Original article

Epileptic Disord 2008; 10 (2): 113-8

Ictal singing: case report and reappraisal of the literature

Carla Bentes[1,2], José Pimentel[2], João Costa[1], Rosa Santos[1], Vasco Rolo[1]

[1] EEG/Sleep Laboratory, Department of Neurosciences
[2] Epilepsy Study Group, Department of Neurosciences, Hospital de Santa Maria, Faculty of Medicine, Lisbon, Portugal

Received November 14, 2007; Accepted February 20, 2008

ABSTRACT – Singing is a rare ictal symptom of focal epilepsy. We report a case of a left-handed woman, with no musical education, experiencing refractory seizures consisting of the singing of a popular Portuguese folksong, with simultaneous, rhythmic hand clapping. A left mesial temporal sclerosis was successfully treated by selective amygdalohippocampectomy. As in most previously reported cases, the epileptogenic zone was located in the left hemisphere, although the ictal onset zone could not be lateralized on scalp EEG. This clinical case supports the evidence that cerebral music production seems to require both hemispheres, in accordance to the concept that brain specializations for music is associated with a dynamic, well-orchestrated interaction of music-specific neural networks. *[Published with video sequences]*.

Key words: ictal singing, ictal semiology, video-EEG monitoring

Phonatory disturbances, including speech disturbances, vocalizations and primitive sounds, as ictal manifestation of focal seizures are well-known phenomena (Theodore *et al.* 1983, Meierkord and Shorvon 1991). However, peri-ictal singing is much rarer (Vidailhet *et al.* 1989, Meierkord and Shorvon 1991, Doherty *et al.* 2002) and its mechanisms are poorly understood. We present a case of ictal singing, with a left mesial temporal epileptogenic zone, in which melody, semantic content and rhythm could be recognized, and attempt to discuss its value as a lateralising sign and as support for the proposed cerebral mechanisms of music production.

Case study

A 29-year-old, left-handed woman, who was illiterate and with no specific musical education, was seen at our institution complaining of sustained epileptic seizures since the age of 12 months. Her seizures began with an epigastric aura, followed by oroalimentary and manual automatisms and with a rare secondary generalization. Recently, her mother had described some episodes with concomitant singing, but could not identify the song. Neurological examination disclosed a slight spastic, right hemiparesis and mental retardation. There was no history of febrile seizures, CNS infection,

Correspondence:
C. Bentes
EEG/Sleep Laboratory,
Department of Neurosciences
and Mental Health,
Hospital de Santa Maria,
Avenida Professor Egas Moniz,
1649-28 Lisboa, Portugal
<carlabentes@fm.ul.pt>

doi: 10.1684/epd.2008.0185

Work presented as a poster at the 7th European Congress on Epilepsy, Helsinki, Finland.

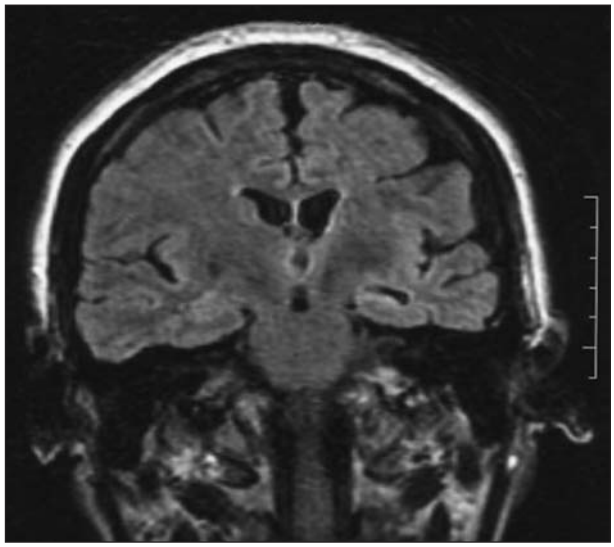

Figure 1. Axial sections of MR of the brain showing left hippocampal atrophy (FLAIR).

trauma, or perinatal complications. Family history was also uneventful.
The patient had received several antiepileptic drug regimes, either as mono- or polytherapy, but the seizures remained pharmacoresistent.
A 1.5 tesla brain MRI, performed at the age of 35 disclosed left hippocampal atrophy along with an ipsilateral basal ganglia asymmetry *(figure 1)*. Interictal EEG showed slight asymmetry of the background activity, in accordance with a left hemisphere dysfunction, and bilateral, independent, anterior temporal sharp waves and spikes with a left predominance.
She refused surgery over the next few years. When she finally accepted to be evaluated for the epilepsy surgery program, the following studies were performed.

