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 transcranial magnetic stimulation (TMS), i.e., with Enobio and StarStim. NE devices are DC-coupled and provide a wide dynamic range for recording of EEG. For this reason, they are ideally suited for TMS work.

NE's test-board provides an electrical interface for simulation of EEG impedances and signals.

In a first test we aimed to study the effects of TMS on a NE test-board (not a human head) using a StarStim device to record EEG. That is, we used the TMS coil to fire directly on top of the test-board, creating strong artifacts.

In a second test we studied the effects of TMS on the EEG recording of a healthy volunteer (eyes closed). We recorded EEG using an Enobio-8 device while the subject underwent a TMS session. Again, the goal was to show that Enobio can be used to record high quality EEG while a subject undergoes TMS. We assumed that large artifacts would be present in the recorded signal but that the system recovers quickly so that no significant data loss occurs.

In the tests described, the TMS equipment used was a MagVenture MagPro R30 TMS Stimulator with a coil of type Cool-B65-RO and installed on a Axilum Robotics TMS-Robot piloted by Localite 2.2 neuronavigation system[1]. Power was typically set at 90% of the max power and the pulse type was biphasic.

In the figures below we show that:
- Lost data due to artifacts is not significant
- Recovery time is quick (10 ms)

The Enobio EEG system was not damaged or saturated. We note that a recovery time of < 40ms for the EEG amplifier would satisfy 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) – well within acceptable limits.

[1] Courtesy of Axilum Robotics, whom we kindly thank.

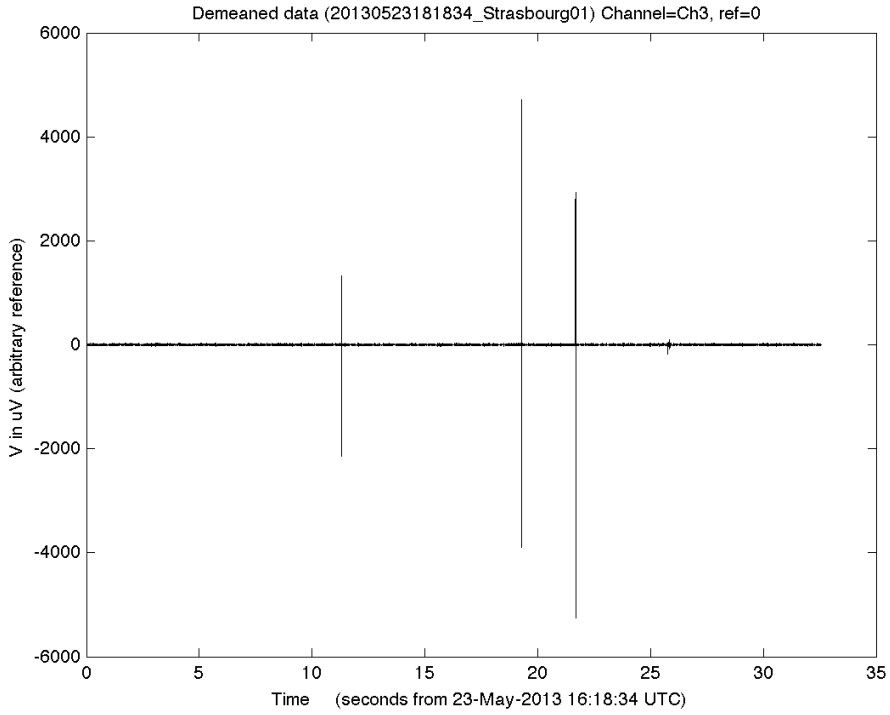

Figure 1: TMS pulses on test board measuring EEG using a StarStim device - Channel 3 after detrending.

