Induction of Human Motor Cortex Plasticity by Theta Burst Transcranial Ultrasound Stimulation

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Background and Hypothesis:

Transcranial ultrasound stimulation (TUS) is a novel, non-invasive neuromodulation method that is beginning to be applied in human subjects. We hypothesize that long-term potentiation (LTP)-like plasticity can be induced in the human motor cortex by repetitive TUS.

Materials and Methods:

Three repetitive TUS protocols, theta burst patterned TUS (tbTUS), regularly patterned TUS (rTUS) and sham TUS, were delivered to motor cortex in 15 healthy subjects in separate sessions in random order. The tbTUS and rTUS had same total sonication duration and total time of stimulation. Motor evoked potentials (MEPs) evoked by single and paired pulse TMS were recorded before and at 5 min, 30 min and 60 min after TUS.

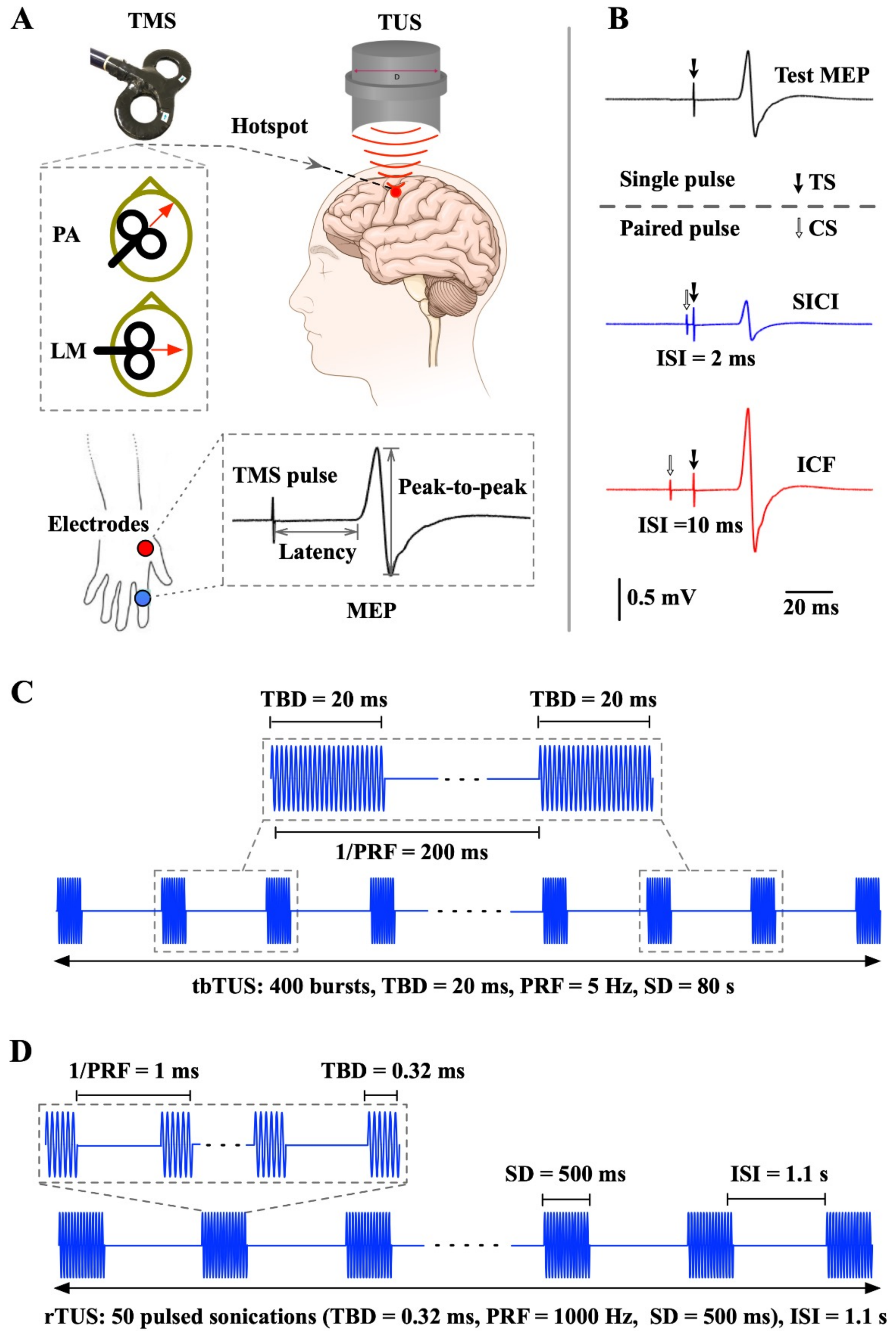

Fig. 1 (A) Schematic of the experimental set-up. (B) Single and paired pulse TMS paradigms. (C) Theta burst patterned TUS. (D) Regularly patterned TUS.

