Title

Neuropsychological and Anatomical-Functional Effects of Transcranial Magnetic Stimulation in Post-Stroke Patients with Cognitive Impairment and Aphasia: A Systematic Review

Abstract

Transcranial magnetic stimulation (TMS) has been found to be promising in the neurorehabilitation of post-stroke patients. Aphasia and cognitive impairment (CI) are prevalent post-stroke; however, there is still a lack of consensus about the characteristics of interventions based on TMS and its neuropsychological and anatomical-functional benefits. Therefore, studies that contribute to creating TMS protocols for these neurological conditions are necessary. To analyze the evidence of the neuropsychological and anatomical-functional TMS effects in post-stroke patients with CI and aphasia and determine the characteristics of the most used TMS in research practice. The present study followed the PRISMA guidelines and included articles from PubMed, Scopus, Web of Science, ScienceDirect, and EMBASE databases, published between January 2010 and March 2023. In the 15 articles reviewed, it was found that attention, memory, executive function, language comprehension, naming, and verbal fluency (semantic and phonological) are the neuropsychological domains that improved post-TMS. Moreover, TMS in aphasia and post-stroke CI contribute to greater frontal activation (in the inferior frontal gyrus, pars triangularis, and opercularis). Temporoparietal effects were also found. The observed effects occur when TMS is implemented in repetitive modality, at a frequency of 1 Hz, in sessions of 30 min, and that last more than 2 weeks in duration. The use of TMS contributes to the neurorehabilitation process in post-stroke patients with CI and aphasia. However, it is still necessary to standardize future intervention protocols based on accurate TMS characteristics.

part of Springer Nature 2024.

Authors

Pezoa–Peña I.; Julio–Ramos T.; Cigarroa I.; Martella D.; Solomons D.; Toloza–Ramirez D.

Author full names

Pezoa–Peña, Ignacio (59167824100); Julio–Ramos, Teresa (59168074500); Cigarroa, Igor (56115080200); Martella, Diana (13408099500); Solomons, Daniel (57221390964); Toloza–Ramirez, David (59167944500)

Author(s) ID

59167824100; 59168074500; 56115080200; 13408099500; 57221390964; 59167944500

Year

2024

Source title

Neuropsychology Review

DOI

10.1007/s11065-024-09644-4

Link

https://www.scopus.com/inward/record.uri?eid=2-s2.0-85195649775&doi=10.1007%2fs11065-024-09644-4&partnerID=40&md5=e2d33bdb044cc901b061c28c7c464071

Affiliations

Master’s program in Neuroscience, Universidad Autonoma de Chile, Temuco, Chile; Laboratory of Language Rehabilitation and Stimulation (LARES), Speech and Language Therapy School, Health Sciences Department, Faculty of Medicine, Pontificia Universidad Católica de Chile, Santiago, Chile; PhD Program in Health Sciences and Engineering, Universidad de Valparaiso, Valparaiso, Chile; Escuela de kinesiología, Facultad de Ciencias de la Salud, Universidad Católica Silva Henríquez, Santiago, Chile; Facultad de Ciencias de la Salud, Universidad Arturo Prat, VIC, Chile; Departamento de Psicología, Facultad de Ciencias Sociales y Humanas, Universidad Loyola, Campus Sevilla, Sevilla, Spain; Institute for Biological and Medical Engineering, Pontificia Universidad Católica de Chile, Santiago, Chile; Millenium Institute for Intelligent Healthcare Engineering (iHEALTH), Santiago, Chile; Exercise and Rehabilitation Sciences Institute, School of Speech Therapy, Faculty of Rehabilitation Sciences, Universidad Andres Bello, Fernández Concha 700, Las Condes, Santiago, 7591538, Chile; Interdisciplinary Center for Neuroscience, Faculty of Medicine, Pontificia Universidad Católica de Chile, Santiago, Chile