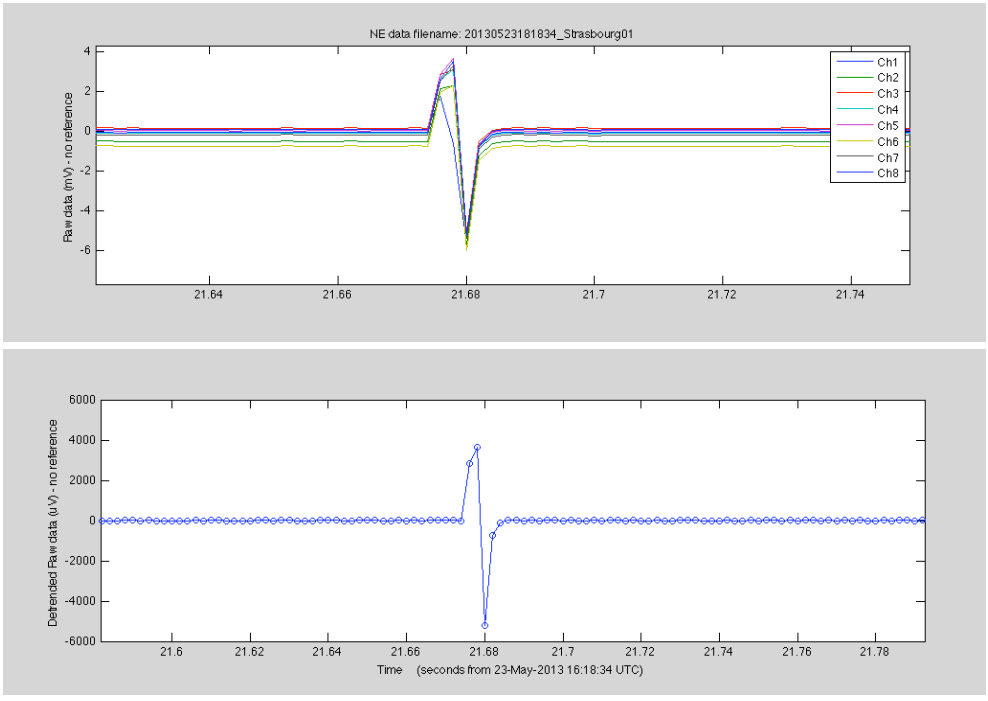

Figure 2: TMS pulses on test board measuring EEG using a StarStim device: close up of artifact. Note time scale (20 ms per division)

