Enobio/StarStim TMS compatibility

Neuroelectrics White Paper WP201306

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In this short White Paper we discuss the compatibility of our EEG devices with transcanial magentic stimulation (TMS), i.e., with Enobio and StarStim.

NEs test-board. Provides an electrical simulation of EEG impedances and signals.

First we show the effect on a NE test-board (not a human head) using a StarStim device. That is, we use the TMS coil to fire directly on top of the test-board, creating strong artifacts.

Then we study the effect on the EEG of a volunteer (eyes closed). We recorded EEG using Enobio while the subject underwent a TMS session in order to test TMS compatibility of the hardware. In other words can Enobio be used to record high quality EEG while a subject undergoes TMS? We assume that large artifacts will be present in the recorded signal and that the system recovers quickly so that no significant data loss occurs.

We aimed to show that:
- Lost data due to artifacts is not significant
- Recovery time is quick
- No amplifier damaged or permanently saturated

A recovery time of <40ms for all amplifiers satisfies all of these criteria. 40ms is chosen as a reasonable threshold based on human physiological response times.

We provide below some examples of TMS pulses in the occipital area on EEG recorded with Enobio data. We conclude that the artifacts induced do not saturate or damage the amplifiers. In addition, the artifact's duration is of a few samples (~ 10 ms).

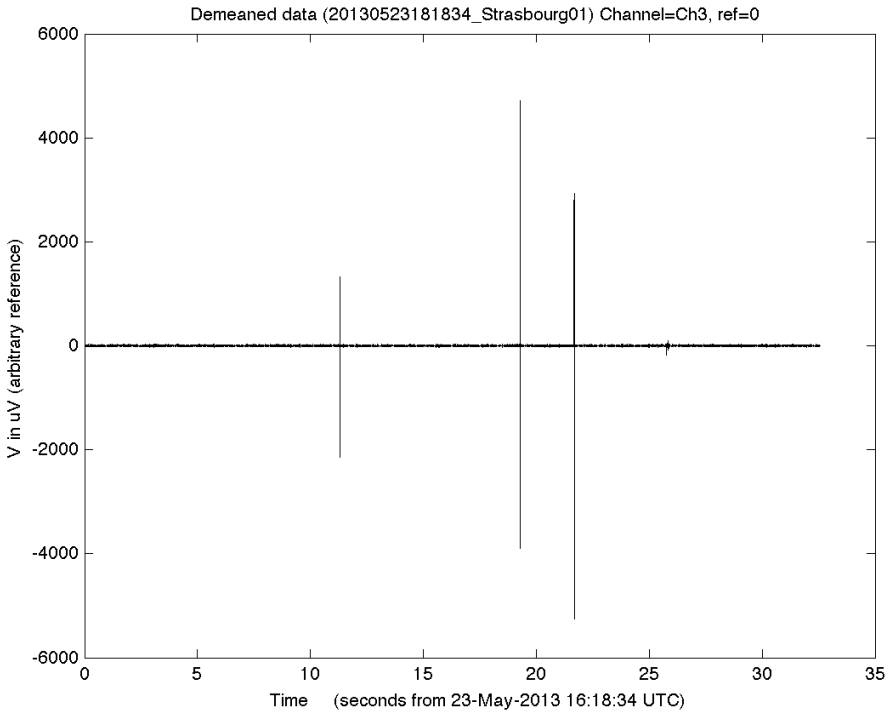

Figure 1: TMS pulses on test board measuring EEG using a StarStim device - Channel 3 after detrending.

