

## Deep transcranial magnetic stimulation for the addiction treatment: Electric field distribution modeling.

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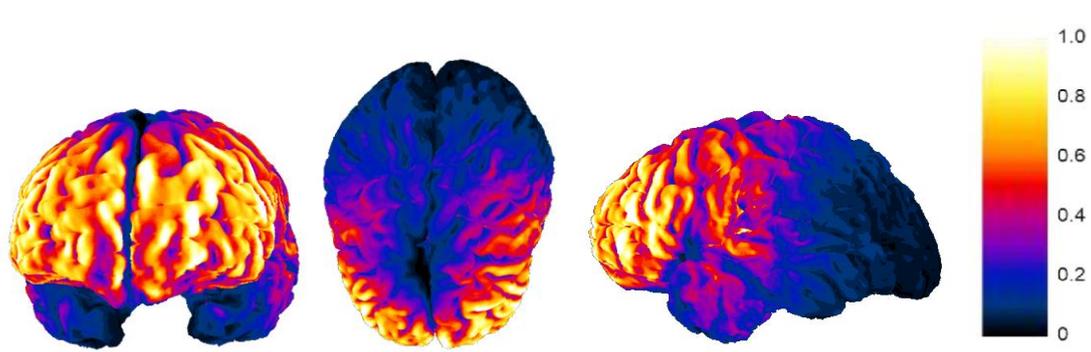
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Deep Transcranial Magnetic Stimulation (dTMS) is a relatively new technique for brain stimulation that has been recently adopted in the treatment of different kind of addictions, including alcohol, cocaine, nicotine addiction and, in a broad sense, obesity or food addiction (for a review on the clinical use of dTMS coils see [1]). The complex dTMS coils (also named Hersed(H)-coils) [2-3] tridimensional structure allows indeed to reach even the deep targets of the brain whose impairment is strictly linked to the progression of those disorders, thus enhancing and enlarging the effect of the stimulation with respect to the extremely focal and superficial traditional TMS systems. In order to precisely characterize their efficacy, the knowledge of the induced electric field distribution in those targets is the first step to be taken.

In this work we hence quantified, by means of computational techniques, both electric field distribution ( $\mathbf{E}$ ) and related parameters, such as focusing power and penetration depth, induced by a specific H-coil (named H4), precisely designed for the addiction treatment.

Results (Fig. 1) show that H4 coil is able to induce peak of the induced  $\mathbf{E}$  over the cingulate cortex and to follow on the insula and on the prefrontal cortex. Moreover, it can induce in the deepest tissues (i.e. nucleus accumbens, ipotalamus and ventral tegmental area) peak  $\mathbf{E}$  levels ranging between the 20-55% of the maximum in the cortex ( $E_{max}$ ) and it can penetrate the prefrontal cortex up to 4 cm with a  $E > 50\% E_{max}$ , thus noticeably reducing the decrease with depth of the traditional TMS coils.



**Figure 1.** Normalized (to  $E_{max}$ )  $\mathbf{E}$  distribution induced by H4 coil over the cortex.

[1] Tendler A, Barnea Ygael N, Roth Y, Zangen A. Deep transcranial magnetic stimulation (dTMS) – beyond depression. *Expert Rev Med Devices* 2016 Oct;13(10):987-1000.

[2] Roth Y, Zangen A, Hallett M. A coil design for transcranial magnetic stimulation of deep brain regions. *Journal of Clinical Neurophysiology: Official Publication of the American Electroencephalographic Society*. 2002;19(4):361–370.

[3] Zangen A, Roth Y, Voller B, et al. Transcranial magnetic stimulation of deep brain regions: evidence for efficacy of the H-coil. *Clinical Neurophysiology: Official Journal of the International Federation of Clinical Neurophysiology*. 2005;116(4):775–779.