Authors with affiliations

Pezoa–Peña I., Master's program in Neuroscience, Universidad Autonoma de Chile, Temuco, Chile; Julio–Ramos T., Laboratory of Language Rehabilitation and Stimulation (LARES), Speech and Language Therapy School, Health Sciences Department, Faculty of Medicine, Pontificia Universidad Católica de Chile, Santiago, Chile, PhD Program in Health Sciences and Engineering, Universidad de Valparaiso, Valparaiso, Chile; Cigarroa I., Escuela de kinesiología, Facultad de Ciencias de la Salud, Universidad Católica Silva Henríquez, Santiago, Chile, Facultad de Ciencias de la Salud, Universidad Arturo Prat, VIC, Chile; Martella D., Departamento de Psicología, Facultad de Ciencias Sociales y Humanas, Universidad Loyola, Campus Sevilla, Sevilla, Spain; Solomons D., Institute for Biological and Medical Engineering, Pontificia Universidad Católica de Chile, Santiago, Chile, Millenium Institute for Intelligent Healthcare Engineering (iHEALTH), Santiago, Chile; Toloza–Ramirez D., Exercise and Rehabilitation Sciences Institute, School of Speech Therapy, Faculty of Rehabilitation Sciences, Universidad Andres Bello, Fernández Concha 700, Las Condes, Santiago, 7591538, Chile, Interdisciplinary Center for Neuroscience, Faculty of Medicine, Pontificia Universidad Católica de Chile, Santiago, Chile

Author Keywords

Aphasia; Brain activation; Neuropsychology; Post-stroke cognitive impairment; Stroke; Transcranial magnetic stimulation

References

Akkad H., Hope T.M.H., Howland C., Ondobaka S., Pappa K., Nardo D., Duncan J., Leff A.P., Crinion J., Mapping spoken language and cognitive deficits in post-stroke

aphasia, NeuroImage: Clinical, 39, (2023); Allendorfer J.B., Nenert R., Vannest J., Szaflarski J.P., A Pilot Randomized Controlled Trial of Intermittent Theta Burst Stimulation as Stand-Alone Treatment for Post-Stroke Aphasia: Effects on Language and Verbal Functional Magnetic Resonance Imaging (fMRI), Medical Science Monitor, 28, (2021); Allendorfer J.B., Storrs J.M., Szaflarski J.P., Changes in white matter integrity follow excitatory rTMS treatment of post-stroke aphasia, Restorative Neurology and Neuroscience, 30, 2, pp. 103-113, (2012); Arheix-Parras S., Barrios C., Python G., Cogne M., Sibon I., Engelhardt M., Dehail P., Cassoudesalle H., Moucheboeuf G., Glize B., A systematic review of repetitive transcranial magnetic stimulation in aphasia rehabilitation: Leads for future studies, Neuroscience & Biobehavioral Reviews, 127, pp. 212-241, (2021); Bai G., Jiang L., Ma W., Meng P., Li J., Wang Y., Wang Q., Effect of low-frequency rTMS and intensive speech therapy treatment on patients with nonfluent aphasia after stroke, The Neurologist, 26, 1, pp. 6-9, (2020); Bai G., Jiang L., Huan S., Meng P., Wang Y., Pan X., Yin S., Zhao Y., Wang Q., Study on low-frequency repetitive transcranial magnetic stimulation improves speech function and mechanism in patients with non-fluent aphasia after stroke, Frontiers in Aging Neuroscience, 14, (2022); Bai Z., Zhang J., Fong K.N.K., Effects of transcranial magnetic stimulation in modulating cortical excitability in patients with stroke: A systematic review and meta-analysis, Journal of NeuroEngineering and Rehabilitation, 19, 1, (2022); Barwood C.H.S., Murdoch B.E., Whelan B.M., Lloyd D., Riek S., O'Sullivan J., Coulthard A., Wong A., Aitken P., Hall G., The effects of low frequency repetitive transcranial magnetic stimulation (rTMS) and sham condition rTMS on behavioural language in chronic non-fluent aphasia: Short term outcomes, Neurorehabilitation, 28, 2, pp. 113-128, (2011); Bath P.M., Lee H.S., Everton L.F., Swallowing therapy for dysphagia in acute and subacute stroke, Cochrane Database of Systematic Reviews, 2018, 10, (2018); Begemann M.J., Brand B.A., Curcic-Blake B., Aleman A., Sommer I.E., Efficacy of non-invasive brain stimulation on cognitive functioning in brain disorders: A meta-analysis,

