

Engineering Solutions to Execute Paired Associative Stimulation Protocol

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Background

- Paired associative stimulation (PAS) leverages spike-timing dependent plasticity (STDP) by coordinating peripheral nerve stimulation with brain stimulation, specifically Transcranial Magnetic Stimulation (TMS), to induce neuroplastic changes.
- PAS can modulate the brain to induce long-term potentiation or depression (LTP or LTD), which holds potential to improve outcomes in individuals with neurological disorders.

Objectives

Purpose: Develop efficient and user-friendly tools for researchers to collect desired data.

1. DETERMINING INDIVIDUAL-SPECIFIC SENSORY THRESHOLD

A sensory threshold is defined as the minimum electrical stimulation required to elicit a constant percept.

2. DETERMINING INDIVIDUAL-SPECIFIC N20

The N20 quantifies the latency of the somatosensory-evoked potential (SEP) generated by the peripheral nerve stimulation reaching the primary somatosensory cortex (S1).

PAS intervention: Peripheral nerve stimulation is administered at an intensity set to 300% of the sensory threshold. The N20 is utilized to determine the time difference between the nerve and brain stimulation for either LTP or LTD effects.

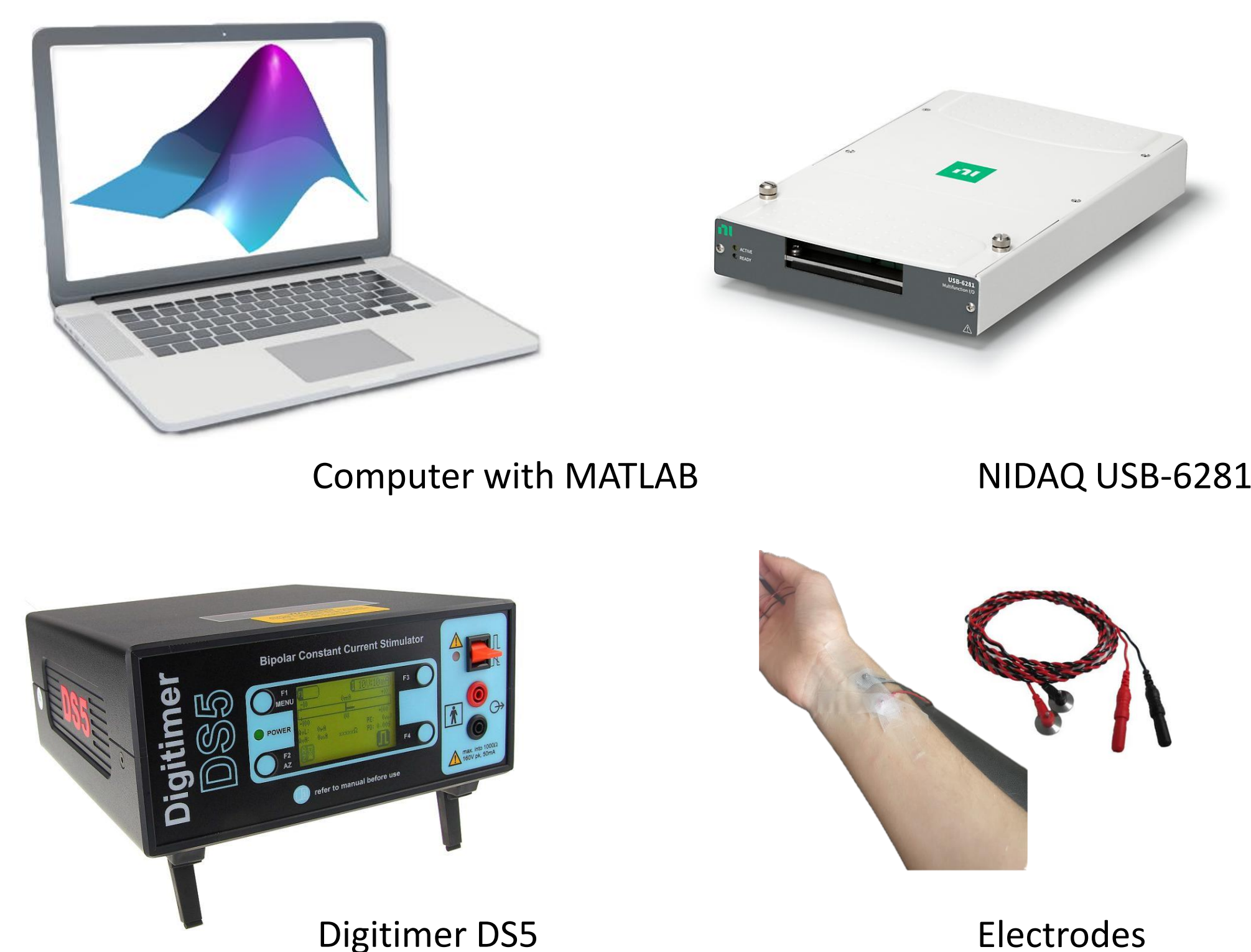
3. STIMULUS RESPONSE CURVE DATA COLLECTION

