# Motor-Evoked Potentials in Single-Pulse Transcranial Magnetic Stimulation: Feature Variation versus Coil Rotation

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## INTRODUCTION

Motor-Evoked Potentials (MEPs) have been used as the direct outputs in quantifying the transcranial magnetic stimulation (TMS), allowing direct evaluations of the cortical activities and neuronal connections in the motor pathways [1]. TMS has the potential to reveal the altered excitability in patients with motor deficit, or prognoses of stroke patients [2].

Adjusting stimulation parameters, such as coil rotation, influences the MEP properties [2]. The variation of other MEP features, such as polyphasity and duration, however, have not studied thoroughly.

## AIM

**To investigate the variation of more complete set of MEP features in single-pulse TMS with respect to the coil rotation.**

## METHOD

Nine healthy right-handed volunteers were studied. The experiment used navigated TMS. The targeted area was the motor representation area of the right first dorsal interosseous. The EMG was recorded at this muscle. Three measurements were performed on each subject, each contains 120 stimuli with an intensity of 120% of the rMT, as the coil was rotated from -135 to 135 degree, with an average of 2.25-degree step.

15 MEP features were studied, include amplitude (Amp), latency (Lat), eDur, iDur, number of turns (NT), number of phases (NP), area-under-the-curve (AUC), Thickness, Size Index, two largest turns' time (T1T, T2T) and amplitude (T1A, T2A), the timing difference of these turns (timeDiff) and the ratio of their amplitudes (ampRatio) [3].