Psychological Medicine, 50, 15, pp. 2465-2486, (2020); 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, 237, (2021); Blaszcz M., Prucnal N., Wrzesniewski K., Pasiut S., Mika P., Kucia M., Stach B., Wozniak M., Mirek E., Physical activity, psychological and functional outcomes in non-ambulatory stroke patients during rehabilitation—A pilot study, Journal of Clinical Medicine, 11, 24, (2022); Blesneag A.V., Slavoaca D.F., Popa L., Stan A.D., Jemna N., Moldovan F.I., Muresanu D.F., Low-frequency rTMS in patients with subacute ischemic stroke: Clinical evaluation of short and long-term outcomes and neurophysiological assessment of cortical excitability, Journal of Medicine and Life, 8, 3, pp. 378-387, (2015); Boehme A.K., Esenwa C., Elkind M.S.V., Stroke risk factors, genetics, and prevention, Circulation Research, 120, 3, pp. 472-495, (2017); Bolgina T., Somashekarappa V., Cappa S.F., Cherkasova Z., Feurra M., Malyutina S., Sapuntsova A., Shtyrov Y., Dragoy O., Repetitive transcranial magnetic stimulation modulates action naming over the left but not right inferior frontal gyrus, Brain Structure and Function, 227, 8, pp. 2797-2808, (2022); Braden A.A., Weatherspoon S.E., Boardman T., Williard T., Adkins A., Gibbs S.K., Wheless J.W., Narayana S., Image-guided TMS is safe in a predominately pediatric clinical population, Clinical Neurophysiology, 137, pp. 193-206, (2022); Breining B.L., Sebastian R., Neuromodulation in post-stroke aphasia treatment, Current Physical Medicine and Rehabilitation Reports, 8, 2, pp. 44-56, (2020); Brodtmann A., Khlif M.S., Egorova N., Veldsman M., Bird L.J., Werden E., Dynamic regional brain atrophy rates in the first year after ischemic stroke, Stroke, 51, 9, pp. e183-e192, (2020); Cha B., Kim J., Kim J.M., Choi J.W., Choi J., Kim K., Cha J., Kim M., Therapeutic effect of repetitive transcranial magnetic stimulation for post-stroke vascular cognitive impairment: A prospective pilot study, Frontiers in Neurology, 13, (2022); Chieffo R., Giatsidis F., Santangelo R., Alyagon U., Comola M., Zangen A., Comi G., Leocani L., Repetitive transcranial magnetic stimulation with

H-coil coupled with cycling for improving lower limb motor function after stroke: An exploratory study, Neuromodulation: Technology at the Neural Interface, 24, 5, pp. 916-922, (2021); Chou Y., That V.T., Sundman M., A systematic review and meta-analysis of rTMS effects on cognitive enhancement in mild cognitive impairment and Alzheimer's disease, Neurobiology of Aging, 86, pp. 1-10, (2020); Chou T.Y., Wang J.C., Lin M.Y., Tsai P.Y., Low-frequency vs. theta burst transcranial magnetic stimulation for the treatment of chronic non-fluent aphasia in stroke: A proof-of-concept study, Frontiers in Aging Neuroscience, 13, (2022); Chou Y., Sundman M., That V.T., Green J., Trapani C., Cortical excitability and plasticity in Alzheimer's disease and mild cognitive impairment: A systematic review and meta-analysis of transcranial magnetic stimulation studies, Ageing Research Reviews, 79, (2022); Cortes M., Black-Schaffer R.M., Edwards D.J., Transcranial magnetic stimulation as an investigative tool for motor dysfunction and recovery in stroke: An overview for neurorehabilitation clinicians, Neuromodulation: Technology at the Neural Interface, 15, 4, pp. 316-325, (2012); de Araujo A.V.L., Barbosa V.R.N., Galdino G.S., Fregni F., Massetti T., Fontes S.L., Silva D., de Silva O., da Monteiro T.D., de Tonks C.B., Magalhaes F.H., Effects of high-frequency transcranial magnetic stimulation on functional performance in individuals with incomplete spinal cord injury: Study protocol for a randomized controlled trial, Trials, 18, 1, (2017); Denslow S., Lomarev M., George M.S., Bohning D.E., Cortical and subcortical brain effects of Transcranial Magnetic Stimulation (TMS)-induced movement: An interleaved TMS/functional magnetic resonance imaging study, Biological Psychiatry, 57, 7, pp. 752-760, (2005); Dionisio A., Gouveia R., Castelhano J., Duarte I.C., Santo G.C., Sargento-Freitas J., Duecker F., Castelo-Branco M., The role of continuous theta burst TMS in the neurorehabilitation of subacute stroke patients: A placebo-controlled study, Frontiers in Neurology, 12, (2021); El-Tamawy M.S., Darwish M.H., Elkholy S.H., Moustafa E.B.S., Abulkassem S.T., Khalifa H.A., Low frequency transcranial magnetic stimulation in subacute ischemic stroke: Number of