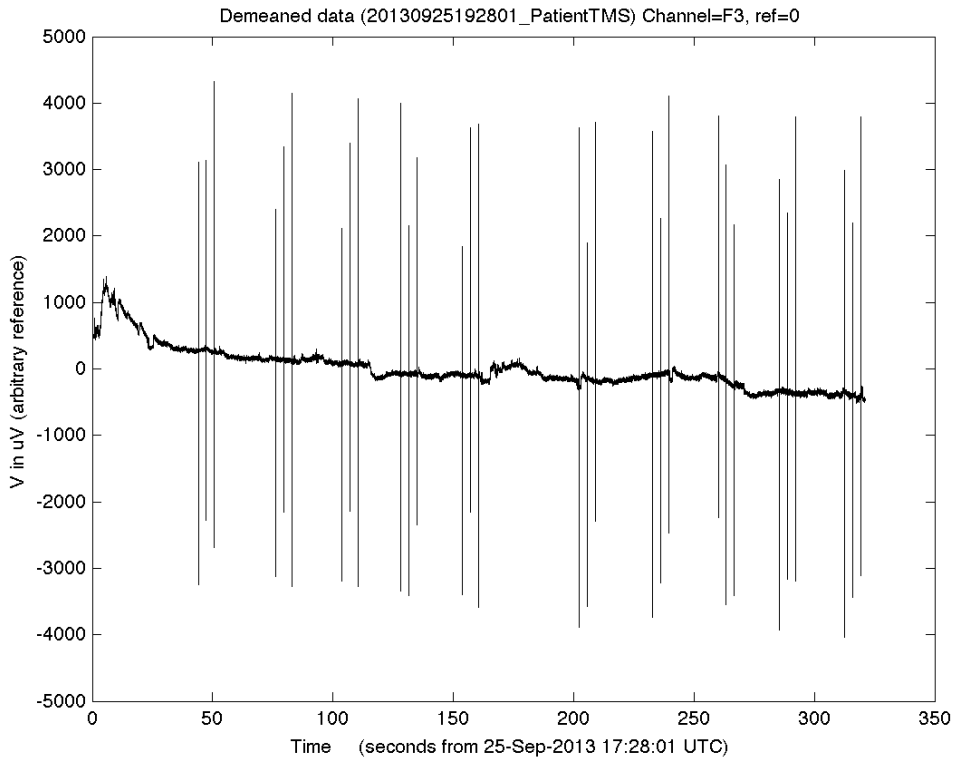

Figure 3: TMS pulses on human head as seen in EEG with an Enobio device

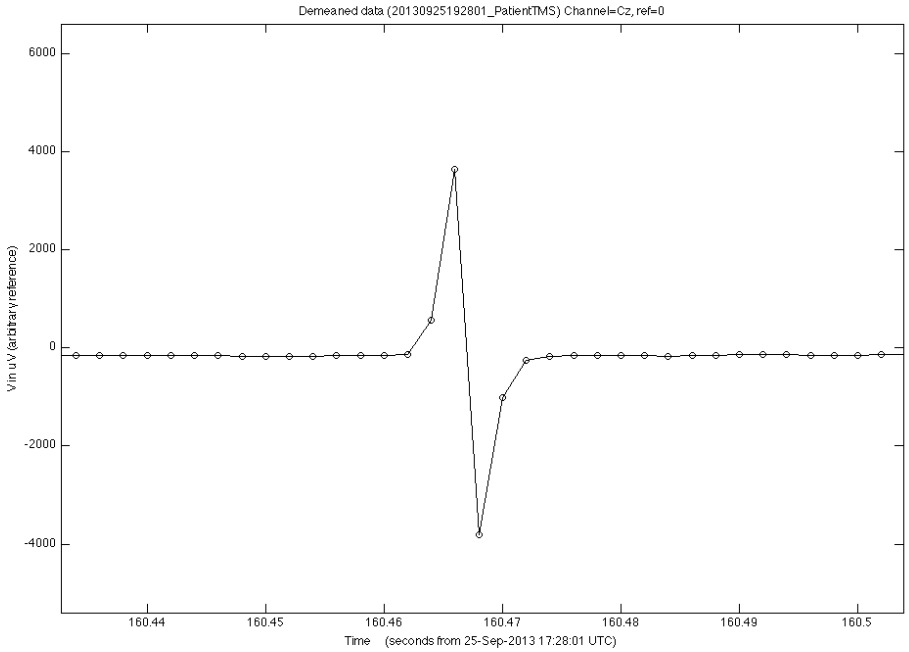

Figure 4: TMS pulses on human head as see in EEG with a Enobio device: close up. Timescale is 20 ms. Each sample taken every 2 ms. EEG data has only been demeaned (no filtering).