The neuroplastic effects of PAS are quantified by motor evoked potential (MEP) amplitudes measured at several precise time intervals after the completion of PAS.

1. Sensory Threshold

Refine an existing MATLAB application that utilizes user feedback to improve sensory threshold estimates.

The MATLAB-controlled computer interfaces with the Digitimer DS5 via a NIDAQ intermediary, facilitating the sending of current to the electrodes.



The MATLAB app interface calculates the average sensation perception from varied intensity biphasic pulses on the median nerve.

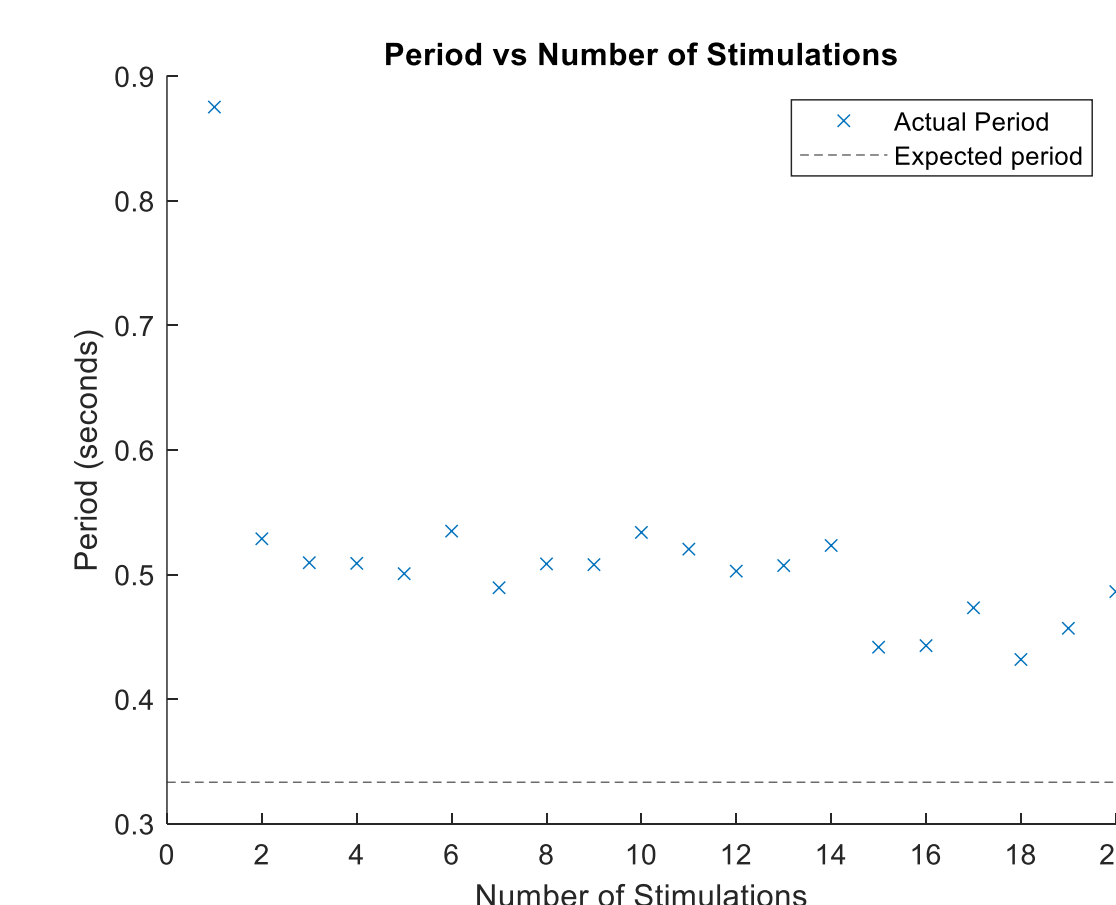


Methods

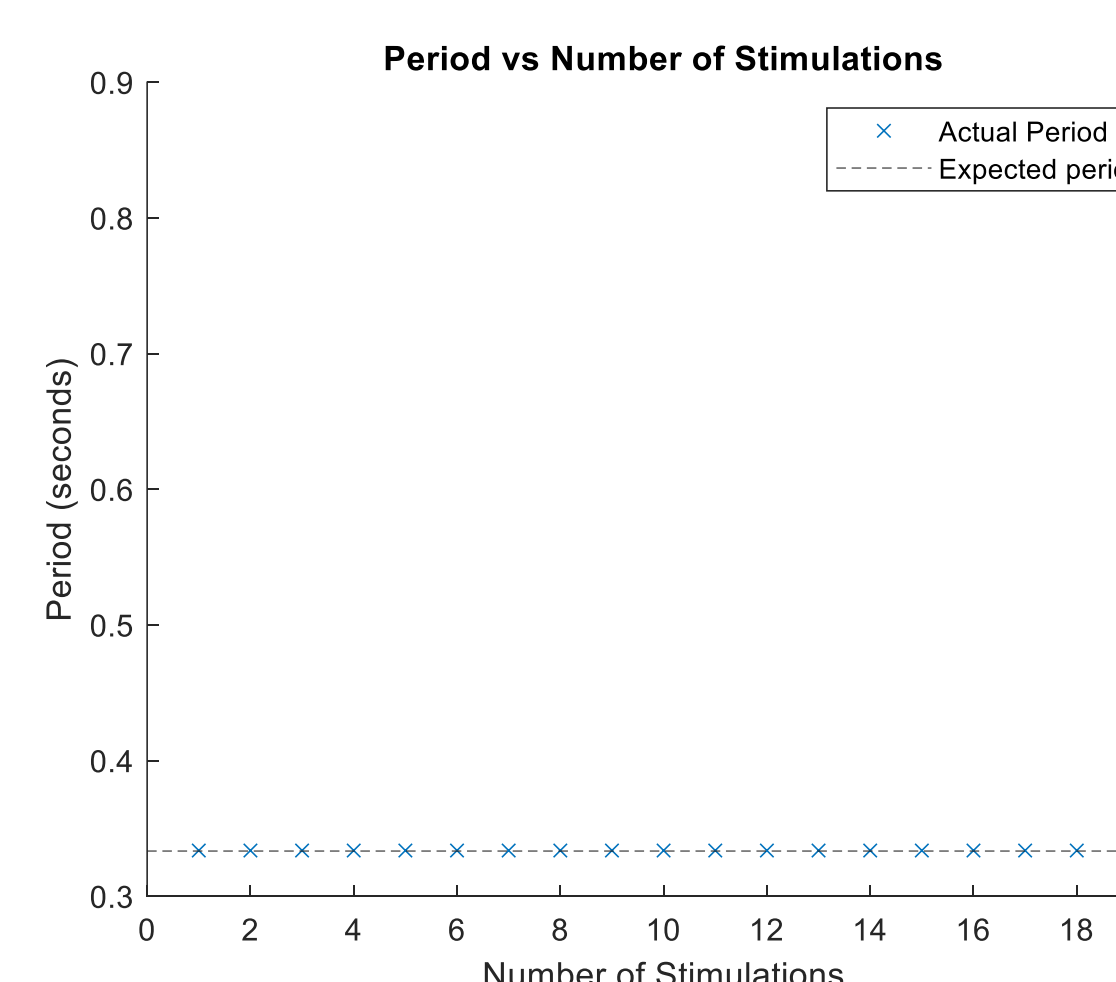
2. N20