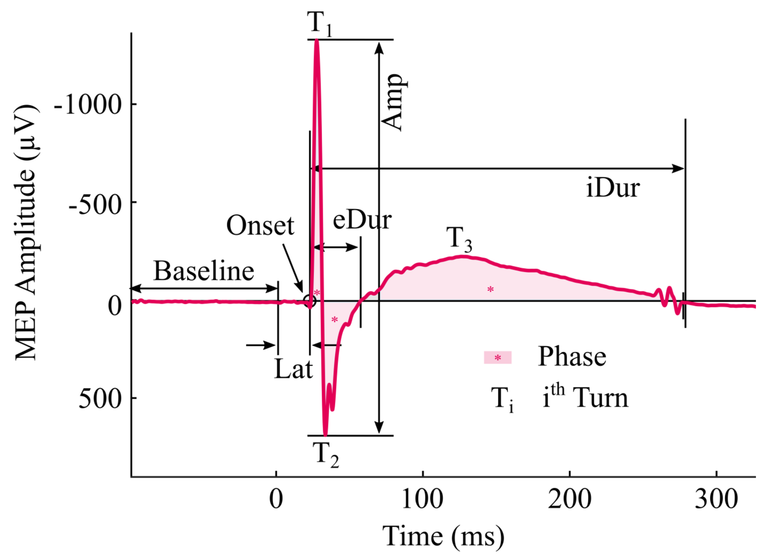


Fig. 1

## RESULTS

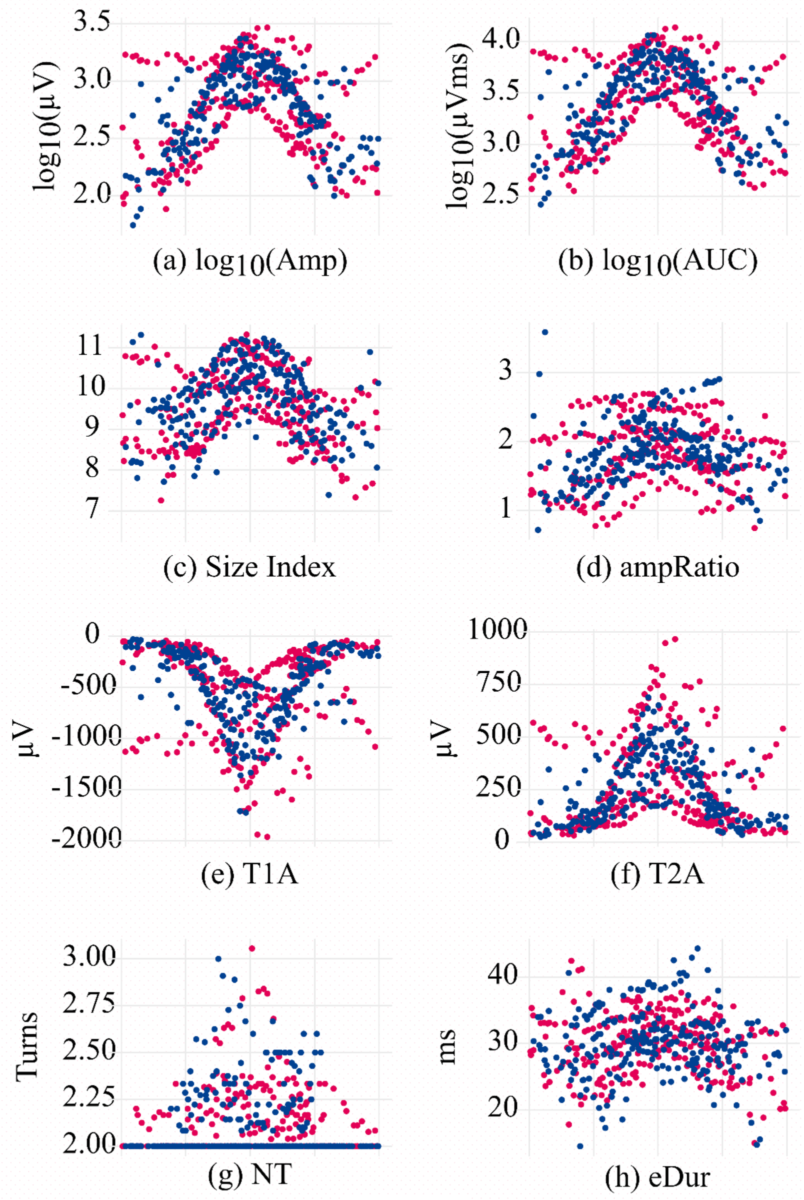


Fig.2

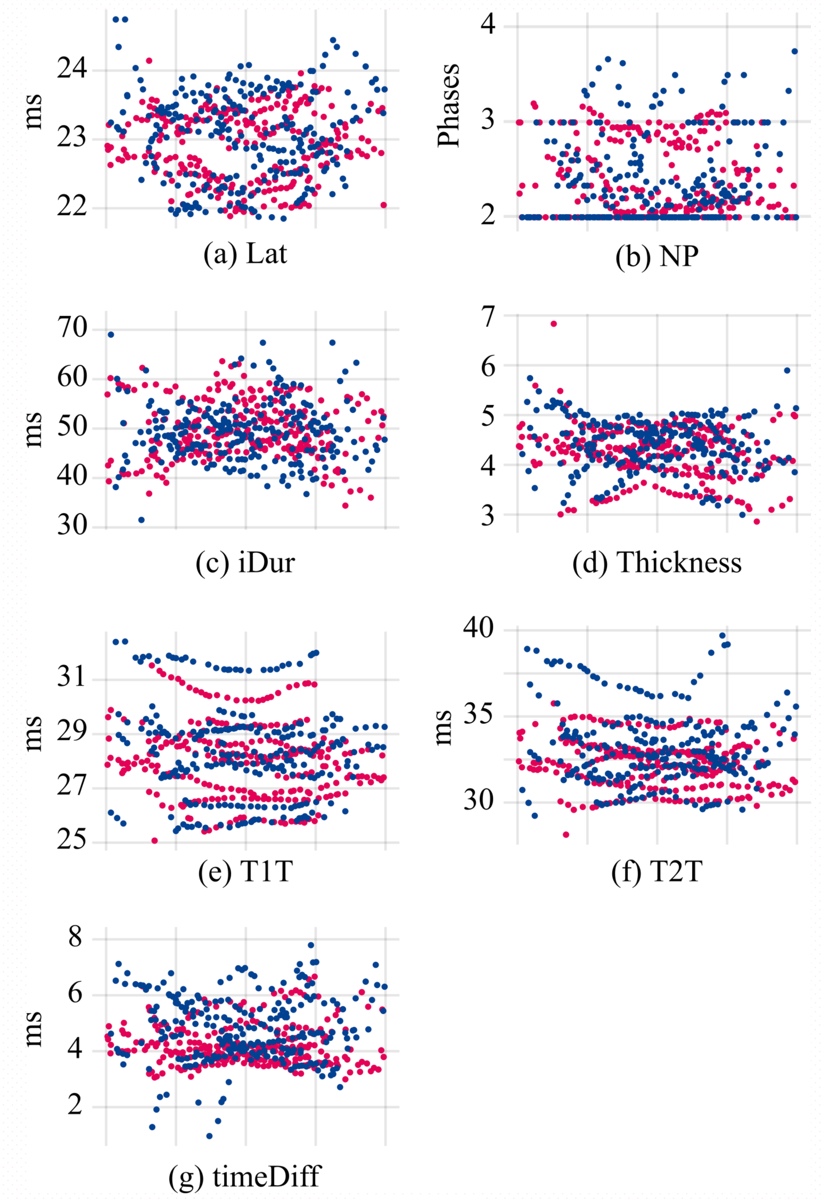


Fig. 3

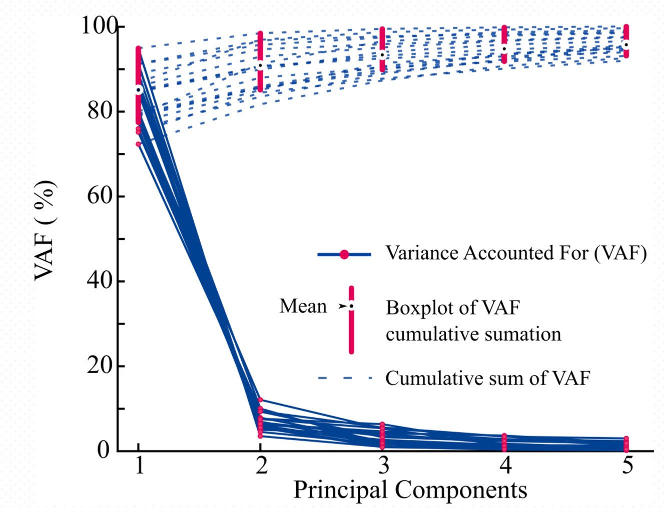


Fig. 4

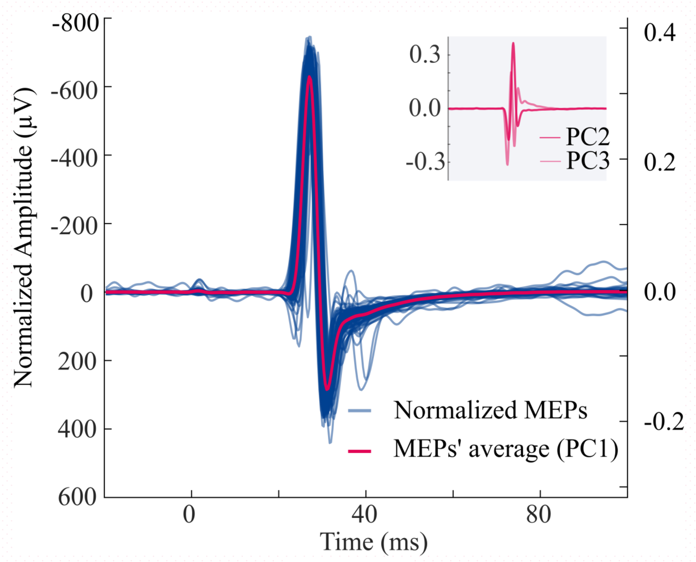


Fig. 5

Table 1

| Feature | ICC |
|---|---|
| Amp | 0.23 |
| AUC | 0.21 |
| SizeIndex | 0.17 |
| ampRatio | 0.38 |
| TA1 | 0.19 |
| TA2 | 0.30 |
| NT | 0.52 |
| eDur | 0.73* |

Table 2

| Feature | ICC |
|---|---|
| Latency | 0.87** |
| NP | 0.82* |
| iDur | -0.19 |
| Thickness | 0.84** |
| T1T | 0.91** |
| T2T | 0.78* |
| timeDiff | 0.65* |

ICC Intra-class correlation, *p < 0.05

**As the coil rotated toward the optimal stimulation angle, its size increased while its shape remained unchanged.**

- Fig. 2 and Table 1 include the scattering plots and intra-class correlations (ICC) of eight features that substantively varied with respect to the coil rotation and had low ICC; six of those (a-f) were relating to the size of MEPs.
- NT varied inconsistently and in-between 2-3; hence, the MEPs stayed monophasic.
- Fig. 3 and Table 2 show seven remaining features, which were consistent despite the coil rotation and had good ICC.
- A set of three first principal components (PCs) of normalized MEPs held approximately 97.9% of the total variation, in which the first PC held 83.6% ± 5.7% (Fig. 4).
- Fig. 5 shows one normalized dataset, where the average, or the first PC, held 86.2% of total variation of the whole dataset.

## CONCLUSION

These results demonstrated the shape of MEPs recorded at right FDI was unaffected by the rotation of the stimulation coil at its cortical representation area.