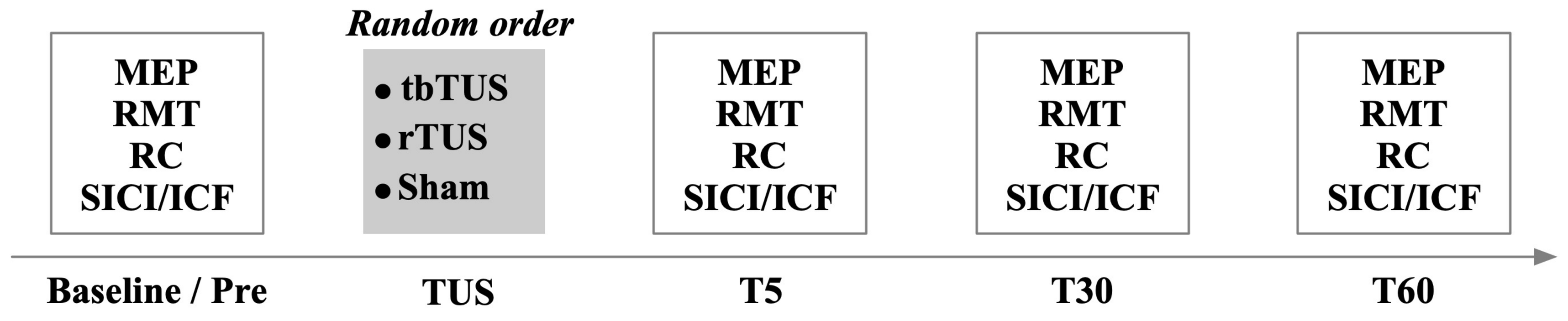

Fig. 2 Experimental paradigms.