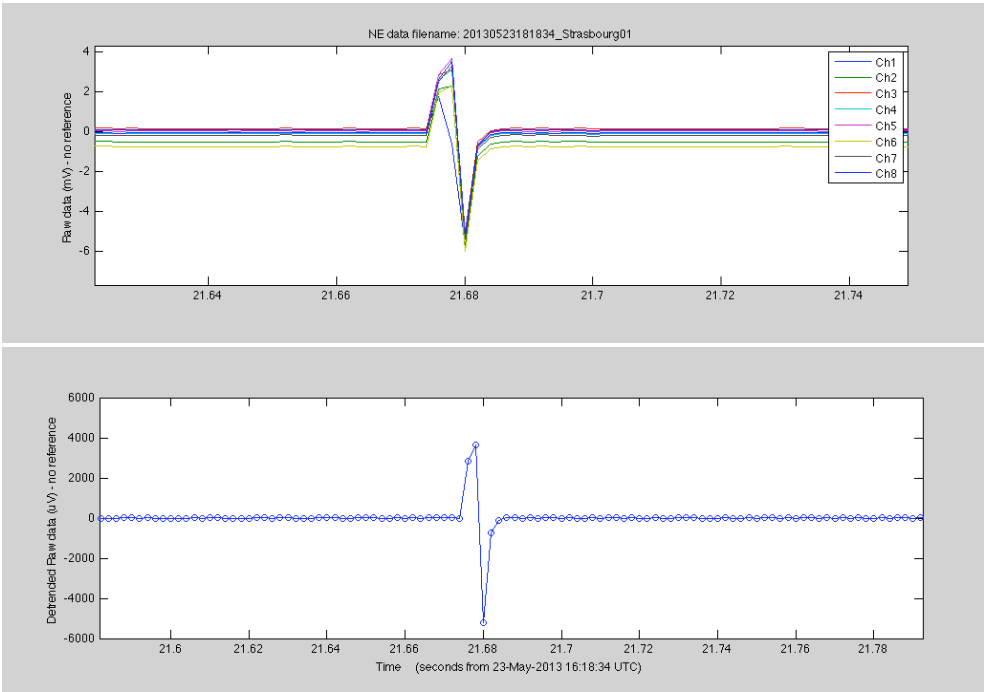

Figure 2: TMS pulses on test board measuring EEG using a StarStim device: close up of artifact. Note time scale (20 ms per division)

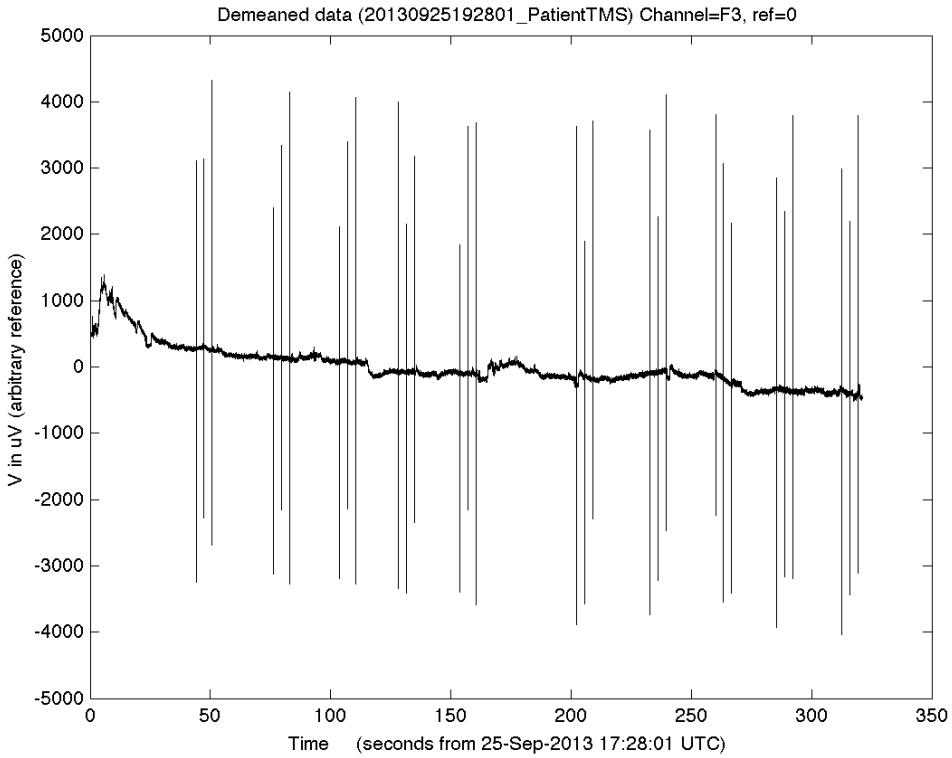

Figure 3: TMS pulses on human head as seen in EEG with an Enobio device

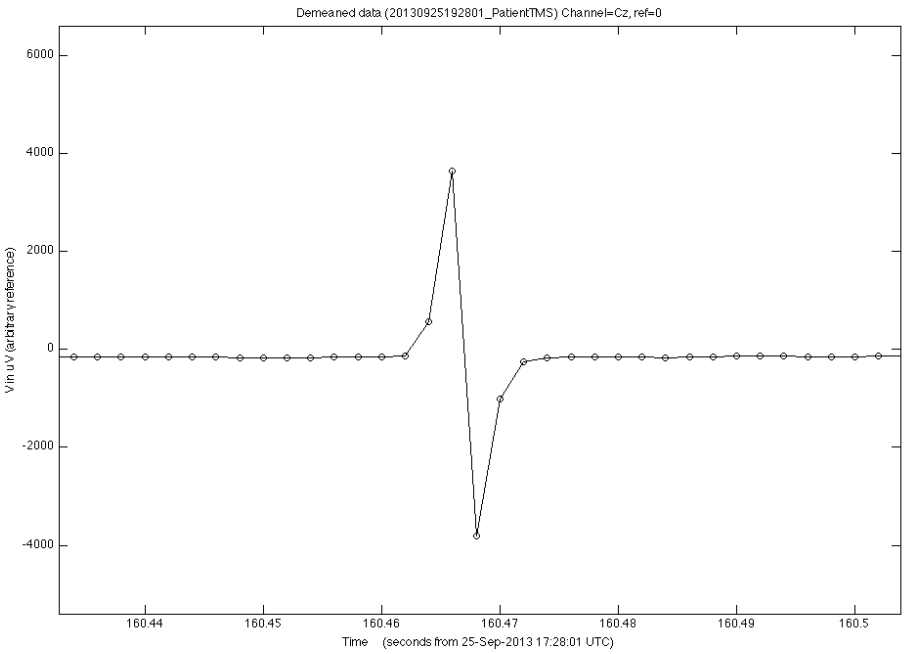

Figure 4: TMS pulses on human head as see in EEG with a Enobio device: close up. Timescale is 20 ms. Each sample taken every 2 ms. EEG data has only been demeaned (no filtering).