Video-EEG monitoring

Several seizures were registered, and were clinically characterised by ongoing activity arrest, discrete chewing and bilateral hand automatisms especially of the left hand, followed by rhythmic hand clapping and the singing of a Portuguese folksong *(figure 2, see video sequence)*. Occasional, understandable ictal speech, responding briefly to simple questions from the observer, occured. Postictally, no aphasia was seen and the patient was not aware of the singing episode.
On the EEG record, after 12 seconds of diffuse electrodecrement, a bilateral, temporal theta (6 Hz) rhythmical activity *(figure 3A)* was observed. Later in the seizure, and in association with the ictal singing, there was a right anterior, temporal lateralization of a 4.5 Hz rhythmic activity *(figure 3B)*. In the postictal period, right anterior, temporal slowness was reported.
Curiously, the EEG ictal frequency (4.5 Hz) during the singing, and the rhythm of the song (1.8 Hz), had a least common multiple of 9.0, meaning that they both coincided with the start of each musical phrase.

Neuropsychological evaluation

Disclosed mental retardation (IQ = 55, Verbal IQ = 64, Performance Q = 53) and multiple cognitive defects (language, memory, executive functions, elementary calculus, verbal initiative and fluency, and non-verbal (visual and visuo-perceptive) capacities.

Interictal SPECT

Showed a left fronto-temporal hypoperfusion.

Although lacking a lateralizing, irritative and ictal onset zone, the patient had a well-defined epileptogenic lesion, and was elected for surgery. A left, selective amygdalohippocampectomy was performed. Neuropathology was consistent with mesial sclerosis associated with neuronal dysplasia and amygdala gliosis. She has been seizure-free since surgery, and the follow-up period is currently 3.5 years.

Discussion

The favourable, post-surgical outcome proved that the epileptogenic zone was localized in the left amygdala-

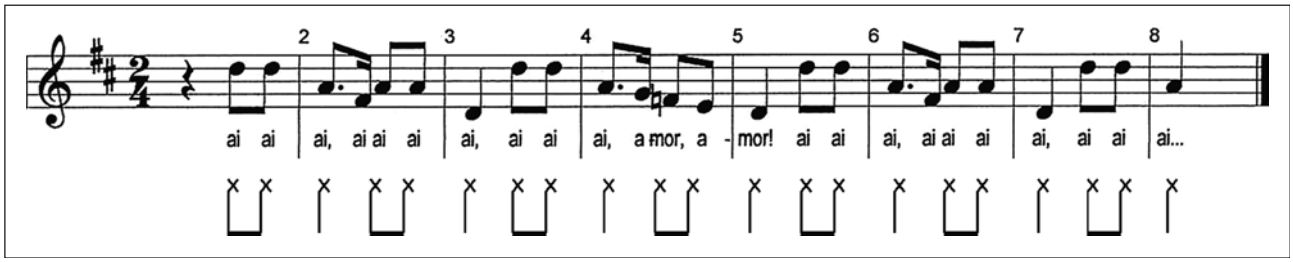

Figure 2. Characteristics of the ictal song, sung by the patient during the seizure.
Tone: D Major, beat: binary (2/4), rhythm: semi- minim = 108 bpm (/60s) = 1.8 Hz, frequencies (notes): scale of size – hundreds, character: popular music / folksong – "malhão".

