Abstract—This paper presents the application of a touch sensitive tablet technology in the functional magnetic resonance imaging (fMRI) of brain activity in brain tumor patients as a part of their preoperative planning. The technology enables comprehensive brain mapping of language processing areas using multi-modal cognitive tests including complex writing and spelling tasks. Highly enhanced specificity is shown for the case of a brain tumor patient by comparing the fMRI results with intraoperative direct cortical stimulation.

I. INTRODUCTION

Central nervous system tumors are a major cause of morbidity and mortality. Although the main goal of neurosurgical oncology is to improve survival by resecting as much of the tumor as possible, this must be tempered by the potential for losses of brain function and behavioral consequences following a radical resection. Functional magnetic resonance imaging (fMRI) has been recently suggested as a useful tool for the non-invasive mapping of eloquent cortex which can improve treatment planning, reduce surgical time and avoid additional medical tests [1,2]. However, most fMRI language localization procedures have used simple verb generation and object naming tasks. We have previously developed an accurate, reliable, and fMRI-compatible tablet based on touchscreen technology [3] which has been used to design and administer a comprehensive battery of multi-modal language tests involving complex writing activities. The technology has potential to substantially enhance specificity of fMRI language mapping which has been reported to be below 60% [4].

II. MATERIALS AND METHODS

The tablet system (Fig. 1) included a touch-sensitive tablet, an elevated support platform, a stylus and a controller box, as well as the necessary cabling and software to administer tasks, record responses and provide task-related feedback on a projection display. A series of carefully-conducted phantom tests as well as human experiments confirmed that the device had no noticeable impact on MRI beyond normal variability [3]. Subjects: Eleven healthy subjects without any history of neurologic impairment (7 male, average age 29±7), and one brain tumor patient (male, 40 y.o.) with low-level glioma in his right frontal lobe were recruited. Tasks: Language tasks composed of speech production and perception (rhyming versus pattern recognition, semantic decision versus pattern recognition) and writing (word copying versus drawing loops) were developed in E-Prime software (Psychology Software Tools Inc., Sharpsburg, PA) using a block design paradigm. Data Acquisition and Analysis: Functional MRI was conducted at a 3Tesla receiver using a 32-channel head coil with data analysis using AFNI software. The image pre-processing pipeline included slice-timing, head motion correction and spatial smoothing. Individual analysis was performed by using a general linear model on normalized data. Conjunction analysis was performed between different tasks using a voxel-wise statistical threshold of p<0.005.

Fig. 1: Left: Patient setup using fMRI compatible tablet, Right: A screen shot of word copying task as displayed through the projection system.

III. RESULTS AND CONCLUSION

Group analysis of healthy subjects produced activation in predicted locations (Broca’s area for rhyming, Broca and Wernike’s area for semantic decisions and the superior parietal lobule for word copying). Imaging results for the brain tumor patient showed bilateral language activation with active areas touching the tumor boundary. The conjunction analysis performed between rhyming and word copying tasks was found to substantially increase the specificity of the activation maps while maintaining the same sensitivity when compared with direct cortical simulation (Fig. 2). This study suggests that by using the new technology that enables applying multimodal brain mapping, the efficiency of fMRI for neurosurgical planning can be substantially enhanced.

Fig. 2: Activation maps for voxels with uncorrected p<0.005. The blue area is the site of direct cortical stimulation during the tumor resection. The purple area marks the positive language site. Left: activation maps from rhyming vs. pattern recognition. Middle: activation maps of word copying vs. loop drawing task. Right: Conjunction analysis.

REFERENCES