



e-ISSN: 2319-8753 | p-ISSN: 2347-6710

IJIRSET

International Journal of Innovative Research in
SCIENCE | ENGINEERING | TECHNOLOGY



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 11, Issue 9, September 2022

ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA

Impact Factor: 8.118



9940 572 462



6381 907 438



ijirset@gmail.com



www.ijirset.com

Transcranial Magnetic Stimulation: Recent Advances

Dr Debopriya Ghosh, Mr. Romel Kumar Ghosh, Dr Ekta Verma

Department of Physiology, University College of Medical Sciences, Delhi, India.

University of Calcutta, Kolkata, India.

Department of Paediatrics, All India Institute of medical Sciences, Gorakhpur, India.

ABSTRACT: The use of transcranial magnetic stimulation (TMS) in clinical settings and in neuroscience is growing. TMS can now be combined with precise neuronavigation and integrated into a multimodal environment. This review included studies on a variety of TMS applications, with a focus on neuronavigated TMS.

KEYWORDS: TMS, Radiology, TMS, EEG, Neuromechanisms.

I. TMS & RECENT ADVANCE:

The use of transcranial magnetic stimulation (TMS) in clinical settings and in neuroscience is growing [1–5]. TMS applications are mostly for diagnostic and therapeutic purposes. TMS can now be combined with precise neuronavigation and integrated into a multimodal environment, primarily by using complementary methods like functional magnetic resonance imaging (fMRI), electroencephalography (EEG), diffusion tensor imaging (DTI), or magnetoencephalography to guide TMS applications (MEG). Such multimodal techniques allow for the identification and categorization of the effects of stimulation, shedding insight on fundamental neurophysiology and TMS effects in the human brain [6–9]. This review included studies on a variety of TMS applications, with a focus on neuronavigated TMS (nTMS) for mapping cortical functions [10–14], treatment and modulatory effects [15–19], and basic neuromechanisms [20–22], all of which were clinically relevant and Sollmann et al. offered new and supplementary information on the parametric requirements essential to guaranteeing practicable mapping accuracy in addition to a thorough analysis of nTMS motor mapping in clinical application [13]. Additionally, it was determined that the supplemental multimodal data employed (such as for fibre tracking of the descending motor tracts) may offer possible assistance and advancements in nTMS applicability, especially in the crucial cohort of patients with motor-eloquent brain tumours [13]. In addition to the generally accepted imaging data, highlighted applications of nTMS in clinical motor mapping include the mode of risk stratification and potential surgical outcome prediction, as well as observations of neural plasticity related to adjustment and relocation of motor functions within the brains of such patients [13]. In order to realise the full potential of nTMS, Sollmann et al. also highlighted the significance of methodological integration into clinical practises and accompanied systems, while taking into account that successful application necessitates thorough knowledge of the application and its methodological limitations [13]. The authors believe that nTMS and its multimodal applications have enormous promise, not only as a tool for surgical planning but also for giving longitudinal data useful for prognostics and follow-up exams [13]. Schramm et al. proved the use of nTMS as a safe and reliable technology for motor mapping in the intensive care unit (ICU) environment and illustrated its potential advantages by applying it to critically sick patients [12]. The authors showed that post-processed CT pictures provide a workable substitute for MRI for neuronavigation in the ICU setting, where computed tomography (CT) imaging is more appropriate than magnetic resonance imaging (MRI), which is often utilised with nTMS [12]. Given that electromyography (EMG) for motor mapping with nTMS is very susceptible to noise paired to poor signals, the ICU environment is infamously difficult. Successful noise reduction to a practicable level has been achieved in the measured EMG signal [12]. Schramm et al. speculated on the ICU's possible use for prognostics and monitoring of a few brief adverse effects of the nTMS motor mapping technique [12]. Zhang et al. identified language-related areas during nTMS language mapping in patients with language-eloquent brain tumours, and they then provided evidence for structural differences on cortical and subcortical levels between language-positive (i.e., locations where upon stimulation, a modulatory effect on language performance was detected) and language-negative (i.e., locations where no effect of nTMS was detected) areas [14]. With nTMS showing that responsiveness to stimulation is critically related to cortical and subcortical interplay and the rate of speech impairment, their findings in patients with

