



A Novel Functional Magnetic Resonance Imaging Paradigm for the Preoperative Assessment of Auditory Perception in a Musician Undergoing Temporal Lobe Surgery

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Key words

- Epilepsies
- Functional MRI
- Music
- Surgery

Abbreviations and Acronyms

ESM: Electrical stimulation mapping

fMRI: Functional magnetic resonance imaging

MBEA: Montreal Battery of Evaluation of Amusia

MRI: Magnetic resonance imaging

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INTRODUCTION

Functional studies have identified that musical perception and memory involves activation of a complex network involving mesiotemporal and multisensory cortices in addition to auditory areas lateralizing to the right hemisphere.¹ Presurgical evaluation for temporal lobe epilepsy routinely assesses speech and memory lateralization and anatomic localization of the motor and visual areas but not baseline musical processing. Such musical processing is paramount in musicians reliant on their musical abilities for their livelihood. Although there are validated tools to assess musical perception, including the international Montreal Battery of Evaluation of Amusia (MBEA),² there are no reported functional magnetic resonance imaging (fMRI) paradigms to assess musical perception, including musical performance, in preoperative patients. We examined the utility of a novel auditory fMRI paradigm in a

■ BACKGROUND: Presurgical evaluation for temporal lobe epilepsy routinely assesses speech and memory lateralization and anatomic localization of the motor and visual areas but not baseline musical processing. This is paramount in a musician. Although validated tools exist to assess musical ability, there are no reported functional magnetic resonance imaging (fMRI) paradigms to assess musical processing. We examined the utility of a novel fMRI paradigm in an 18-year-old left-handed pianist who underwent surgery for a left temporal low-grade ganglioglioma.

■ METHODS: Preoperative evaluation consisted of neuropsychological evaluation, T1-weighted and T2-weighted magnetic resonance imaging, and fMRI. Auditory blood oxygen level-dependent fMRI was performed using a dedicated auditory scanning sequence. Three separate auditory investigations were conducted: listening to, humming, and thinking about a musical piece.

■ RESULTS: All auditory fMRI paradigms activated the primary auditory cortex with varying degrees of auditory lateralization. Thinking about the piece additionally activated the primary visual cortices (bilaterally) and right dorsolateral prefrontal cortex. Humming demonstrated left-sided predominance of auditory cortex activation with activity observed in close proximity to the tumor.

■ CONCLUSIONS: This study demonstrated an fMRI paradigm for evaluating musical processing that could form part of preoperative assessment for patients undergoing temporal lobe surgery for epilepsy.

musician who underwent temporal lobe surgery for a left temporal ganglioglioma.

MATERIALS AND METHODS

Clinical Case and Surgical Procedure

The patient was an 18-year-old left-handed musician who played the piano, clarinet, saxophone, percussion, and accordion. The patient was concerned that the proposed surgery would be detrimental to his musical prowess. He had normal childhood development and initially presented to a pediatrician at age 11 years with focal complex seizures characterized by vacant staring, swallowing noises, lip smacking, repeated chest patting, and nonsensical vocalization. Episodes lasted <1 minute and were followed by somnolence and a lack of recall of the event. A left temporal presumed ganglioglioma was discovered

on cranial magnetic resonance imaging (MRI) with video electroencephalography demonstrating left temporal spike and slow wave activity. Antiepileptic drug treatment was started with carbamazepine; however, this was later withdrawn, as it altered the patient's appreciation of pitch, a rare side effect more typically described in Japanese women.³

Despite treatment with lamotrigine and levetiracetam, seizure control was not achieved, and consequently preoperative evaluation for epilepsy surgery was undertaken. Following detailed assessment (outlined below), the patient underwent a lesionectomy via a subpial anterosuperior temporal gyrus approach with near-total resection of the tumor, which resulted in the patient becoming seizure-free. Our normal approach for such a case would have been a standard 4-cm left (Spencer type) anterior temporal lobectomy, but

