

AN AUTOMATED PATIENT GUIDANCE SYSTEM FOR FUNCTIONAL MRI IN NEUROSURGICAL TREATMENT PLANNING

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Purpose The goal of surgical tumor resection is the complete removal of the tumor while preserving as much of the surrounding functional tissue as possible [1]. Functional magnetic resonance imaging (fMRI) enables a noninvasive method of identifying healthy functional tissue in the vicinity of tumor. When the tumor is near the motor cortex, repetitive motions of the hand and foot are typically used as activation tasks [2]. Visual cues consisting of a flashing circle around a stationary crosshair have typically been used to indicate periods of task performance. However, this form of presentation is not optimal for patients with memory impairment or visual deficits. The purpose of this work was to evaluate a new Patient Guidance System (PGS) we have developed for presurgical planning with the goal of consistently activating the motor cortex and aiding the patient in performing the task.

Methods Ten healthy, right handed volunteers (5 male, 5 female) performed right hand sequential finger tapping and right toe flexion using two presentation methods: 1) a circle/crosshair display, and 2) the Patient Guidance System which provides intuitive visual and audio cues related to task performance.

All images were acquired with a Siemens 1.5T Magnetom Avanto MR scanner (Siemens, Erlangen, Germany) using a 12-channel bird-cage head coil. A 3D T1-weighted gradient echo sequence was first acquired. Utilizing the same slice coverage as the 3D image, a gradient echoplanar imaging (EPI) sequence was then employed to acquire the BOLD signal. All fMRI presentations used a block design paradigm consisting of alternating rest and task conditions of 16s each. Visual stimuli were projected from a video projector (Psychology Software Tools, Inc.) to a mirror affixed to the head coil. The circle/crosshair display consisted of a white fixation cross and a blinking white circle around the cross over a black background. Subjects were instructed to perform either a right hand sequential finger tap or a right toe flex during the blinking circle portion of the task. The Patient Guidance System consisted of a video presentation of either the finger or the toe task (Fig. 1). During the start of each task, verbal recorded instructions were given over headphones. A countdown timer was presented in the bottom right hand corner of the video to inform the participants of required time to perform the task. To the left of the video, a timeline was presented to update the participants on total time left for each task. Each functional scan lasted 6m 24s. Analysis was carried out using the Functional Magnetic Resonance Imaging of the Brain (FMRIB) Software Library (FSL).

Results Mixed effects group analysis using a corrected p-value less than 0.05 revealed significant activation in the target motor areas for both the crosshair and PGS presentation techniques (Table 1). Images of the group analysis results are shown in Fig. 2 and Fig 3. Mixed effects group analysis using a two-sample paired t-test showed no significant group differences between the crosshair and PGS presentations in the target motor areas. Average relative head motion for the two methods is shown in Table 2. The differences in head motion between the methods were tested using a paired t-test and were not significant for either the finger or toe tasks.

Conclusions The use of the PGS consistently activated the target motor regions, engaged the subjects during scanning, and did not significantly impact head motion. Future work will focus on implementing more tasks into the PGS and directly comparing it to the standard presentation in clinical populations.

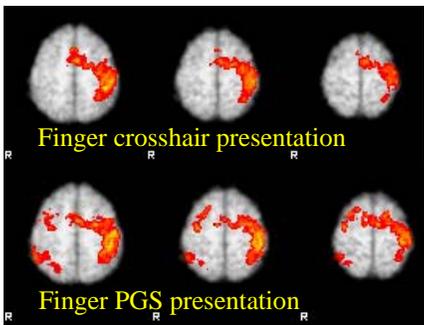


Fig. 2. Mixed effects group average for the finger tapping task.

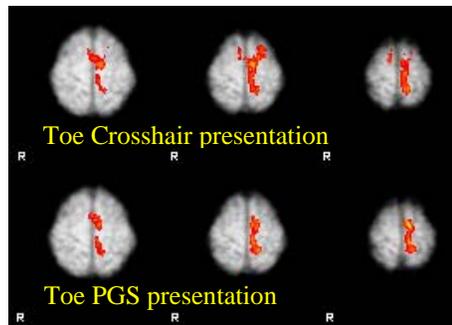


Fig. 3. Mixed effects group average for the toe flexion task.

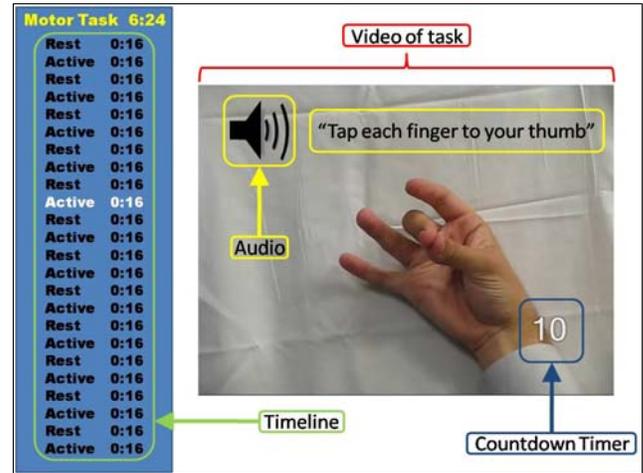


Fig 1. Patient Guidance System

Region (Left Hemisphere)	Crosshair Finger	PGS Finger	Crosshair Toe	PGS Toe
Motor Cortex	2483	2568	785	689
Somatosensory Cortex	3817	4019	734	650
Premotor Cortex	3103	3094	1428	1074

Table 1. Number of voxels activated ($p < 0.05$).

Task	Mean	Std. Dev.
Crosshair-Finger	0.0930	0.0283
PGS-Finger	0.1100	0.0374
Crosshair-Toe	0.1090	0.0354
PGS-Toe	0.1240	0.0679

References

1. Sunaert S. J. Magn. Reson. Imaging. 2006; 23:887-905.
2. Tieleman Ann, et al. Eur Radiol. 2009; 19:2523-2534.