Control peripheral nerve stimulation with customization of stimulation parameters (e.g., number of stimulations, intensity, frequency, pulse shape, and duration).

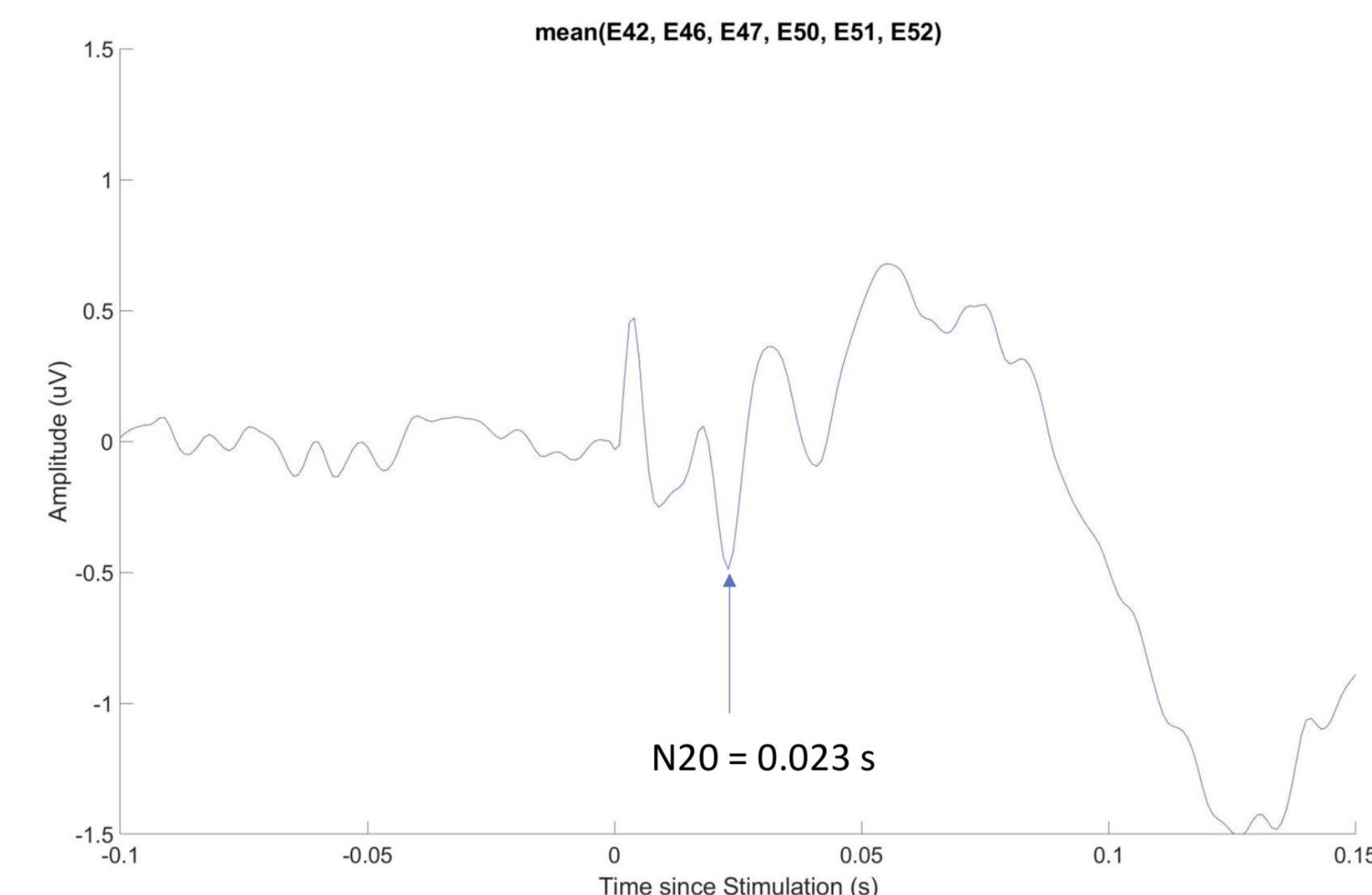
Pairing the timing of the pulses from the stimulator with the EEG activity is critical in determining an accurate N20. The original MATLAB code delivered the pulses at varied incorrect frequencies.



