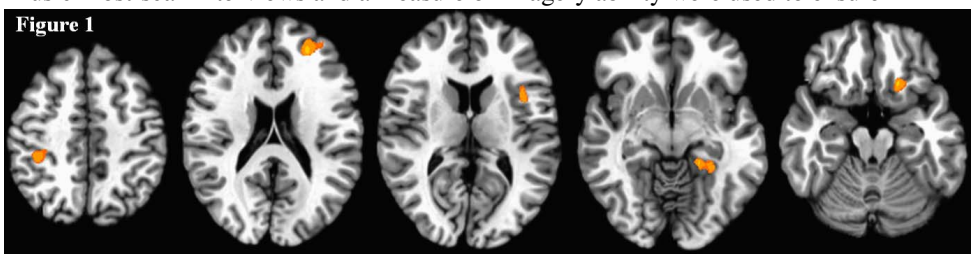
Effect of rhythmic auditory stimulation on cortical activation during the mental imagery of walking in patients with multiple sclerosis

Katherine A Koenig[1], Mark J Lowe[1], Darlene K Stough[2], Lisa Gallagher[2], Dwyer Conklyn[3], and Francois Bethoux[2]
[1]The Cleveland Clinic, Cleveland, Ohio, United States, [2]Neurological Institute, The Cleveland Clinic, Cleveland, Ohio, United States, [3]DBC3 Music Therapy, Independence, Ohio, United States

Target audience: This information will be of interest to researchers of multiple sclerosis.
Purpose: Previous research has shown that rhythmic auditory stimulation (RAS) improves gait in patients with central nervous system disorders, and our own work has shown that patients with multiple sclerosis (MS) experience an improvement in gait parameters after RAS training [1,2]. Here we present results of a preliminary analysis of the effect of RAS therapy on the pattern of cortical activation during mental imagery of walking, as measured by functional MRI (fMRI).
Methods: In an IRB-approved protocol, 12 patients with gait disturbance from MS (mean age 53.9 ± 5.4, 4 males) participated in RAS training and were scanned at 3T in a 12-ch receive head coil. Scans included T1-MPRAGE and two functional MRI scan at 2x2x4mm voxels, 1954 Hz/pix BW, 31 axial slices, TR/TE/FA=2800/29/80. During both functional scans, participants performed a walking visualization task in a block design. During the "walking" block participants were asked to imagine walking on strong, sturdy legs at their optimum walking ability, and were instructed to focus on imagining their actual body movements. During "non-walking" blocks participants were shown brief sentences about general subjects. During the first functional scan, participants were instructed to imagine walking at a pace that felt most comfortable to them (no RAS, -RAS). During the second functional scan, a custom music track was played (RAS, +RAS). The track was set at the optimum walking pace of the patient plus ten percent, and participants were instructed to imagine walking in pace to the music. Post-scan interviews and a measure of imagery ability were used to ensure participants completed the functional tasks. Student's t-maps were spatially normalized and a voxelwise paired t-test was used to compare walking imagery during -RAS and +RAS, and activation levels were compared to the cognitive and physical domains of the Modified Fatigue Impact Scale (MSIF).



Results: Five regions showed significant differences between +RAS and -RAS, with all regions showing increased activation during -RAS ($p < 0.01$, corrected for multiple comparisons, Figure 1). During -RAS, increased activation in the left parahippocampal gyrus was related to lower levels of cognitive fatigue (Figure 2). This relationship was not seen during +RAS and was not seen in other brain areas.

Discussion: During mental imagery of walking, RAS produced decreased activation in the left superior frontal gyrus, involved in spatial processing and working memory, the left insula, the left subcallosal gyrus, the right inferior parietal lobule, and the left parahippocampal gyrus, involved in memory encoding and recognition, particularly related to environmental scenes. In the -RAS condition, level of cognitive fatigue was negatively related to parahippocampal activation. It is possible that the RAS stimulus mitigates the effect of cognitive fatigue on visualization. It may also make it easier to visualize walking, and that in the -RAS condition participants rely on visualization of the walking environment to facilitate walking imagery. Patients with increased cognitive fatigue have a more difficult time sustaining the visualization.
Conclusion: RAS produces changes in functional activation in patients with MS. Further work will assess change over time with RAS training and will related cortical changes to changes in gait.
References: [1] Conklyn, D. et al., Neurorehabil Neural Repair. 2010; 24: 835-42. [2] Bethoux, F. et al., Int J MS Care. 2012; 14 (Suppl. 2): 10. This research was supported by a grant from The Kelvin and Eleanor Smith Foundation. The authors would like to thank Jane Ehrman for her assistance with imagery training and implementation.

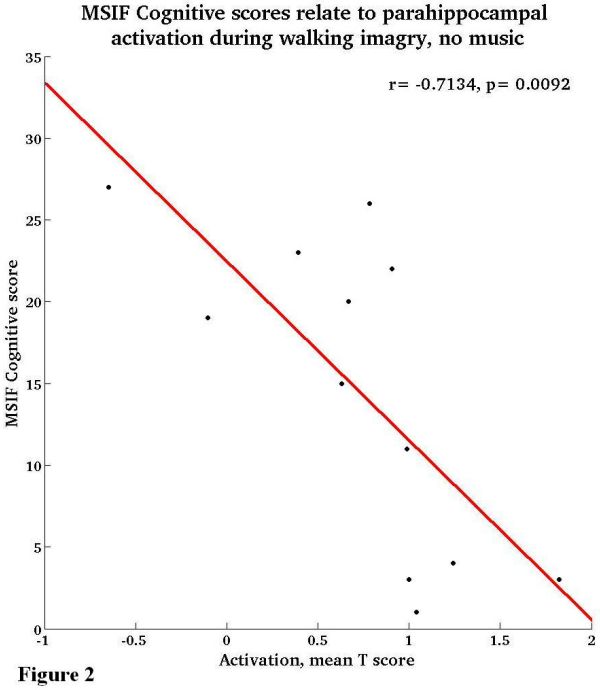


Figure 2