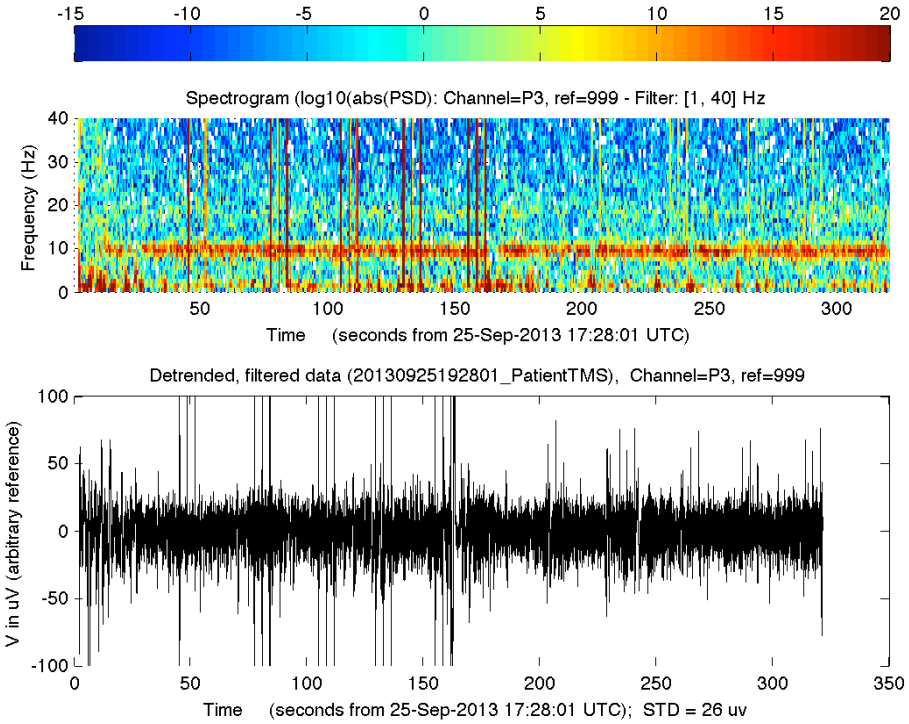

Figure 5: Spectrogram of subject's EEG (channel is Cz, with a global reference). Transient TMS artifacts can clearly be seen (in triads), but do not saturate the EEG.

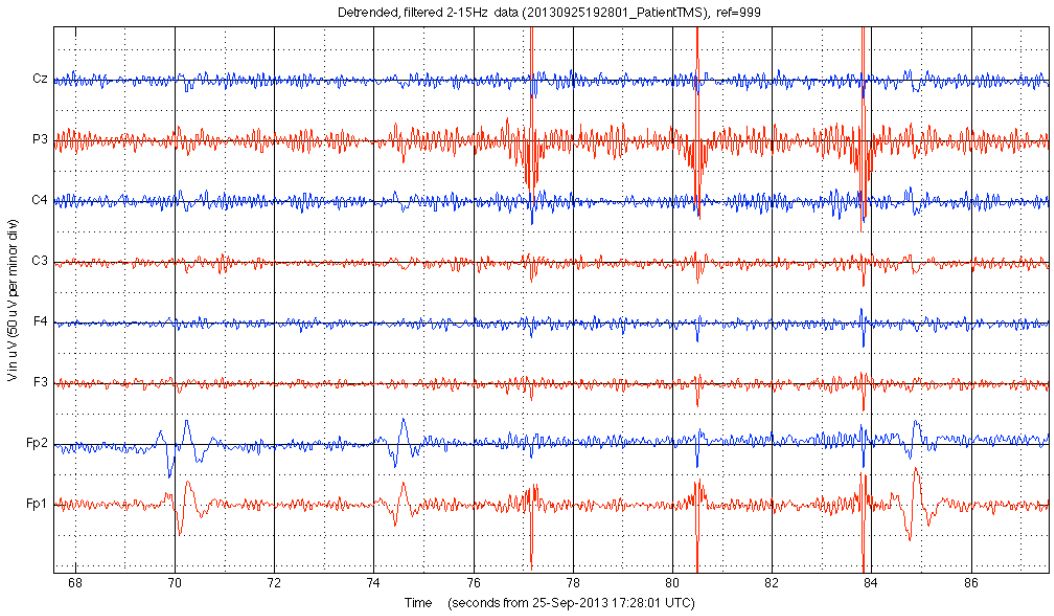

Figure 5: Filtered EEG (2-15 Hz). Observe Alpha bursts in occipital channels (P3, near stimulation site). Transient (but filtered) TMS artifacts can clearly be seen (in triads), but do not saturate the EEG.