The code was revised to ensure consistent delivery of pulses at the inputted frequency.



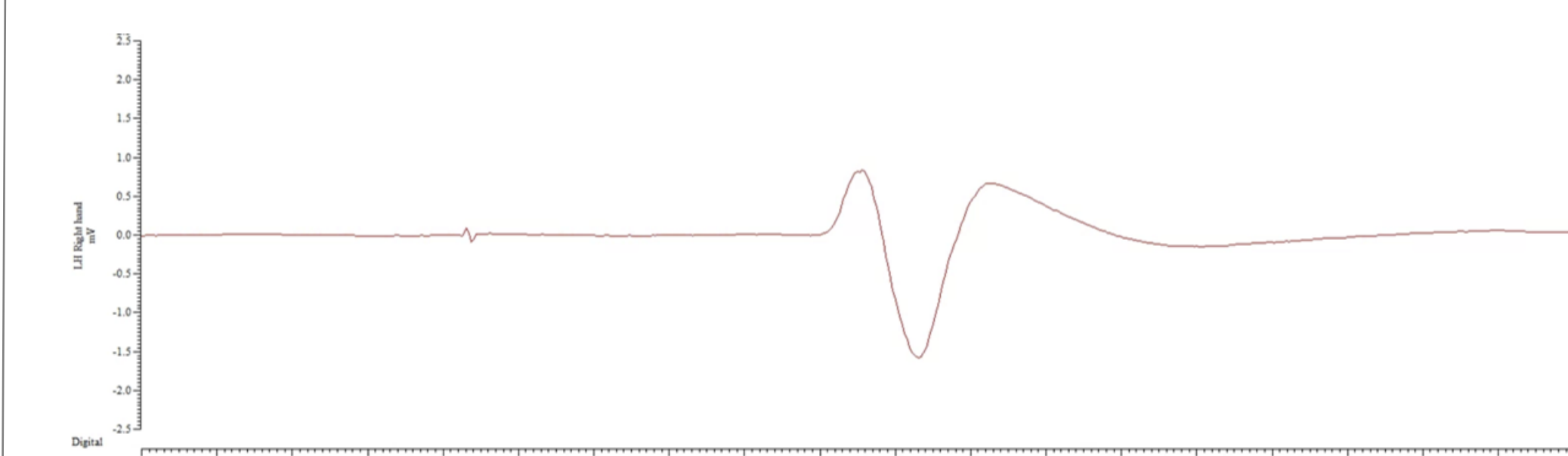
The figure below demonstrates the successful pairing of the stimulations with EEG activity. The dip at 0.023s indicates the subjects N20 latency.