sessions that altered cortical excitability, Neurorehabilitation, 47, 4, pp. 427-434, (2020); Fahmy E.M., Elshebawy H.M., Effect of high frequency transcranial magnetic stimulation on recovery of chronic post-stroke aphasia, Journal of Stroke and Cerebrovascular Diseases, 30, 8, (2021); Ferro M., Lamanna J., Spadini S., Nespoli A., Sulpizio S., Malgaroli A., Synaptic plasticity mechanisms behind TMS efficacy: Insights from its application to animal models, Journal of Neural Transmission, 129, 1, pp. 25-36, (2022); Ford H., Hahn L., Clarke P., Gill S., Carnell B., Galletly C., A comparison of 15 minute vs 30 minute repetitive transcranial magnetic stimulation sessions for treatment resistant depression – are longer treatment sessions more effective?, Journal of Affective Disorders, 282, pp. 974-978, (2021); Fox M.D., Halko M.A., Eldaief M.C., Pascual-Leone A., Measuring and manipulating brain connectivity with resting state functional connectivity magnetic resonance imaging (fcMRI) and transcranial magnetic stimulation (TMS), Neuroimage, 62, 4, pp. 2232-2243, (2012); Ge R., Humaira A., Gregory E., Alamian G., MacMillan E.L., Barlow L., Todd R., Nestor S., Frangou S., Vila-Rodriguez F., Predictive value of acute neuroplastic response to rTMS in treatment outcome in depression: A concurrent TMS-fMRI trial, American Journal of Psychiatry, 179, 7, pp. 500-508, (2022); Georgiou A.M., Kambanaros M., The effectiveness of transcranial magnetic stimulation (TMS) paradigms as treatment options for recovery of language deficits in chronic poststroke aphasia, Behavioural Neurology, 2022, (2022); Georgiou A., Konstantinou N., Phinikettos I., Kambanaros M., Neuronavigated theta burst stimulation for chronic aphasia: Two exploratory case studies, Clinical Linguistics & Phonetics, 33, 6, pp. 532-546, (2019); Georgiou A.M., Phinikettos I., Giasafaki C., Kambanaros M., Can transcranial magnetic stimulation (TMS) facilitate language recovery in chronic global aphasia post-stroke? Evidence from a case study, Journal of Neurolinguistics, 55, (2020); Gholami M., Pourbaghi N., Taghvatalab S., Evaluation of rTMS in patients with poststroke aphasia: A systematic review and focused meta-analysis, Neurological Sciences, 43, 8, pp. 4685-4694, (2022); Goldberg E.B., Meier E.L., Sheppard S.M.,

Breining B.L., Hillis A.E., Stroke recurrence and its relationship with language abilities, Journal of Speech Language and Hearing Research, 64, 6, pp. 2022-2037, (2021); Gong C., Hu H., Peng X.M., Li H., Xiao L., Liu Z., Zhong Y.B., Wang M.Y., Luo Y., Therapeutic effects of repetitive transcranial magnetic stimulation on cognitive impairment in stroke patients: A systematic review and meta-analysis, Frontiers in Human Neuroscience, 17, (2023); Halevi D.R., Bursaw A.W., Karamchandani R.R., Alderman S.E., Breier J.I., Vahidy F.S., Aden J.K., Cai C., Zhang X., Savitz S.I., Cognitive deficits in acute mild ischemic stroke and TIA and effects of rt-PA, Annals of Clinical and Translational Neurology, 6, 3, pp. 466-474, (2019); Halko M.A., Eldaief M.C., Horvath J.C., Pascual-Leone A., Combining transcranial magnetic stimulation and fMRI to examine the default mode network, Journal of Visualized Experiments, (2010); Hallett M., Transcranial magnetic stimulation: A primer, Neuron, 55, 2, pp. 187-199, (2007); Han K., Liu J., Tang Z., Su W., Liu Y., Lu H., Zhang H., Effects of excitatory transcranial magnetic stimulation over the different cerebral hemispheres dorsolateral prefrontal cortex for post-stroke cognitive impairment: A systematic review and meta-analysis, Frontiers in Neuroscience, 17, (2023); Hara T., Abo M., Kobayashi K., Watanabe M., Kakuda W., Senoo A., Effects of low-frequency repetitive transcranial magnetic stimulation combined with intensive speech therapy on Cerebral Blood Flow in Post-stroke Aphasia, Translational Stroke Research, 6, 5, pp. 365-374, (2015); Harvey D.Y., Podell J., Turkeltaub P.E., Faseyitan O., Coslett H.B., Hamilton R.H., Functional reorganization of right prefrontal cortex underlies sustained naming improvements in chronic aphasia via repetitive transcranial magnetic stimulation, Cognitive and Behavioral Neurology, 30, 4, pp. 133-144, (2017); Havrankova P., Jech R., Walker N.D., Operto G., Tauchmanova J., Vymazal J., Dusek P., Hromcik M., Ruzicka E., Repetitive TMS of the somatosensory cortex improves writer’s cramp and enhances cortical activity, Neuro Endocrinology Letters, 31, 1, pp. 73-86, (2010); Higgins J.P., Savovic J., Page M.J., Elbers R.G., Sterne J.A., Chapter 8: Assessing risk of bias in a randomized trial,