Different from previous studies [1], that stated the Lat and Amp were inversely correlated, Lat and Amp in this study had no correlation. Amp varied as the coil rotates and reached maximum when the coil is at the optimal angle (0º), whereas Lat was constant at 23.0 ± 0.5 ms and had the high ICC of 0.87.

## ACKNOWLEDGEMENT

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## REFERENCES

[1] P. M. Rossini, D. Burke, R. Chen, L. G. Cohen, Z. Daskalakis, R. Di Iorio, V. Di Lazzaro, F. Ferreri, P. B. Fitzgerald, M. S. George, M. Hallett, J. P. Lefaucheur, B. Langguth, H. Matsumoto, C. Miniussi, M. A. Nitsche, A. Pascual-Leone, W. Paulus, S. Rossi, J. C. Rothwell, H. R. Siebner, Y. Ugawa, V. Walsh and U. Ziemann, "Non-invasive electrical and magnetic stimulation of the brain, spinal cord, roots and peripheral nerves: Basic principles and procedures for routine clinical and research application. An updated report from an I.F.C.N. Committee," Clin. Neurophysiol., vol. 126, no. 6, 1071-1107, Jun. 2015.

[2] R. Ilmoniemi, J. Ruohonen and J. Karhu, "Transcranial magnetic stimulation - A new tool for functional imaging of the brain," Crit. Rev. Biomed. Eng., vol. 27, 241-284, Feb 1999.

[3] D. T. A. Nguyen, S. M. Rissanen, P. Julkunen, E. Kallioniemi and P. A. Karjalainen, "Principal Component Regression on Motor Evoked Potential in Single-Pulse Transcranial Magnetic Stimulation," IEEE Trans. Neural Syst. Rehabil. Eng., vol. 27, no. 8, 1521-1528, Jul 2019.

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