A Novel Tablet Computer Platform for Advanced Language Mapping during Awake Craniotomy Procedures

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Learning Objectives

By the conclusion of this session, participants should be able to 1) describe the importance of awake craniotomy procedures for resecting brain tumors near eloquent brain regions; 2) discuss, in small groups, the need for improved behavioral testing procedures for intra-operative brain mapping during awake craniotomy; and 3) identify the effectiveness of tablet computing strategies for pre-operative functional magnetic resonance imaging and intra-operative mapping of language function using written as well as overt responses.

Introduction

Tumors in the vicinity of eloquent brain regions are often treated by awake craniotomy, including intra-operative mapping of brain function by electrical stimulation. During such procedures and particularly in the case of intra-operative language mapping, there is a need to move beyond simple and traditional behavioral testing paradigms (e.g. number counting, picture naming) towards those that are more cognitively challenging and that have higher ecological validity. There is also a need to standardize such paradigms across pre-operative functional magnetic resonance imaging (fMRI) and intra-operative mapping procedures, to improve spatial concordance and enhance the utility of fMRI for surgical planning.

Methods

We describe the development of a computerized platform to enhance behavioral testing during pre-operative fMRI (Fig.1) and intraoperative mapping procedures in awake craniotomy (Vid.1, Fig.2).

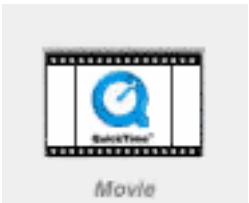Figure 1: Behavioral testing platform during pre-operative functional MRI
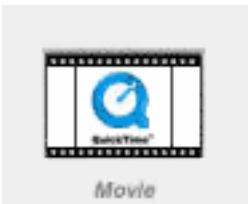
The platform architecture, its advantage over traditional testing methods, and usage for language mapping are presented in this work.

Video 1: Intraoperative behavioral testing platform (*Globe and Mail,Saving Cyla 2014*)

Figure 2: Patient monitoring system integrated into intraoperative testing platform (Globe and Mail, Saving Cyla 2014)

The core of the platform is based on novel tablet computing technology that, in addition to administering tasks involving overt speech, permits language mapping involving easily quantified written responses (Video.2).

Video 2: Visual stimuli for a Word Copying language task

Results

Two illustrative cases demonstrate the efficacy of using the behavioral testing platform to administer sophisticated language paradigms (Fig.3).

In both cases, usage of a writing task to assess language production helped confirm an area of speech apraxia that was inadequately characterized based on traditional testing. Preoperative functional imaging of the same writing task also predicted this finding, displaying excellent spatial agreement.
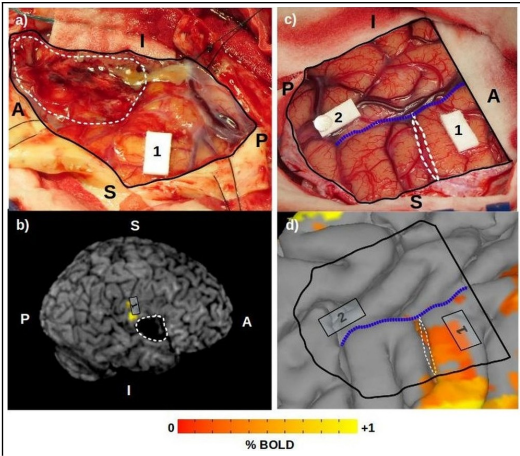

Figure 3: Illustrative patient cases

Conclusions

The sole usage of traditional testing paradigms can be limiting. Comprehensive assessment of language function pre-operatively and intra-operatively will require the incorporation of more sophisticated and ecologically valid behavioral tests. The technology presented here provides a means to do so.

References

1.Tam F, Churchill N.W, et al. 2011, Human Brain Mapping, 32(2): 240-48
2. Garavaglia M, Das S, et al. 2014, J Neurosurg Anesthesiol, 26(3): 226-33
3. Morrison M, Tam F, et al. 2015, J Neurosurg (accepted)