Cochrane Handbook for Systematic Reviews of Interventions version 6.3 (updated February 2022), (2022); Hong Z., Zheng H., Luo J., Yin M., Ai Y., Deng B., Feng W., Hu X., Effects of low-frequency repetitive transcranial magnetic stimulation on language recovery in poststroke survivors with aphasia: An updated meta-analysis, Neurorehabilitation and Neural Repair, 35, 8, pp. 680-691, (2021); Hou M., di, Santoro V., Biondi A., Shergill S.S., Premoli I., A systematic review of TMS and neurophysiological biometrics in patients with schizophrenia, Journal of Psychiatry and Neuroscience, 46, 6, pp. E675-E701, (2021); Hugues N., Pellegrino C., Rivera C., Berton E., Pin-Barre C., Laurin J., Is high-intensity interval training suitable to promote neuroplasticity and cognitive functions after stroke?, International Journal of Molecular Sciences, 22, 6, (2021); Iglesias A.H., Transcranial magnetic stimulation as treatment in multiple neurologic conditions, Current Neurology and Neuroscience Reports, 20, 1, (2020); Iriarte I.G., George M.S., Transcranial magnetic stimulation (TMS) in the elderly, Current Psychiatry Reports, 20, 1, (2018); Keser Z., Buchl S.C., Seven N.A., Markota M., Clark H.M., Jones D.T., Lanzino G., Brown R.D., Worrell G.A., Lundstrom B.N., Electroencephalogram (EEG) with or without transcranial magnetic stimulation (TMS) as biomarkers for post-stroke recovery: A narrative review, Frontiers in Neurology, 13, (2022); Khedr E.M., El-Fetoh N.A., Ali A.M., El-Hammady D.H., Khalifa H., Atta H., Karim A.A., Dual-hemisphere repetitive transcranial magnetic stimulation for rehabilitation of poststroke aphasia, Neurorehabilitation and Neural Repair, 28, 8, pp. 740-750, (2014); Kielar A., Patterson D., Chou Y., Efficacy of repetitive transcranial magnetic stimulation in treating stroke aphasia: Systematic review and meta-analysis, Clinical Neurophysiology, 140, pp. 196-227, (2022); Kim W.S., Kwon B.S., Seo H.G., Park J., Paik N.J., Low-frequency repetitive transcranial magnetic stimulation over contralesional motor cortex for motor recovery in subacute ischemic stroke: A randomized sham-controlled trial, Neurorehabilitation and Neural Repair, 34, 9, pp. 856-867, (2020); Kindler J., Schumacher R., Cazzoli D., Gutbrod K., Koenig M., Nyffeler T., Dierks T., Muri R.M.,