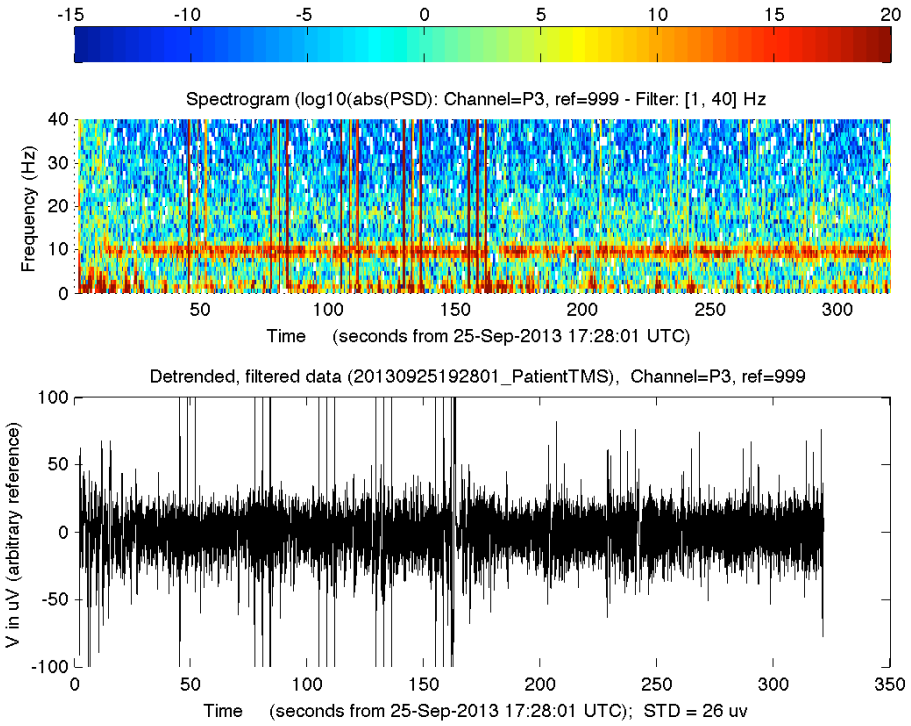

Figure 5: Spectrogram of subject's EEG (channel is Cz, with a global reference). Transient TMS artifacts can clearly be seen (in triads), but do not saturate the EEG.

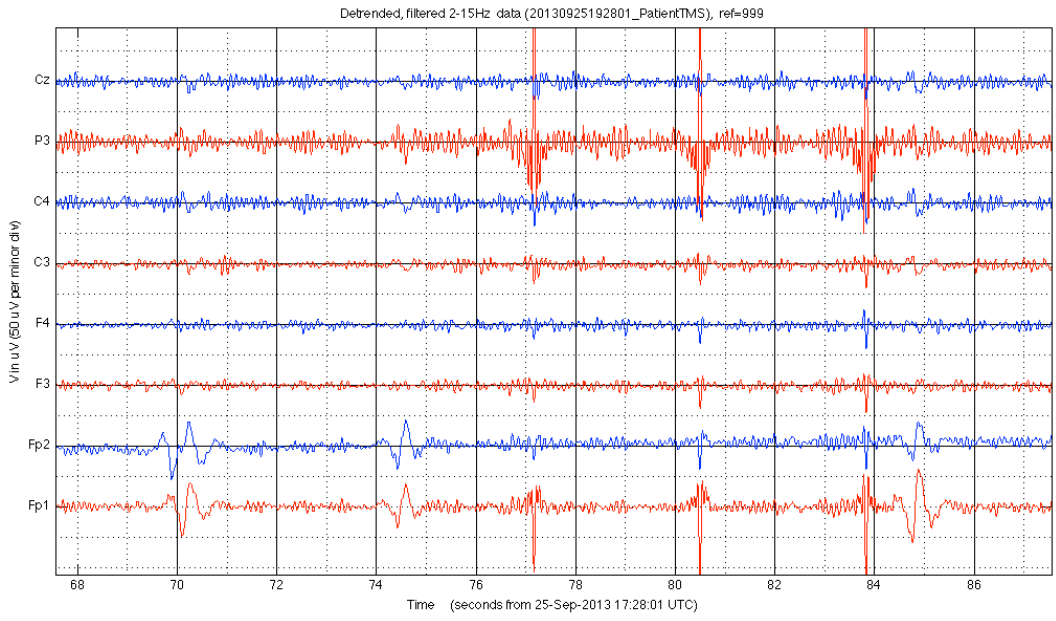

Figure 5: Filtered EEG (2-15 Hz). Observe Alpha bursts in occipital channels (P3, near stimulation site). Transient (but filtered) TMS artifacts can clearly be seen (in triads), but do not saturate the EEG.