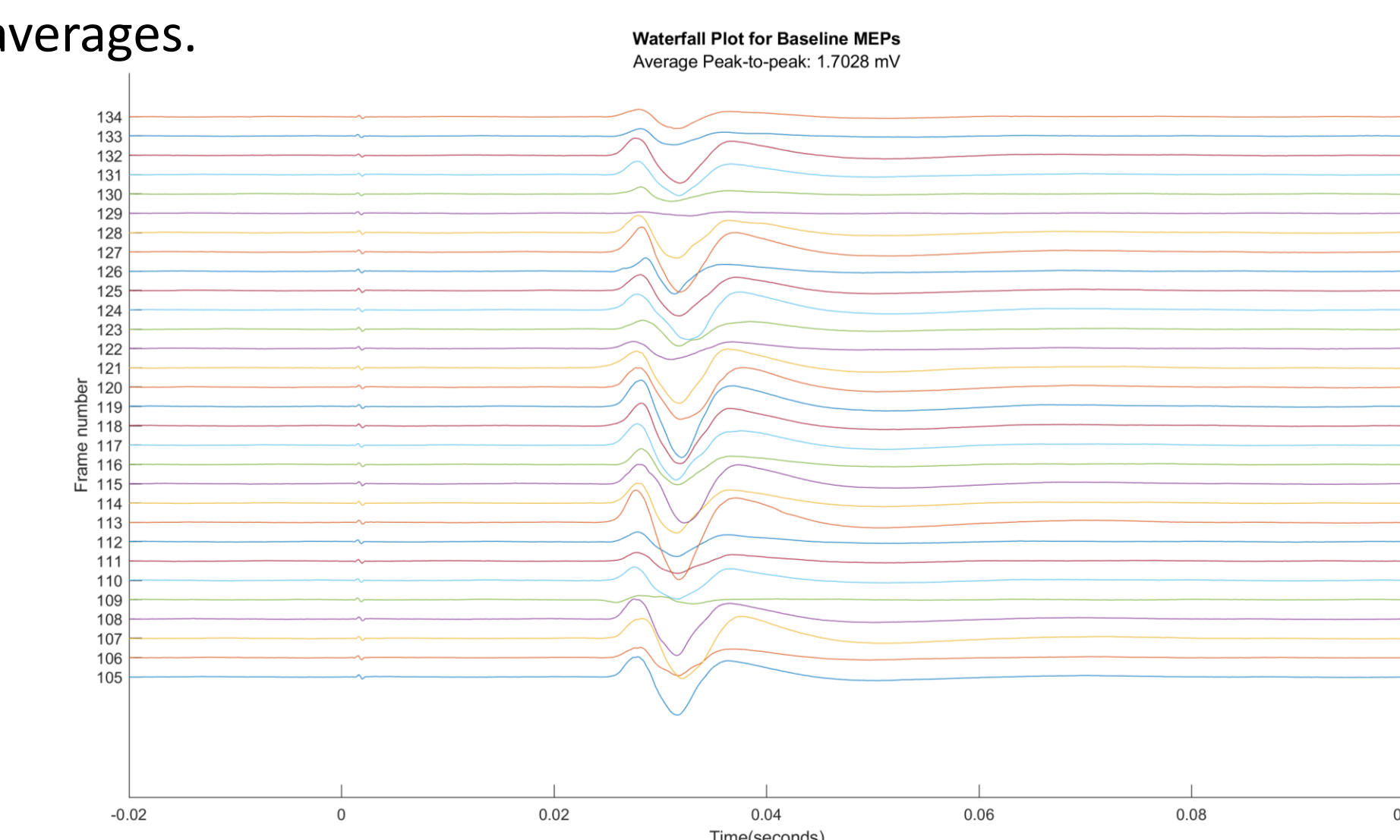
3. Stimulus Response Curve

Construct a stimulus-response curve which plots average muscle response to TMS at baseline and post-treatment intervals to inform researcher on participants' response to PAS.

Individual trials of MEP's (30 trials per time frame) are collected using Signal CED Software.



The trials are then exported by grouped time intervals within Signal. Analysis using MATLAB is performed to 1) identify peak-to-peak MEP amplitudes per trial and 2) calculate grouped time averages.



The Stimulus Response Curve visually tracks the evolving response to the PAS intervention using group averages and adjusts as time intervals are added.