Theta burst stimulation over the right Broca's Homologue induces improvement of naming in aphasic patients, Stroke, 43, 8, pp. 2175-2179, (2012); Klomjai W., Katz R., Lackmy-Vallee A., Basic principles of transcranial magnetic stimulation (TMS) and repetitive TMS (rTMS), Annals of Physical and Rehabilitation Medicine, 58, 4, pp. 208-213, (2015); Lefaucheur J.P., Chapter 37 transcranial magnetic stimulation, Handbook of Clinical Neurology, 160, pp. 559-580, (2019); Lefaucheur J.P., Andre-Obadia N., Antal A., Ayache S.S., Baeken C., Benninger D.H., Cantello R.M., Cincotta M., de Carvalho M., Ridder D.D., Devanne H., Lazzaro V.D., Filipovic S.R., Hummel F.C., Jaaskelainen S.K., Kimiskidis V.K., Koch G., Langguth B., Nyffeler T., Garcia-Larrea L., Evidence-based guidelines on the therapeutic use of repetitive transcranial magnetic stimulation (rTMS), Clinical Neurophysiology, 125, 11, pp. 2150-2206, (2014); Lefaucheur J.P., Aleman A., Baeken C., Benninger D.H., Brunelin J., Lazzaro V.D., Filipovic S.R., Grefkes C., Hasan A., Hummel F.C., Jaaskelainen S.K., Langguth B., Leocani L., Londero A., Nardone R., Nguyen J.P., Nyffeler T., Oliveira-Maia A.J., Oliviero A., Ziemann U., Evidence-based guidelines on the therapeutic use of repetitive transcranial magnetic stimulation (rTMS): An update (2014–2018), Clinical Neurophysiology, 131, 2, pp. 474-528, (2020); Li K.P., Sun J., Wu C.Q., An X., Wu J.J., Zheng M.X., Hua X.Y., Xu J.G., Effects of repetitive transcranial magnetic stimulation on post-stroke patients with cognitive impairment: A systematic review and meta-analysis, Behavioural Brain Research, 439, (2023); Li Y., Luo H., Yu Q., Yin L., Li K., Li Y., Fu J., Cerebral functional manipulation of repetitive transcranial magnetic stimulation in cognitive impairment patients after stroke: An fMRI study, Frontiers in Neurology, 11, (2020); Lin B.F., Yeh S.C., Kao Y.C.J., Lu C.F., Tsai P.Y., Functional remodeling associated with language recovery after repetitive transcranial magnetic stimulation in chronic aphasic stroke, Frontiers in Neurology, 13, (2022); Liu Y., Yin M., Luo J., Huang L., Zhang S., Pan C., Hu X., Effects of transcranial magnetic stimulation on the performance of the activities of daily living and attention function after stroke: A randomized controlled

trial, Clinical Rehabilitation, 34, 12, pp. 1465-1473, (2020); Long H., Wang H., Zhao C., Duan Q., Feng F., Hui N., Mao L., Liu H., Mou X., Yuan H., Effects of combining high- and low-frequency repetitive transcranial magnetic stimulation on upper limb hemiparesis in the early phase of stroke, Restorative Neurology and Neuroscience, 36, 1, pp. 21-30, (2018); Luk K.Y., Ouyang H.X., Pang M.Y.C., Low-frequency rTMS over contralesional M1 Increases ipsilesional cortical excitability and motor function with decreased interhemispheric asymmetry in subacute stroke: A randomized controlled study, Neural Plasticity, 2022, (2022); Mahoney J.J., Hanlon C.A., Marshalek P.J., Rezai A.R., Krinke L., Transcranial magnetic stimulation, deep brain stimulation, and other forms of neuromodulation for substance use disorders: Review of modalities and implications for treatment, Journal of the Neurological Sciences, 418, (2020); Malpu-Wiederhold C., Farias-Ulloa C., Cigarroa I., Martella D., Foncea-Gonzalez C., Julio-Ramos T., Mendez-Orellana C., Tollos-Ramirez D., Perfiles cognitivos-lingüísticos en personas mayores con deterioro Cognitivo Leve, Demencia Vascular, Demencia Con Cuerpos De Lewy y Enfermedad De Parkinson, Revista Ecuatoriana De Neurologia, 31, 3, pp. 69-85, (2023); Martin D.M., McClintock S.M., Forster J., Loo C.K., Does therapeutic repetitive transcranial magnetic stimulation cause Cognitive Enhancing effects in patients with neuropsychiatric conditions? A systematic review and Meta-analysis of Randomised controlled trials, Neuropsychology Review, 26, 3, pp. 295-309, (2016); Molina-Ampuero K., Mendez-Orellana C., Fredes-Roa C., Toloza-Ramirez D., La Terapia musical y sus implicaciones en la neurorrehabilitación en pacientes con ictus y con demencia, Neurology Perspectives, 1, 1, pp. 66-81, (2021); Montano A., Hanley D.F., Hemphill J.C., Chapter 13 hemorrhagic stroke, Handbook of Clinical Neurology, 176, pp. 229-248, (2021); Murrell J.E., Pisegna J.L., Juckett L.A., Implementation strategies and outcomes for occupational therapy in adult stroke rehabilitation: A scoping review, Implementation Science, 16, 1, (2021); Oathes D.J., Zimmerman J.P., Duprat R., Japp S.S., Scully M., Rosenberg B.M., Flounders M.W., Long H., Deluisi J.A., Elliott