glioblastomamultiforme added new information about the relationship between speech and language function and brain anatomy [14]. They believed that the outcomes further boosted trust in nTMS-based tractography and language mapping in the therapeutic situation [14]. In their work, Baro et al. described the use of nTMS-based tractography in neurosurgery on a bilingual patient who had undergone nTMS mapping for both languages (Romanian and Italian) and was suffering from a brain tumour in the left temporal lobe [10]. In both language-related assessments, this technique was thought to reveal the anterior part of the lesion's genuine eloquence [10]. The outcome was confirmed following surgery, with both languages' linguistic ability staying unaltered [10]. Action naming may be more advantageous in nTMS mapping in terms of mistake rates and may thus increase the accuracy of nTMS-aided preoperative planning, according to Ohlerthet al., who conducted this study to further refine the protocol of language mapping with nTMS. Their discoveries could significantly affect nTMS language mapping practises in clinical settings, where an object-naming task is often utilised despite its lack of specificity. Phipps et al. reviewed the existing heterogeneous literature-based evidence for using repetitive TMS (rTMS) to improve or restore memory, for example, for applications in the treatment of Alzheimer's disease, and provided several recommendations for the design of upcoming studies using rTMS to modulate human memory performance [17]. With regard to the potential analgesic effects of rTMS for the treatment of chronic refractory pain, Freigang et al. compared two treatment targets and sequences against a sham setting in multi-session therapy for lower back pain, and they discovered signs that treatment on the left dorsolateral prefrontal cortex with 5-Hz rTMS may induce more pain and stress relief than treatment on the primary motor cortex (M1) with 20 Hz [16]. Additionally, Xu et al. research on patients with post-stroke aphasia showed that an intermittent theta-burst stimulation (TBS) protocol on the ipsilesional M1 could cause immediate neural activity and functional connectivity changes in motor, language, and other brain regions as seen through fMRI, which could aid in functional recovery [18]. Dragic' et al. found that continuous TBS counteracted the effects of experimental autoimmune encephalomyelitis (EAE)-induced effects on adenosine signalling in rats in an experimental setting to shed insight on the effectiveness of rTMS in the treatment of multiple sclerosis (MS) [19]. Additionally, it decreased microglia and astrocyte reactivity, indicating a possible TBS-induced reduction in the neuroinflammatory process linked to MS [19]. In their exploratory work combining EEG and rTMS modulation, Casanova et al. discovered that visually evoked and induced gamma oscillations were more pronounced in ASD participants than in neurotypical controls before rTMS modulation [15]. The gamma responses to task-relevant stimuli were significantly reduced following rTMS therapy for ASD, and participants made fewer mistakes as a result [15]. Additionally, scores on behavioural questionnaires used to measure irritation, hyperactivity, and repetitive behaviour following therapy reduced [15]. Regarding the potential contribution of TMS in conjunction with EEG to the comprehension of the mechanisms underlying normal brain ageing, Guerra et al. present a status update and summing review on previously reported data [20]. Tabarelli et al. looked at a sizable open dataset [22] to continue their combined TMS and EEG research and show the functional phase-dependent interactions between frontal, parietal, and occipital parts of the brain to enable EEG-state-dependent TMS. They discovered consistent connection between the parietal and prefrontal areas, but less consistent and weaker connectivity between the occipito-prefrontal and occipito-parietal regions [22]. According to the authors, these findings are an important complement to brain-state-dependent TMS for individuals, with potential implications for tailored therapeutic nTMS [22]. According to Kariminezhad et al., the individual repetition suppression (RS) responses seen in the MEP amplitudes were related to the individual paired associate stimulation (PAS) response, whether expressed as long-term depression (LTD)-like or long-term potentiation (LTP)-like effects on motor-evoked potentials (MEPs) [21]. This discovery was viewed as a positive step by Kariminezhad et al. for forecasting the success of TMS neuromodulation based on the unique RS effect [21].

