Acoustic feedback during motor dexterity training modulates brain structure in healthy adult individuals

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Introduction. In healthy individuals, gray matter (GM) structural changes occur following motor learning. The influence of music/sound listening on the previous changes has never been investigated.

Objective. To assess, in healthy subjects, the short-term structural changes of the brain GM and white matter (WM) associated with a manual dexterity training, with and without acoustic feedback, and to investigate whether these changes persist three months after cessation of the motor training.

Methods. Forty-five healthy subjects (mean age=21.6 years, range:18-30 years) without any musical experience performed a motor training, consisting of 10 sessions of 30 minutes each of playing pre-defined sequences of keys with a standard keyboard with the right hand. Subjects were randomized into 3 groups: the “sound” group played the sequence with acoustical feedback, the “no-sound” group played it without acoustical feedback, and the “music” group played it without feedback, but listening to music. All the subjects underwent structural magnetic resonance imaging (MRI), on a 3.0 Tesla scanner at baseline (T0 - before training), after 2 weeks (W2 - immediately after finishing the training), and after a follow up of 3 months (M3). The following MRI sequences were acquired: 1) 3D T1-weighted fast field echo (TR=25 ms, TE=4.6 ms, FA=30°, 220 axial slices, voxel=0.89x0.89x1 mm), and 2) pulsed-gradient spin-echo single shot echo-planar sequence with diffusion-encoding gradients applied in 35 non collinear directions and b factor=900 s/mm^2 (TR=8283.2 ms, TE=80 ms, 55 axial slices, SENSE reduction factor=2). Longitudinal changes of GM and WM volumes were assessed using Tensor Based Morphometry (TBM) and SPM8 (www.fil.ion.ucl.ac.uk/spm): after halfway alignment between baseline and follow-up scans, the High Dimensional Warping was used to warp the follow-up over the baseline scans. From this deformation field, the Jacobian determinant was calculated and transformed into a common space defined by the template created from the baseline images using the non linear registration method DARTEL (1). After smoothing, both intra and inter group longitudinal changes were assessed. WM architecture changes were investigated using Tract-Based Spatial Statistics (TBSS) (http://www.fmrib.ox.ac.uk/fsl/tbss/index.html). Using a paired t-test, longitudinal changes of fractional anisotropy (FA) were assessed within each group.

Results. At W2, the three groups of subjects experienced a GM increase in the right precentral gyrus. Left precentral gyrus volume increased in the “sound” and “no-sound” groups at W2, while it increased at M3 in the “music” group (Figure 1). Right cerebellum volume increased in the “sound” and “music” groups at W2, while it increased at M3 in the “no-sound” group. Significant decreases of GM volumes were detected in the three study groups both at W2 and M3. At W2, the “no-sound” group had an increased WM volume in the left frontal lobe, which persisted at M3. In the “no-sound” group only, TBSS analysis showed a decreased FA at W2 in the WM of the occipital and parietal lobes, as well as a decreased FA in the right corticospinal tract and superior longitudinal fasciculus at M3.

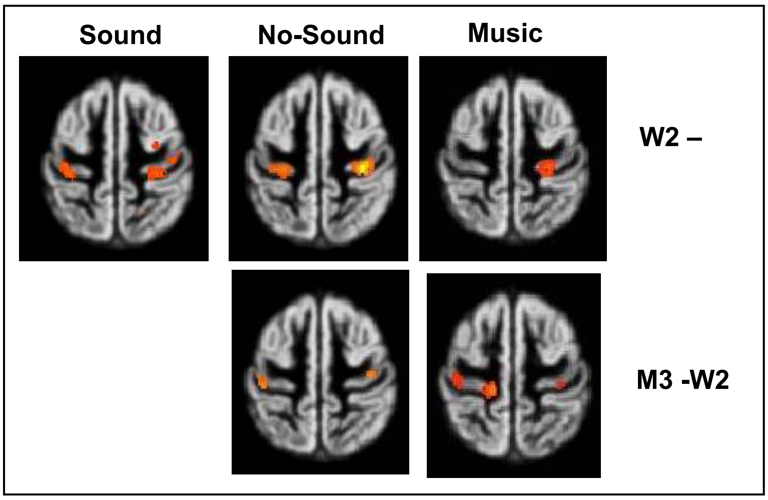

Figure 1. GM increase at week 2 (W2) and month 3 (M3) in all groups.

Conclusions. In healthy individuals, the feedback strategy applied during motor training modulates structural rewiring of the brain GM and WM. All the groups of our study experienced similar structural changes, but with a different temporal evolution. In particular, structural changes seemed to occur more rapidly in the sound group. These results might have important implications for the development of rehabilitation strategies in patients with different central nervous system conditions.

References. 1. Ashburner J. Neuroimage 2007;38:95-113.