M., Shandler G., Shinohara R.T., Linn K.A., Resting fMRI-guided TMS results in subcortical and brain network modulation indexed by interleaved TMS/fMRI, Experimental Brain Research, 239, 4, pp. 1165-1178, (2021); Ouzzani M., Hammady H., Fedorowicz Z., Elmagarmid A., Rayyan—a web and mobile app for systematic reviews, Systematic Reviews, 5, 1, (2016); Page M.J., McKenzie J.E., Bossuyt P.M., Boutron I., Hoffmann T.C., Mulrow C.D., Shamseer L., Tetzlaff J.M., Akl E.A., Brennan S.E., Chou R., Glanville J., Grimshaw J.M., Hrobjartsson A., Lalu M.M., Li T., Loder E.W., Mayo-Wilson E., McDonald S., Moher D., The PRISMA 2020 statement: An updated guideline for reporting systematic reviews, Bmj, 372, (2021); Philip N.S., Barredo J., Aiken E., Larson V., Jones R.N., Shea M.T., Greenberg B.D., van't Wout-Frank M., Theta-burst transcranial magnetic stimulation for posttraumatic stress disorder, American Journal of Psychiatry, 176, 11, pp. 939-948, (2019); Riddle J., Scimeca J.M., Pagnotta M.F., Inglis B., Sheltraw D., Muse-Fisher C., D'Esposito M., A guide for concurrent TMS-fMRI to investigate functional brain networks, Frontiers in Human Neuroscience, 16, (2022); Rossi S., Hallett M., Rossini P.M., Pascual-Leone A., Safety, ethical considerations, and application guidelines for the use of transcranial magnetic stimulation in clinical practice and research, Clinical Neurophysiology, 120, 12, pp. 2008-2039, (2009); Ruiz M.L., Sarasa M.L.R., Rodriguez L.S., Benito-Leon J., Ristol E.G.A., Arce S.A., Evidencias actuales Sobre La estimulación magnética transcraneal y su utilidad potencial en la neurorrehabilitación postictus: Ampliando horizontes en El tratamiento de la enfermedad cerebrovascular, Neurología, 33, 7, pp. 459-472, (2018); Sanches C., Stengel C., Godard J., Mertz J., Teichmann M., Migliaccio R., Valero-Cabre A., Past, present, and future of non-invasive brain stimulation approaches to treat cognitive impairment in neurodegenerative diseases: Time for a comprehensive critical review, Frontiers in Aging Neuroscience, 12, (2021); Sasaki N., Mizutani S., Kakuda W., Abo M., Comparison of the effects of high- and low-frequency repetitive transcranial magnetic stimulation on upper limb hemiparesis in the early phase of

stroke, Journal of Stroke and Cerebrovascular Diseases, 22, 4, pp. 413-418, (2013); Schiza E., Matsangidou M., Neokleous K., Pattichis C.S., Virtual reality applications for neurological disease: A review, Frontiers in Robotics and AI, 6, (2019); Schlaug G., Marchina S., Wan C.Y., The Use of non-invasive brain stimulation techniques to facilitate recovery from post-stroke aphasia, Neuropsychology Review, 21, 3, (2011); Shen Q., Hu M., Feng W., Li K.P., Wang W., Narrative review of noninvasive brain stimulation in stroke rehabilitation, Medical Science Monitor, 28, pp. e938298-e938291, (2022); Siebner H., Rothwell J., Transcranial magnetic stimulation: New insights into representational cortical plasticity, Experimental Brain Research, 148, 1, pp. 1-16, (2003); Siebner H.R., Funke K., Aberra A.S., Antal A., Bestmann S., Chen R., Classen J., Davare M., Lazzaro V.D., Fox P.T., Hallett M., Karabanov A.N., Kesselheim J., Beck M.M., Koch G., Liebetanz D., Meunier S., Miniussi C., Paulus W., Ugawa Y., Transcranial magnetic stimulation of the brain: What is stimulated? – A consensus and critical position paper, Clinical Neurophysiology, 140, pp. 59-97, (2022); Somaa F.A., de Graaf T.A., Sack A.T., Transcranial magnetic stimulation in the treatment of neurological diseases, Frontiers in Neurology, 13, (2022); Sonmez A.I., Camsari D.D., Nandakumar A.L., Voort J.L.V., Kung S., Lewis C.P., Croarkin P.E., Accelerated TMS for depression: A systematic review and meta-analysis, Psychiatry Research, 273, pp. 770-781, (2019); Stenberg J., Haberg A.K., Follestad T., Olsen A., Iverson G.L., Terry D.P., Karlsen R.H., Saksvik S.B., Karaliute M., Ek J.A.N., Skandsen T., Vik A., Cognitive reserve moderates cognitive outcome after mild traumatic brain Injury, Archives of Physical Medicine and Rehabilitation, 101, 1, pp. 72-80, (2020); Stern Y., How can cognitive reserve promote cognitive and neurobehavioral health?, Archives of Clinical Neuropsychology, 36, 7, pp. 1291-1295, (2021); Szaflarski J.P., Griffis J., Vannest J., Allendorfer J.B., Nenert R., Amara A.W., Sung V., Walker H.C., Martin A.N., Mark V.W., Zhou X., A feasibility study of combined intermittent theta burst stimulation and modified constraint-induced aphasia therapy in chronic post-stroke