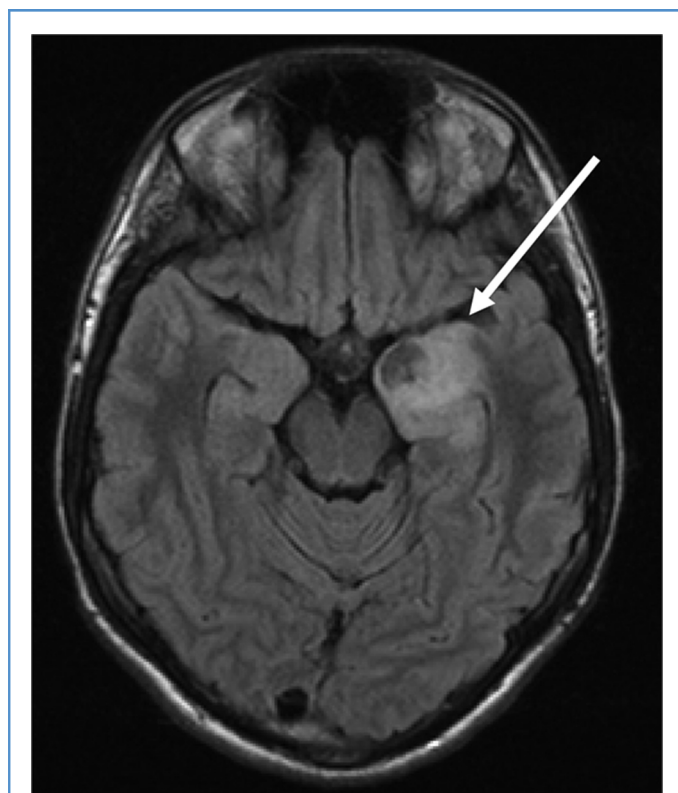


Figure 1. T1-weighted magnetic resonance imaging of the brain demonstrating medial left temporal lobe grade I ganglioglioma (arrow).

this was not used owing to concerns raised by the fMRI evaluation. The extent of the resection was hindered by draining veins. The patient was informed that the chances of being rendered seizure-free would likely be reduced by this approach and that if his seizures continued, a more aggressive surgical approach with an awake procedure using electrical stimulation mapping (ESM) would be proposed.

Structural MRI

The patient underwent T1-weighted and T2-weighted structural whole-brain MRI on a 3T Philips Achieva platform (Philips Medical Systems, Best, The Netherlands) with an 8-channel phased array head coil. The image acquisition parameters are as follows: T1-weighted three-dimensional spoiled gradient-echo sequence: slice thickness = 1.2 mm, no interslice gap, matrix size 256×256 , field of view = 22×22 cm, flip angle 15° , echo time = 3 ms, repetition time = 8 ms; T2-weighted: slice thickness = 3 mm, 36–52 slices per volume, no interslice gap, matrix size 256×224 , field of view = 22×22 cm, flip angle

90° , echo time = 125–165 ms, repetition time = 9000 ms. Structural MRI demonstrated a medial temporal lobe lesion in keeping with a ganglioglioma with mild mass effect involving the left amygdala and hippocampus (Figure 1).

Preoperative Auditory fMRI with Musical Paradigm

Auditory blood oxygen level-dependent fMRI was performed using a modified T2*-weighted echo-planar imaging gradient-echo sequence: slice thickness = 3.0 mm, matrix size 64×64 , field of view = 24×24 cm, flip angle 90° , echo time = 30 ms, repetition time = 52,000 ms. The auditory fMRI paradigm consisted of a 2-condition AB box-car (block) design with stimuli and rest (15-second epochs; 10 blocks). The patient was engaged in brief training sessions before the fMRI scan. Three fMRI investigations were conducted, as follows:

1. Listening to a familiar musical piece (instrumental classical music, selected by the patient). This paradigm was chosen

to examine auditory and extra-auditory substrates of musical processing.

2. Humming the selected piece in absence of musical stimuli. This paradigm was chosen to examine musical motor performance and memory of the familiar piece.
3. Thinking about the selected musical piece. This paradigm was chosen to reflect the common practice of mental musical imagery often used in professional musicians to enhance performance.

Preoperative and Postoperative Neuropsychometrics and Wada Test

Preoperative and postoperative neuropsychological testing was performed using the Wechsler Adult Intelligence Scale—Third Edition.³ Confirmation of lateralization of language and contralateral memory integrity was achieved via a Wada test (intracarotid sodium amobarbital injection).⁴

Preoperative and Postoperative MBEA Scores

The MBEA was used to assess 6 music processing components: scale, contour, interval, rhythm, metric, and music memory using 30 musical phrases based on a cognitive neuropsychological model of musical processing.²

RESULTS

Neuropsychometrics and Wada Test

Preoperative testing revealed an asymmetric neuropsychological profile in the nonanticipated direction with verbal scores being greater than nonverbal/visual scores. The subsequent Wada test showed right-hemisphere language dominance with the contralateral hemisphere being considered capable of supporting memory to an adequate degree. Index scores for verbal comprehension, perceptual organization, and full-scale IQ were all very superior. The working memory index score was superior, and the processing speed index score was high average. Verbal comprehension and perceptual organization index scores were symmetric. Index scores for auditory immediate and delayed memory were high average. The measured visual immediate memory score was average and remained average on delay.

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