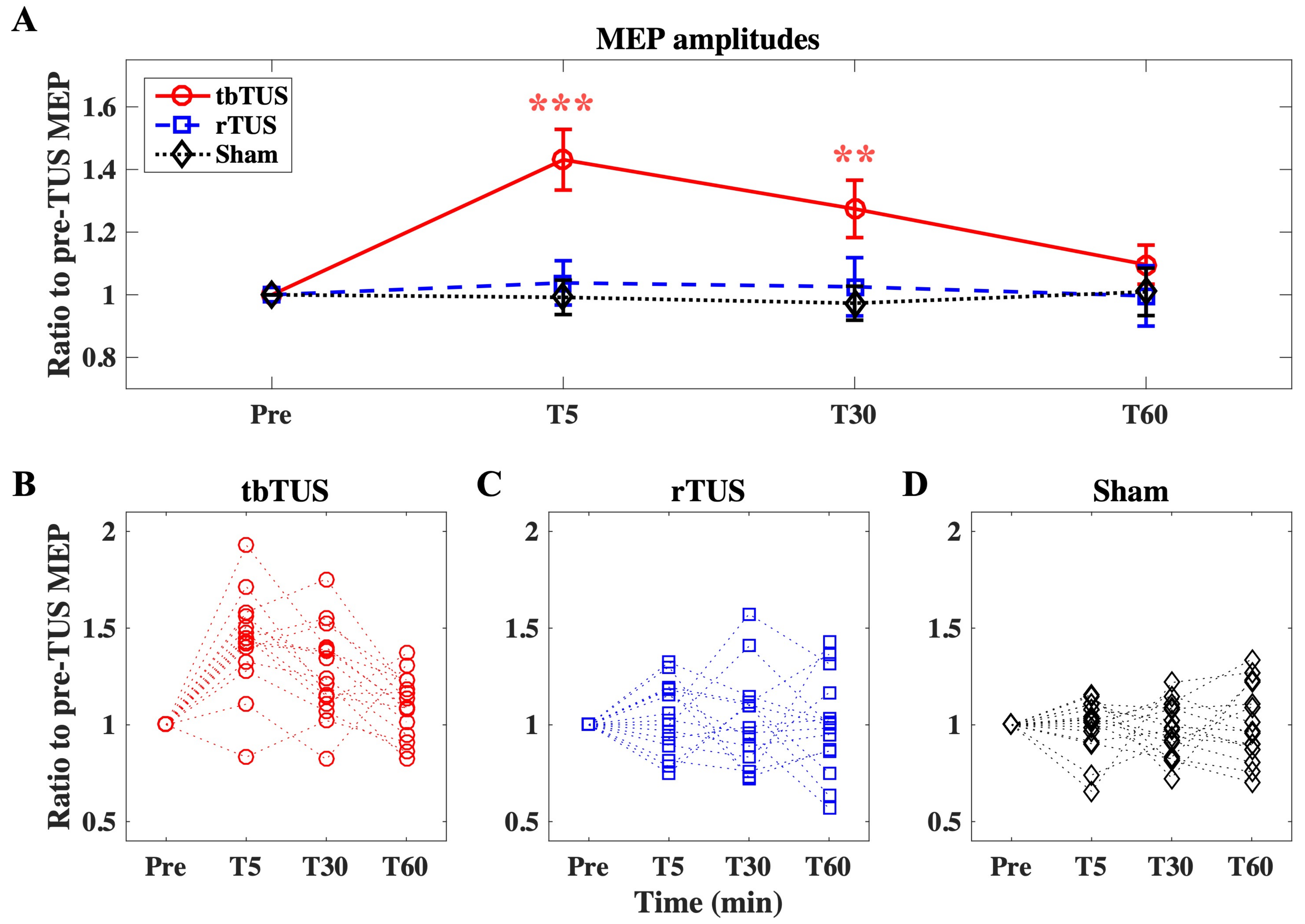

Fig. 3 Effect of repetitive TUS on MEP amplitudes.

Results:

1. MEP amplitudes significantly increased at 5 min (43.4%) and 30 min (27.5%) and returned to baseline level at 60 min after tbTUS.
2. SICI was significantly attenuated at 5 min and 30 min, and ICF was significantly enhanced at 5 min after tbTUS.
3. rTUS and sham TUS had no effect on the MEP amplitudes elicited by both single and paired pulse TMS

Conclusion:

The tbTUS protocol is capable of inducing LTP-like plasticity in human for at least 30 min. The plasticity occurred at the cortical level and involved both inhibitory and excitatory cortical circuits. This LTP-like plasticity was specific to tbTUS and could not be due to sensory confounds associated with TUS.

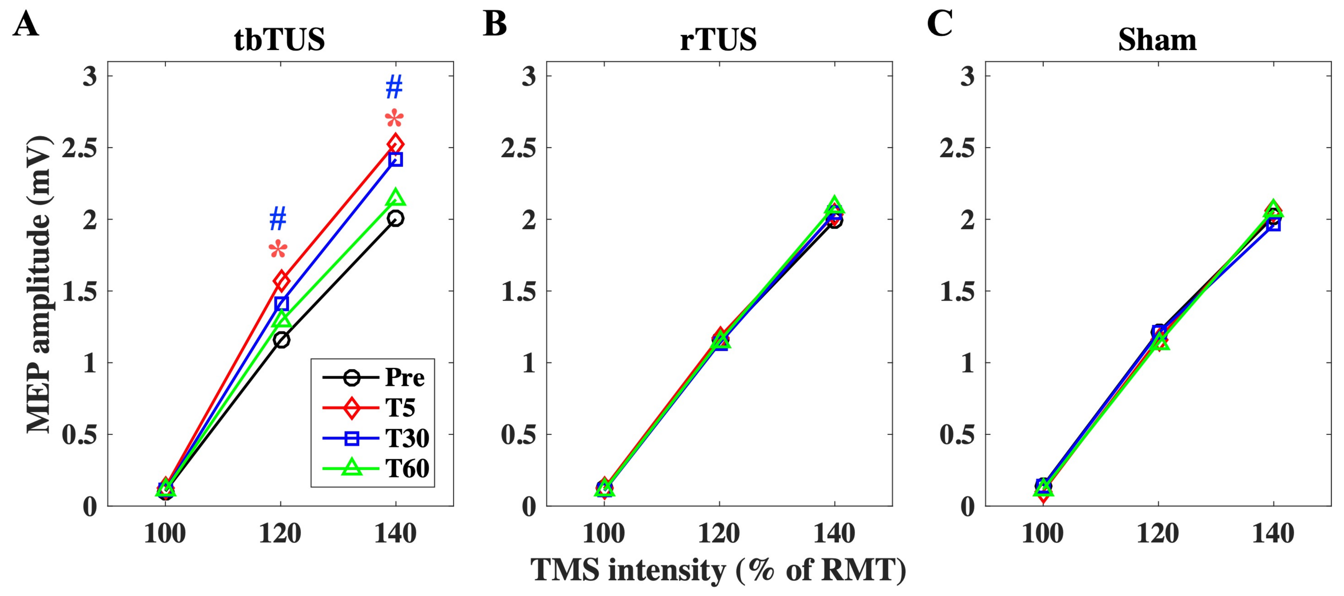

Fig. 4 Effect of repetitive TUS on MEP recruitment curve (RC).