aphasia, Restorative Neurology and Neuroscience, pp. 1-16, (2018); Szaflarski J.P., Nenert R., Allendorfer J.B., Martin A.N., Amara A.W., Griffis J.C., Dietz A., Mark V.W., Sung V.W., Walker H.C., Zhou X., Lindsell C.J., Intermittent theta burst stimulation (iTBS) for treatment of chronic post-stroke aphasia: Results of a pilot randomized, double-blind, sham-controlled trial, Medical Science Monitor, 27, (2021); Szaflarski J.P., Vannest J., Wu S.W., DiFrancesco M.W., Banks C., Gilbert D.L., Excitatory repetitive transcranial magnetic stimulation induces improvements in chronic post-stroke aphasia, Medical Science Monitor: International Medical Journal of Experimental and Clinical Research, 17, 3, pp. 132-139, (2011); Thut G., Pascual-Leone A., A review of combined TMS-EEG studies to characterize lasting effects of repetitive TMS and assess their usefulness in cognitive and clinical neuroscience, Brain Topography, 22, 4, (2009); Toloza Ramirez D., Martella D., Reserva cognitiva y demencias: Limitaciones Del efecto protector en El Envejecimiento Y El deterioro cognitivo, Revista Mdica De Chile, 147, 12, pp. 1594-1612, (2019); Tosun A., Ture S., Askin A., Yardimci E.U., Demirdal S.U., Incesu T.K., Tosun O., Kocyigit H., Akhan G., Gelal F.M., Effects of low-frequency repetitive transcranial magnetic stimulation and neuromuscular electrical stimulation on upper extremity motor recovery in the early period after stroke: A preliminary study, Topics in Stroke Rehabilitation, 24, 5, pp. 361-367, (2017); Vabalaite B., Petruseviciene L., Savickas R., Kubilius R., Ignatavicius P., Lendraitiene E., Effects of high-frequency (HF) repetitive transcranial magnetic stimulation (rTMS) on upper extremity motor function in stroke patients: A systematic review, Medicina, 57, 11, (2021); Vitti E., Hillis A.E., Treatment of post-stroke aphasia: A narrative review for stroke neurologists, International Journal of Stroke, 16, 9, pp. 1002-1008, (2021); Vlachos I., Kugiumtzis D., Tsalikakis D.G., Kimiskidis V.K., TMS-induced brain connectivity modulation in genetic generalized epilepsy, Clinical Neurophysiology, 133, pp. 83-93, (2022); Yao L., Zhao H., Shen C., Liu F., Qiu L., Fu L., Low-frequency repetitive transcranial magnetic stimulation in patients with poststroke aphasia:

Systematic review and meta-analysis of its effect upon communication, Journal of Speech Language and Hearing Research, 63, 11, pp. 3801-3815, (2020); Yin M., Liu Y., Zhang L., Zheng H., Peng L., Ai Y., Luo J., Hu X., Effects of rTMS treatment on cognitive impairment and resting-state brain activity in stroke patients: A randomized clinical trial, Frontiers in Neural Circuits, 14, (2020); Zhang J., Zhong D., Xiao X., Yuan L., Li Y., Zheng Y., Li J., Liu T., Jin R., Effects of repetitive transcranial magnetic stimulation (rTMS) on aphasia in stroke patients: A systematic review and meta-analysis, Clinical Rehabilitation, 35, 8, pp. 1103-1116, (2021)

Correspondence Address

D. Toloza–Ramirez; Exercise and Rehabilitation Sciences Institute, School of Speech Therapy, Faculty of Rehabilitation Sciences, Universidad Andres Bello, Santiago, Fernández Concha 700, Las Condes, 7591538, Chile; email: david.toloza@me.com

Publisher

Springer

ISSN

10407308

CODEN

NERVE

Language of Original Document

English

Abbreviated Source Title

Neuropsychol. Rev.

Document Type

Review

Publication Stage

Article in press

Source

Scopus

EID

2-s2.0-85195649775