II. CONCLUSION

The original articles, reviews, and case studies included in this Special Issue all offer engaging reading, strong supporting data, significant suggestive findings, and summarising conclusions based on recent literature. As a result, they are very interesting to anyone involved in clinical applications of nTMS or neuroscience research. We would like to express our appreciation to the writers for their work and wish the readers a joyful and profitable reading experience.

REFERENCES

1. Rossi, S.; Hallett, M.; Rossini, P.M.; Pascual-Leone, A.; Safety of TMS Consensus Group. Safety, ethical considerations, and application guidelines for the use of transcranial magnetic stimulation in clinical practice and research. Clin. Neurophysiol. Off. J. Int. Fed. Clin. Neurophysiol. 2009, 120, 2008–2039. [CrossRef] [PubMed]
2. Rossi, S.; Antal, A.; Bestmann, S.; Bikson, M.; Brewer, C.; Brockmoller, J.; Carpenter, L.L.; Cincotta, M.; Chen, R.; Daskalakis, J.D.; et al. Safety and recommendations for TMS use in healthy subjects and patient populations, with

- up- dates on training, ethical and regulatory issues: Expert Guidelines. Clin. Neurophysiol. Off. J. Int. Fed. Clin. Neurophysiol. 2021, 132, 269–306. [CrossRef] [PubMed]
3. Hallett, M. Transcranial magnetic stimulation: A primer. *Neuron* 2007, 55, 187–199. [CrossRef] [PubMed]
 4. Hallett, M. Transcranial magnetic stimulation and the human brain. *Nature* 2000, 406, 147–150. [CrossRef] [PubMed]
 5. Sollmann, N.; Meyer, B.; Krieg, S.M. Implementing Functional Preoperative Mapping in the Clinical Routine of a Neurosurgical Department: Technical Note. *World Neurosurg.* 2017, 103, 94–105. [CrossRef]
 6. Bergmann, T.O.; Varatheeswaran, R.; Hanlon, C.A.; Madsen, K.H.; Thielscher, A.; Siebner, H.R. Concurrent TMS-fMRI for causal network perturbation and proof of target engagement. *NeuroImage* 2021, 237, 118093. [CrossRef]
 7. Kimiskidis, V.K. Transcranial magnetic stimulation (TMS) coupled with electroencephalography (EEG): Biomarker of the future. *Rev. Neurol.* 2016, 172, 123–126. [CrossRef]
 8. Bestmann, S.; Ruff, C.C.; Blankenburg, F.; Weiskopf, N.; Driver, J.; Rothwell, J.C. Mapping causal interregional influences with concurrent TMS-fMRI. *Exp. Brain Res.* 2008, 191, 383–402. [CrossRef]
 9. Esposito, R.; Bortoletto, M.; Miniussi, C. Integrating TMS, EEG, and MRI as an Approach for Studying Brain Connectivity. *Neuroscientist* 2020, 26, 471–486. [CrossRef]
 10. Baro, V.; Caliri, S.; Sartori, L.; Facchini, S.; Guarrera, B.; Zangrossi, P.; Anglani, M.; Denaro, L.; d'Avella, D.; Ferreri, F.; et al. Preoperative Repetitive Navigated TMS and Functional White Matter Tractography in a Bilingual Patient with a Brain Tumor in Wernicke Area. *Brain Sci.* 2021, 11, 557. [CrossRef]
 11. Ohlerth, A.K.; Bastiaanse, R.; Negwer, C.; Sollmann, N.; Schramm, S.; Schroder, A.; Krieg, S.M. Bihemispheric Navigated Transcranial Magnetic Stimulation Mapping for Action Naming Compared to Object Naming in Sentence Context. *Brain Sci.* 2021, 11, 1190. [CrossRef] [PubMed]
 12. Schramm, S.; Haddad, A.F.; Chyall, L.; Krieg, S.M.; Sollmann, N.; Tarapore, P.E. Navigated TMS in the ICU: Introducing Motor Mapping to the Critical Care Setting. *Brain Sci.* 2020, 10, 1005. [CrossRef] [PubMed]