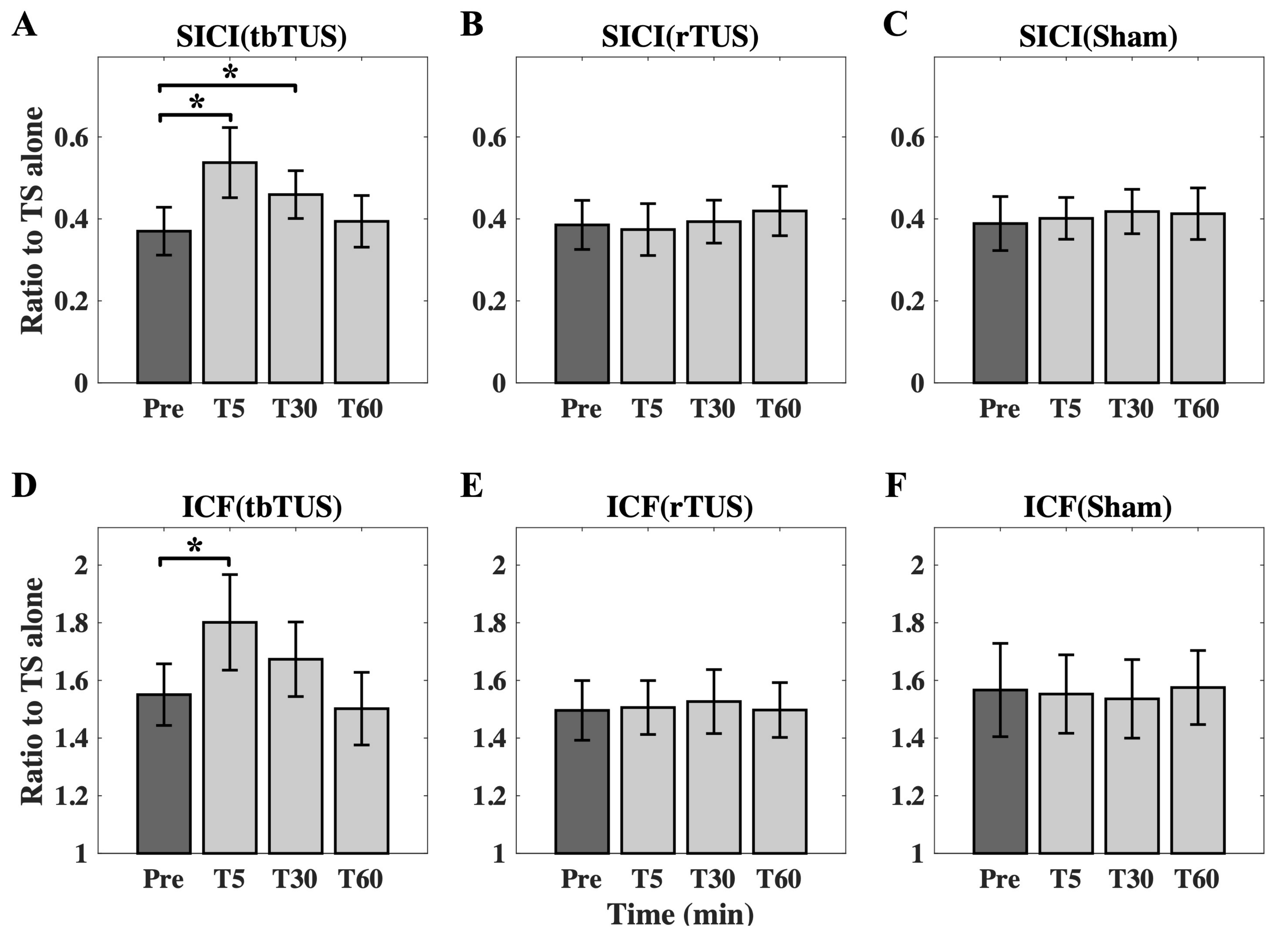

Fig. 5 Effect of repetitive TUS on short intracortical inhibition (SICI) and facilitation (ICF).

Significance:

tbTUS is a novel paradigm to induce cortical plasticity in human and has the potential to be developed for neuromodulation treatment for neurological and psychiatric disorders, and to advance neuroscience research.

Acknowledgements

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UHN Krembil Brain Institute

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