

Investigating Transcranial magnetic stimulation (TMS) effects using Pulsed Arterial Spin Labeling (PASL)

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Introduction: Transcranial magnetic stimulation (TMS) has been applied to investigate cortical function. Moreover, TMS has been employed to treat a variety of pathologies such as major depression, schizophrenia, posttraumatic stress disorder, etc. The exact mechanism of action of TMS is still unknown. In the visual cortex of the cat it was recently shown that TMS led to an initial increase and subsequent longer lasting decrease in tissue oxygenation and haemoglobin concentration¹. It was argued that the full potential of TMS depends not only on a basic understanding of its neural effects, but also on the ability to make direct measurements of these changes in the human brain². In the present pilot study we use TMS in combination with arterial spin labeling (ASL)^{3,4} in order to address the question of whether an effect of TMS is detectable with ASL in subject performing a task. We aimed to explore putative TMS effects on CBF measure.

Methods: Two healthy subjects (one female, age 28 year, one male, age 29 year) were investigated in this pilot study. Imaging was performed on a 3.0 T TRIO (Siemens, Erlangen, Germany) using a 8 channel head coil. Perfusion Weighted Imaging using a PASL was performed using a Fair QUIPSSII perfusion mode³ and the following parameters: 16 slices, voxel size=3.4x3.4x6.0 mm, TA=10 min, lambda=0.9 mL/g, alpha=95%, TE/TR/TI1/TI2/T1(blood,3T)[ms]=15/3000/700/1800/1496. Absolute CBF maps for ASL were calculated using MATLAB/SPM programs. Prior to the functional imaging a set of 3-D high resolution, magnetization-prepared rapid-acquisition gradient echo (MP-RAGE) sequence was performed (TE=2.2 ms, TR=1950 ms, FA=9°, FOV=256 mm, matrix size=256 x 256, 176 sagittal slices with voxel size=1 x 1 x 1 mm³). The subject performed an externally-paced finger-tapping task with the left and right fingers, alternated ON/OFF lasting 30 sec each for the total duration of the PASL run. The PASL run was repeated two times: one before the application of TMS (pre TMS) and one after the application of TMS (post TMS). SPM2 was used for preprocessing of PASL data. For the TMS experiment, repetitive magnetic pulses were generated with a TMS stimulator (MagPro, MagVenture A/S, Denmark) and delivered by a figure-eight-coil (MCF-B65, with static fluid cooling MagVenture A/S, Denmark). The left motor cortex was stimulated with single pulses to determine the individual motor threshold (MT) by corresponding muscle twitching of the subject's relaxed small hand muscles. The left motor cortex was then stimulated at an intensity of 80% of the MT using a theta burst protocol of 200 bursts. Each burst consisted of three pulses at 30 Hz, repeated at intervals of 100 ms⁵. Thus, 600 TMS pulses were applied within 45 seconds.

Results: As expected the finger tapping task produced activation in the left and right precentral gyrus (precG) prior the application of TMS. In order to evaluate potential differences in CBF values in the pre/post TMS condition we extracted the time course of the CBF signal [ROI masks based on the Talairach Daemon (e.g. WFU atlas⁶)] in two brain regions: 1) in the left/right side of the precG and in 2) the early visual area V1 for comparison. In both sides of precG we observe a reduction of the CBF signal over the whole time course of 33.7 % for left and 41.7% for right side after TMS application as compared to pre TMS. In contrast, whole brain CBF values increased post TMS (64.3 ml/100g/min) as compared to pre TMS (59.8 ml/100g/min). Increase was also observed in the reference region V1.

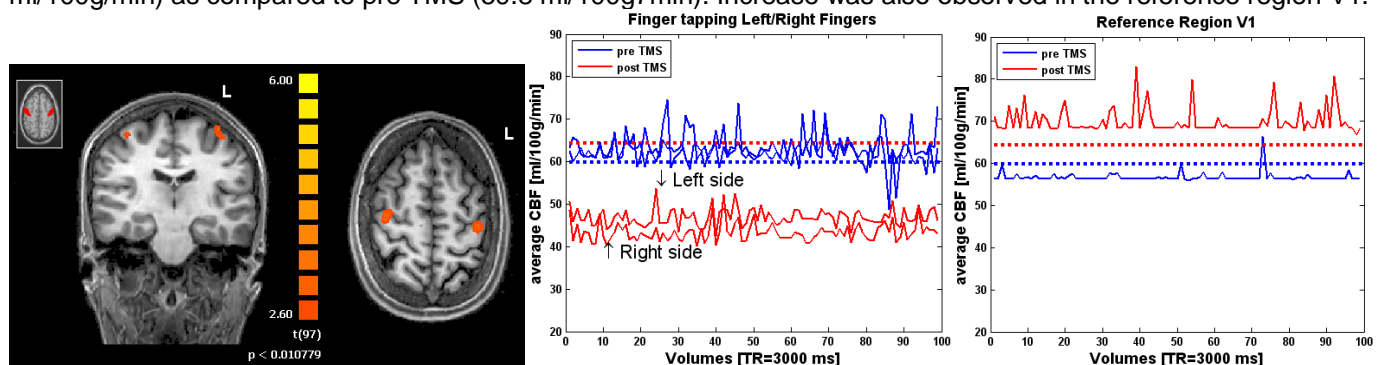


Figure: (Left) Perfusion activation map due to finger tapping with both fingers. (Middle) Time course of CBF signal extracted from the left/right precentral gyrus ROI mask. Pre TMS (blue solid line) and post TMS (red solid line). (Right) Time course of CBF signal extracted from the reference region V1- ROI mask. Pre TMS (blue line) and post TMS (red line). Mean whole brain CBF displayed (pre TMS=blue dotted line) and (post TMS=red dotted line)

Conclusions: The effect of TMS stimulation on the metabolic response extracted in a brain region responsible for the execution of a finger tapping task was investigated with ASL. Although we present data based on two subjects only, the observed reduction of CBF signal after TMS stimulation may be interpreted as a potential sign suggesting that it is possible to 1) detect and 2) to map subtle metabolic changes induced by TMS stimulation using ASL. Our results are in line with findings of H₂O-PET-study^{7,8} but in contrast to another PET study⁹. It has to demonstrate in a larger cohort if the putative TMS effect observed with ASL is robust.

References:

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