 13. Sollmann, N.; Krieg, S.M.; Saisanen, L.; Julkunen, P. Mapping of Motor Function with Neuronavigated Transcranial Magnetic Stimulation: A Review on Clinical Application in Brain Tumors and Methods for Ensuring Feasible Accuracy. *Brain Sci.* 2021, 11, 897. [CrossRef] [PubMed]
 14. Zhang, H.; Schramm, S.; Schroder, A.; Zimmer, C.; Meyer, B.; Krieg, S.M.; Sollmann, N. Function-Based Tractography of the Language Network Correlates with Aphasia in Patients with Language-Eloquent Glioblastoma. *Brain Sci.* 2020, 10, 412. [CrossRef] [PubMed]
 15. Casanova, M.F.; Shaban, M.; Ghazal, M.; El-Baz, A.S.; Casanova, E.L.; Opris, I.; Sokhadze, E.M. Effects of Transcranial Magnetic Stimulation Therapy on Evoked and Induced Gamma Oscillations in Children with Autism Spectrum Disorder. *Brain Sci.* 2020, 10, 423. [CrossRef]
 16. Freigang, S.; Lehner, C.; Fresnoza, S.M.; Mahdy Ali, K.; Hlavka, E.; Eitler, A.; Szilagyi, I.; Bornemann-Ciment, H.; Deutschmann, H.; Reishofer, G.; et al. Comparing the Impact of Multi-Session Left Dorsolateral Prefrontal and Primary Motor Cortex Neuronavigated Repetitive Transcranial Magnetic Stimulation (nrTMS) on Chronic Pain Patients. *Brain Sci.* 2021, 11, 961. [CrossRef]
 17. Phipps, C.J.; Murman, D.L.; Warren, D.E. Stimulating Memory: Reviewing Interventions Using Repetitive Transcranial Magnetic Stimulation to Enhance or Restore Memory Abilities. *Brain Sci.* 2021, 11, 283. [CrossRef]
 18. Xu, S.; Yang, Q.; Chen, M.; Deng, P.; Zhuang, R.; Sun, Z.; Li, C.; Yan, Z.; Zhang, Y.; Jia, J. Capturing Neuroplastic Changes after iTBS in Patients with Post-Stroke Aphasia: A Pilot fMRI Study. *Brain Sci.* 2021, 11, 1451. [CrossRef]
 19. Dragic, M.; Zeljkovic, M.; Stevanovic, I.; Adzic, M.; Stekic, A.; Mihajlovic, K.; Grkovic, I.; Ilic, N.; Ilic, T.V.; Nedeljkovic, N.; et al. Downregulation of CD73/A2AR-Mediated Adenosine Signaling as a Potential Mechanism of Neuroprotective Effects of Theta- Burst Transcranial Magnetic Stimulation in Acute Experimental Autoimmune Encephalomyelitis. *Brain Sci.* 2021, 11, 736. [CrossRef]
 20. Guerra, A.; Rocchi, L.; Grego, A.; Berardi, F.; Luisi, C.; Ferreri, F. Contribution of TMS and TMS-EEG to the Understanding of Mechanisms Underlying Physiological Brain Aging. *Brain Sci.* 2021, 11, 405. [CrossRef]
 21. Kariminezhad, S.; Karhu, J.; Säisänen, L.; Reijonen, J.; Könönen, M.; Julkunen, P. Brain Response Induced with Paired Associative Stimulation Is Related to Repetition Suppression of Motor Evoked Potential. *Brain Sci.* 2020, 10, 674. [CrossRef] [PubMed]
 22. Tabarelli, D.; Brancaccio, A.; Zrenner, C.; Belardinelli, P. Functional Connectivity States of Alpha Rhythm Sources in the Human Cortex at Rest: Implications for Real-Time Brain State Dependent EEG-TMS. *Brain Sci.* 2022, 12, 348. [CrossRef] [PubMed]



INNO SPACE
SJIF Scientific Journal Impact Factor
Impact Factor: 8.118



ISSN INTERNATIONAL
STANDARD
SERIAL
NUMBER
INDIA



INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

 **9940 572 462**  **6381 907 438**  **ijirset@gmail.com**



www.ijirset.com

Scan to save the contact details