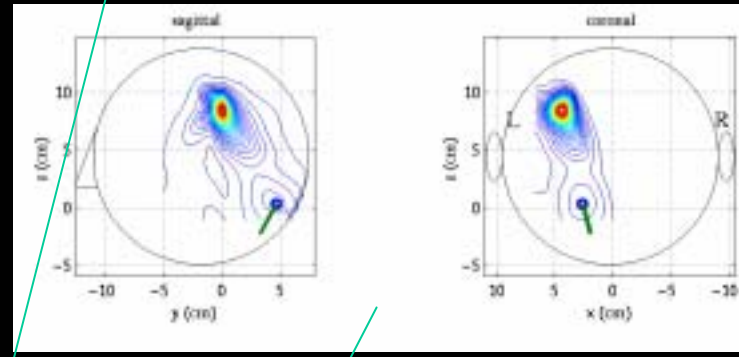
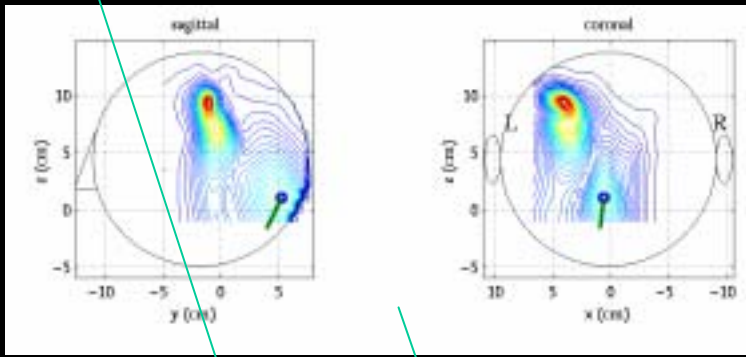
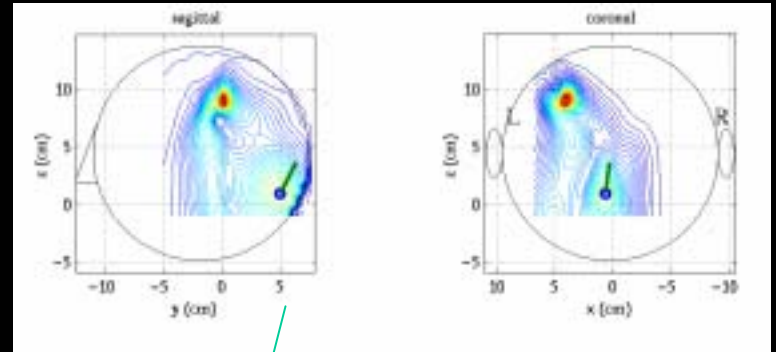
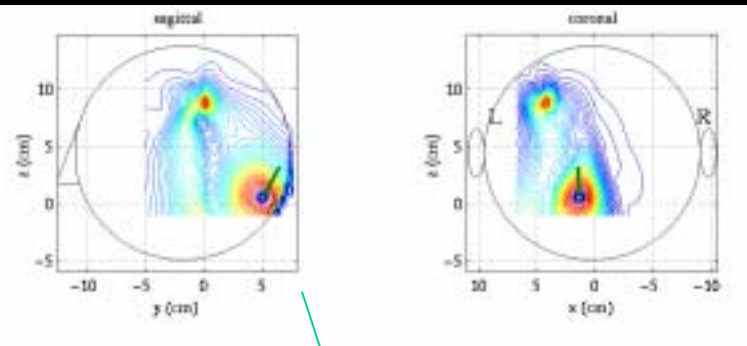
MRI overlay results at 18 ms



MRI overlay results at 43 ms



Right median nerve stimulation (Subject B)



Left median nerve stimulation (Subject B)

