Comparison of pulse waveform and effects of transcranial magnetic stimulation with novel and established stimulation devices

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INTRODUCTION

The responses to single and paired-pulse stimulation has been shown to be dependent on the pulse waveform (Sommer et al, 2006), which will differ slightly between manufacturers. As new models enter the market it is important to examine their efficacy, to assess the comparability of trials and clinical interventions performed with different apparatus.

METHODS

Pulses were recorded using Deymed DuoMAG and Magstim 200²/Bistim stimulators with figure of eight coils. Amplitude and pulse-width were measured for both stimulators at 100%, 75%, 50% and 25% of maximum output for both single and paired pulse stimulation modes.

12 young healthy subjects were tested using single and paired-pulse stimulation to the FDI representation of the motor cortex of the dominant hemisphere. EMG was recorded from the FDI muscle on the contralateral limb. Motor Thresholds were recorded at rest (AMT) and with 10% of maximal active contraction (AMT). Input-output curves were recorded at 90%, 110%, 130% and 150% of RMT. The onset of MEP latency was recorded at 110% of AMT and the duration of cortical silent period at 150% AMT.

Paired pulse stimulation was performed at a interstimulus interval of 2.5ms to measure Short Intracortical Inhibition (SICI). Conditioning stimulus intensity was set at 70%, 80% and 90% AMT in combination with a 1mV test stimulus in sequential recordings to create a SICI input-output curve.

RESULTS

Experiment 1 : Coil pulse waveforms

Pulse waveforms were recorded at 25%, 50%, 75% and 100% of maximum stimulator output.

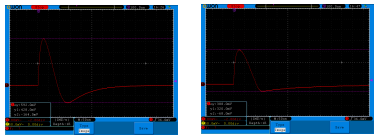

Fig 1. Pulse waveform of (A) Magstim 2002 and (B) Deymed DuoMAG (single pulse mode)

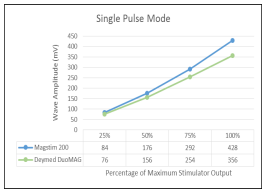

Fig 2. Wave amplitude with increasing stimulator output

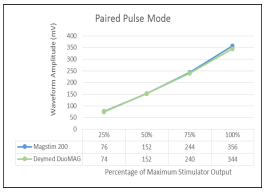

Fig 3. Wave amplitude with increasing stimulator output (paired-pulse)

Experiment 2 (*n* = 12):

Motor-Evoked Potentials

RMT was not significantly different between the two stimulators (Magstim 47.7% vs Deymed 47.3 % , p=.646) and were strongly correlated within subjects (p<.001, r=.956). AMT was also not significantly different between stimulators (38.1% vs 37.3%, p=. 349) and strongly correlated (p<.001, r =. 913).

Average MEP latency was 222.3ms vs 222.1ms (p=.739), with strong correlation within subjects (p<.001, r=.880). Cortical silent period was also similar with both stimulators (127.8ms vs 136.4ms) and also strongly correlated with (p=.100, r =.794).

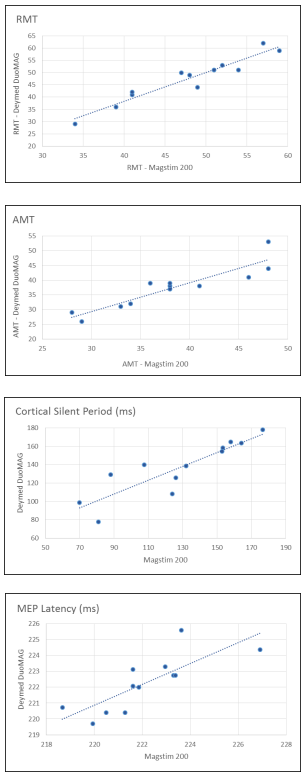

Fig 4 (i) RMTvs RMT scatterplot (ii) AMT vs AMT (iii) cortical silent period (iv) MEP latency

Input Output Curves

Recruitment curves for both stimulators were sigmoidal, with significant linear (p<.001), quadratic (p=.003) and cubic (p=.01) relationships. There was however no significant effect of stimulator (p=.673) or stimulator*intensity interaction (p=.813).

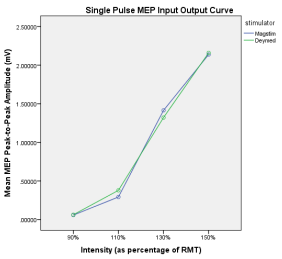

Fig 4. sigmoid input-output curve with increasing intensity of TMS

Paired-Pulse Stimulation

A TMS MEP can be supressed when preceded by a below-threshold conditioning pulse at an interstimulus interval of 1-5ms (Rothwell et al., 2009) through activation of GABAergic intracortical inhibitory circuits.

With increasing intensity of the conditioning stimulus, there was a linear decrease on test pulse amplitude with both stimulators in paired-pulse mode (p<.001) but no effect of stimulator (p=.673) or stimulator*intensity interaction (p=. 813).

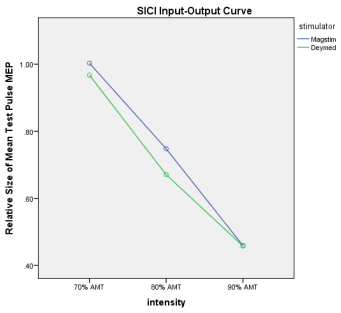

Fig 5. Relative size of mean test pulse MEP following conditioning stimulus at 70%, 80% and 90% AMT

DISCUSSION

The relationship between TMS pulse waveform and electro-magnetic induction within the CNS is only partially understood, with much insight arising from systematic variation in stimulator waveform between different models. The Deymed DuoMAG uses a slightly shorter wavelength and a slightly smaller peak amplitude than the widely used Magstim 200². This does not appear to result in any significant difference in MEP induction. Previous studies have shown that broader pulsewidths lower the induction threshold, whilst reducing the amplitude of the stimulus increases threshold (Delvendhal, 2014). It seems that the variation of these two characteristics between the two stimulators are either neglible in their effect, or possibly compensatory to each other and/or any other unobserved variations in stimulator design.

CONCLUSION

Despite subtle differences in peak pulse amplitude and pulse-width between the two devices, these results suggest that the DuoMAG and Magstim 200² stimulators produce comparable measurements of common markers of corticospinal excitability and intra-cortical inhibition.

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