Echo time dependence of basal ganglia activation at 3T during motor task

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Introduction. Imaging the basal ganglia is technically challenging. Therefore, convincing imaging data were most often shown in the striatum but rarely in the globus pallidus. In the globus pallidus, ferromagnetic particles deposit normally with age, leading to reduced T_2* and signal intensity in functional MR images. It is generally accepted that BOLD response should be higher when the echo time (TE) matches the T2* of the structure. Therefore, adapting the TE of BOLD gradient echo fMRI time series to the T2* of the globus pallidus may improve signal detection in this structure.

Material and methods. Experiments were conducted using a 3T magnet (Siemens). T2* measurements in the putamen and the globus pallidus were first performed in four right-handed healthy volunteers using axial gradient echo segmented EPI images (TR/α: 5s/90°, bandwidth: 1954Hz/pixel, 5 segments, FOV: 256 x 256 mm², voxel size: 2 x 2 x 2 mm^3, partial-fourier imaging 6/8). TEs ranged from 10 to 180 ms.
The TE study was subsequently performed in seven other right-handed healthy volunteers (3 men, 4 women; age range: 25.2 ± 5.6 years). Two sets of single shot axial slices were obtained (TR/angle: 3s/90°, in plane resolution: 1.5x1.5x1.5 mm^2, no gap, 144 acquisitions, 32 slices, partial-fourier 5/8). Two TEs were used matching the T2* measured in the globus pallidus (28 ms) and the putamen (42 ms). All other parameters were held constant between the two sequences. During the fMRI session, subjects had to perform a sequence of 8 moves on a keyboard using fingers 2 to 5 of the left hand at a fixed rate of 3 Hz paced by a metronome (1). To be able to perform this sequence at such a high rate, subjects were asked to practice the sequence 10–20 min daily during two weeks before the MRI session. During this daily practice, they were instructed to repeatedly tap the sequence in a rapid, self-paced and accurate manner. For each fMRI run, subjects alternated 10 epochs of 21 sec (7 volumes) of rest and 21 sec of the motor conditions. Functional scans were corrected for subject motion and baseline drift. High and low-pass temporal filtering was performed. Images were smoothed with an isotropic Gaussian spatial filter (FWHM = 5 mm). Data were then analyzed after normalization in stereotactic space by using SPM99.Random effect group analysis was performed using the same threshold for all studies.

Results.
The group analysis showed activation in basal ganglia structures including the striatum, the globus pallidus, the subthalamic nucleus, the thalamus and the red nucleus.
Activation volume was 1.52 times (putamen) and 1.46 times (globus pallidus) larger at TE 42 ms than TE 28 ms but the difference did not reach significance ($F = 2.6$, $P = 0.16$) (Figure 1).
Signal increase was significantly larger at TE 42 ms than TE 28 ms in the putamen (1.64 times) and in the globus pallidus (1.47 times) (Figure 2) ($F = 34.7$, $P < 0.001$).

Figure 1.

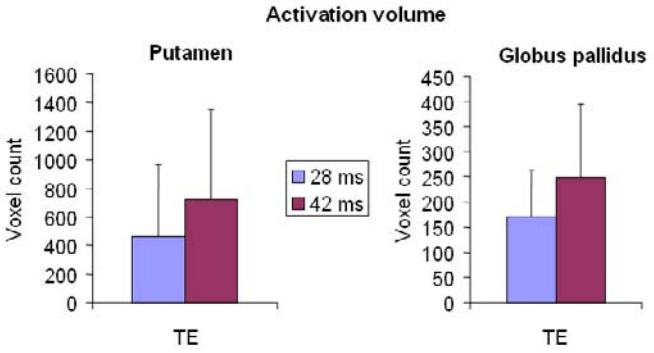
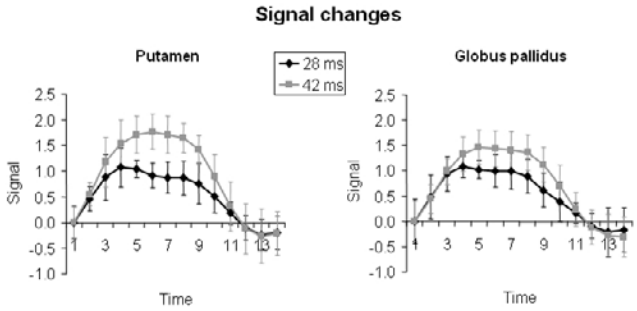


Figure 2.



Conclusion.
As expected, the percent signal change increased with increasing TE. Matching TE and T2* did not increase activation volume in both structures. Within the range of TEs studied, the lack of significant gain in activation detection when matching TE and T2* versus non matching may be explained by the fact that, as long as the SNR is high enough, a large part of signal fluctuations are of physiological origin and of BOLD nature, so that both percent signal change and fluctuation vary together, cancelling the benefit of matching TE=T2* (2). As activation volume did not change significantly at TE = 42 ms compared to TE = 28 ms in all structures studied, there was no gain in decreasing the TE of BOLD images to match the T2* of the globus pallidus. As longer TEs allow potentially increasing the spatial resolution and/or reducing the needed fraction of partial-fourier, these results suggest an advantage of using TE = 42 ms. Even if not significant, it remains to be investigated why there was a trend to obtain higher activation volume with increasing TE in both structures, including the globus pallidus when TE is longer than T2*.

References. (1) Lehéricy et al. PNAS 2005, (2) Hyde et al. Magn Reson Med 2001.

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