Neurophysiologie Clinique/Clinical Neurophysiology (2015) **45**, 159—166

Disponible en ligne sur
ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com/en

ELSEVIER MASSON

Neurophysiologie Clinique Clinical Neurophysiology

ORIGINAL ARTICLE/ARTICLE ORIGINAL

TMS-related potentials and artifacts in combined TMS-EEG measurements: Comparison of three different TMS devices

Gestion des artefacts lors de la mesure des potentiels liés à la stimulation magnétique transcrânienne (SMT) lors des enregistrements combinés EEG-SMT : comparaison de trois systèmes

J. Van Doren, B. Langguth, M. Schecklmann*

University of Regensburg, Department of Psychiatry and Psychotherapy, Universitaetsstrasse 84, 93053 Regensburg, Germany

Received 11 September 2014; accepted 15 February 2015
Available online 16 April 2015

KEYWORDS
Transcranial magnetic stimulation;
Electroencephalography;
Artifact;
Evoked potential;
Magnetic field

Summary

Objectives. — Simultaneous use of transcranial magnetic stimulation (TMS) and electroencephalography (EEG) allows the measurement of TMS-induced cortical activity. A challenge in the interpretation of the cortical responses to TMS pulses is the differentiation between stimulation artifacts and cortical signals. Thus, we investigated TMS-evoked potentials and artifacts with respect to different TMS devices.

Methods. — Physical properties of the magnetic field produced by a MagStim®, Magventure® and Deymed® stimulator were determined. Six subjects were stimulated over the left motor cortex hot spot of the right index finger 42 times with 120% motor threshold, while wearing a 60-electrode EEG cap.

Results. — For each device we found a linear increase of field strength with a linear increase of machine output. The Magventure® system differed from the MagStim® and the Deymed® system with respect to field strength (higher), magnetic flux duration (shorter), motor threshold (lower), recovery time from the TMS artifact (shorter), motor evoked potentials (MEPs) latency (shorter), and had a reversed first artifact trajectory. There were no differences with respect to validity of the MEPs (number of valid epochs), MEP amplitudes, latency or amplitude of the second TMS artifact, or latency or amplitude of TMS-evoked potentials (TEPs).

* Corresponding author. Tel.: +49 941 941 2054; fax: +49 941 941 2065.
E-mail address: martin.schecklmann@medbo.de (M. Schecklmann).

http://dx.doi.org/10.1016/j.neucli.2015.02.002

Conclusions. — All of the used devices are well suited for TMS-EEG measurements, but the technical differences (e.g., pulse length) should be taken into account for the interpretation of the results of these experiments. Our results further confirm that adjustment of the stimulation intensity according to individual motor threshold seems to be an effective method to obtain comparable MEP and TEP amplitudes with different stimulation devices.

MOTS CLÉS
Stimulation magnétique transcrânienne ;
Électroencéphalographie ;
Artefact ;
Potentiels évoqués ;
Champ magnétique

Résumé
But de l'étude. — L'enregistrement de l'EEG au cours de la stimulation magnétique transcrânienne (SMT) permet la mesure de potentiels liés à la SMT. L'interprétation de ceux-ci se heurte à la difficulté de différencier les artefacts de stimulation et les réponses d'origine cérébrale. Trois systèmes d'enregistrement ont été comparés par rapport à ce problème.
Méthodes. — Nous avons déterminé les propriétés physiques des champs magnétiques produits par les stimulateurs MagStim®, Magventure® et Deymed®. Six sujets porteurs d'un casque EEG à 60 électrodes ont été stimulés à 42 reprises en regard de l'aire de représentation de l'index droit, à 120 % du seuil moteur.
Résultats. — Pour chaque système, l'intensité du champ a augmenté linéairement en fonction de la sortie annoncée du stimulateur. Le système Magventure® se différenciait des deux autres sur base de l'intensité du champ (plus élevée), de la durée du flux magnétique (plus courte), du seuil moteur (plus faible), du temps de récupération de l'artefact (plus court), du temps de latence du potentiel moteur (plus court) ; il montrait de surcroît une inversion de la première partie de l'artefact. Par contre, aucune différence ne fut constatée au niveau du nombre d'époques acceptables, des amplitudes des potentiels moteurs, du temps de latence ou de l'amplitude du second artefact ou du temps de latence ou de l'amplitude des potentiels liés à la SMT.
Conclusions. — Alors que tous les systèmes étudiés sont bien adaptés aux enregistrements simultanés EEG-SMT, des différences techniques doivent être prises en compte en vue de l'interprétation des résultats. Nos résultats confirment que l'ajustement de la puissance de stimulation sur base des seuils moteurs individuels constitue la meilleure garantie d'obtention de potentiels moteurs ou liés à la SMT comparables lorsqu'ils ont été obtenus au moyen de systèmes de stimulation différents.

Introduction

Transcranial magnetic stimulation (TMS) is a tool for non-invasive stimulation of the brain that is widely being used to study healthy and diseased cortical function [22]. It is additionally being developed as a therapeutic intervention in neuro-psychiatric disorders such as schizophrenia [1], depression [8], and tinnitus [13] and is being explored as possible technique for the enhancement of cognitive functions [15].

In summary, effect sizes for these approaches are small to moderate. To enhance the efficacy of TMS, it is necessary to increase the knowledge about the exact neurophysiological mechanism of TMS over the various brain regions. For this, combined measurements of TMS and electroencephalography (EEG) are highly recommended since EEG can measure fast TMS-induced neural activity with high temporal resolution. The challenge is to differentiate the neural response to TMS from the relatively large artifacts created by the TMS pulse. Many techniques have been suggested for the minimization of this artifact, such as good electrode impedance (< 5kΩ), not stimulating over highly muscular areas (stick to the midline), avoiding auditory and startle reflex artifacts by using earplugs and/or masking, and avoiding somatosensory artifacts by dampening the coil vibration on the head by using foam [9,16,23,28]. In addition, hardware modification and a variety of offline data analyses have been suggested to improve the quality of data [7,26,29,10].

The TMS artifact is characterized as a sharp first peak starting at the time of stimulation and lasting 5 ms [28] followed by a second artifact occurring around 5—10 ms post-stimulation [19]. The first artifact is attributable to the electrical charge generated by the TMS pulse, while the second is thought to be of muscular origin [19]. This first artifact is to distinguish from a later artifact in some types of machines generated by the recharging of the TMS device.

The signals of interest for stimulation of the motor cortex are motor-evoked potentials (MEPs) and TMS-evoked potentials (TEPs). Both are well characterized and are considered valid measurements of the effect of the TMS pulse on the brain. The MEP is a biphasic, evoked activity with a specific latency that is detected by electromyography in the corresponding muscle of the stimulated homunculus area. It is the result of the net activation of the motor cortex, propagated via activation of pyramidal cells and the cortico-spinal tract, with a specific conductance time to the muscle in the periphery. The TEPs are EEG-evoked potentials with various peaks including the P60 and the N100 [19,2,14]. The P60 is thought to be a signal that is evoked from the sulci of the primary motor cortex and reflective of inhibition [12], whereas the N100 has been described as a neural correlate of inhibition and associated to attention [3,17]. Both peaks additionally