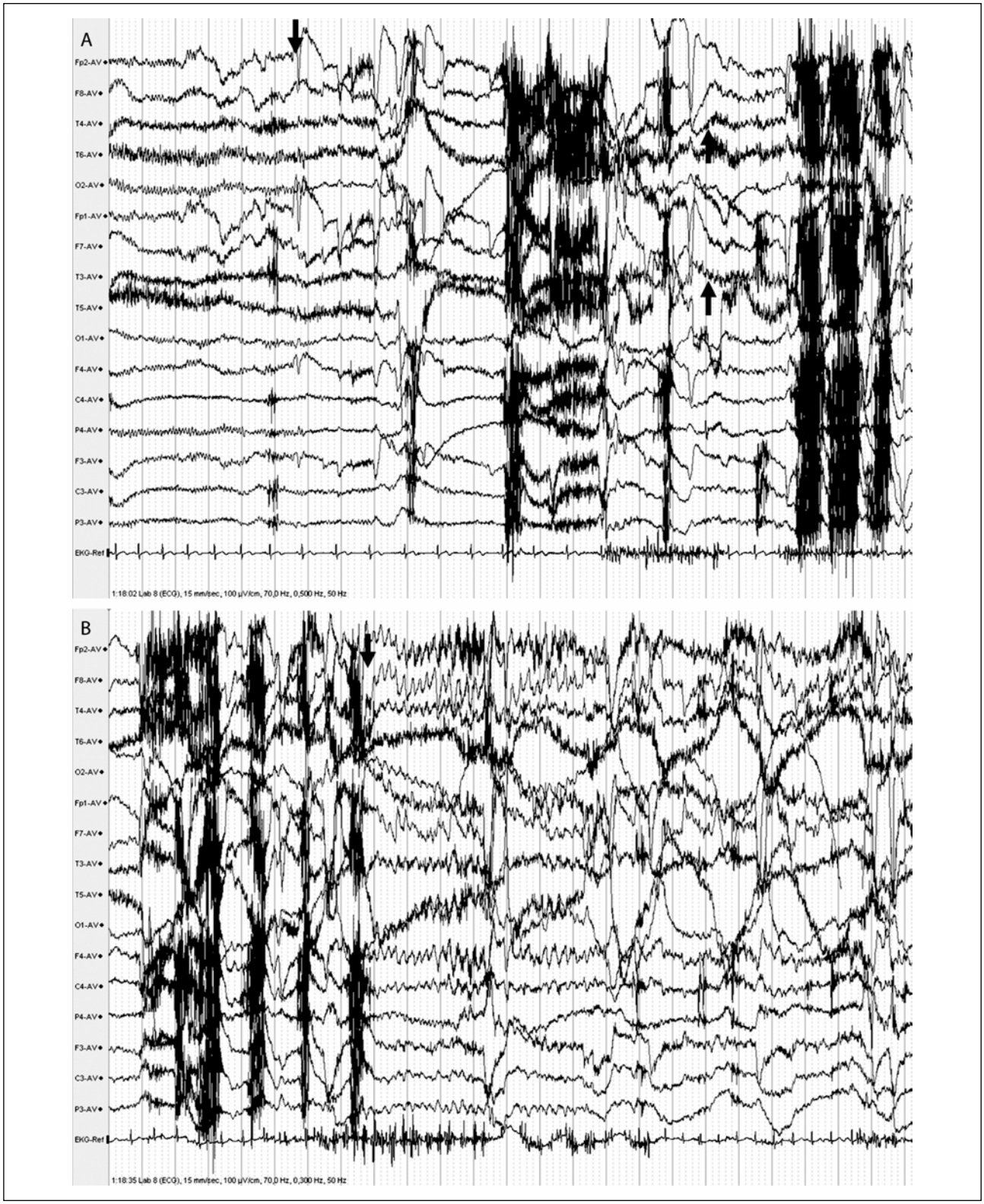

Figure 3. Important aspects of the video-EEG monitoring. **A**) The bilateral temporal ictal onset. Diffuse electrodecrement (downward black arrow) followed by bilateral temporal rhythmical theta (upward black arrows). **B**) The late right lateralization of ictal activity (downward black arrow).

Table 1. Comparison of the ictal singing cases described in the literature.

	Case 1 Vidailhet *et al.* 1989	**Case 2 Meierkord *et al.* 1991**	**Case 3 Dorherty et al. 2002**	**Case 4 Dorherty *et al.* 2002**	**Case 5 Bartolomei *et al.* 2007**	**Case 6 Bartolomei *et al.* 2007**	**Case 7 Bentes *et al.* 2008**
Patient laterality	Right-handed	Right-handed	Right-handed	Left-handed	uk	uk	Left-handed
Epileptogenic lesion	Left mesial frontal tumor	Normal CT scan	Left frontotemporal encephalo-malacia	Left mesial temporal sclerosis	Right posttraumatic lesion	Right focal cortical dysplasia	Left mesial temporal sclerosis
Irritative zone	No	Right mid temporal	Bilateral frontotemporal (left predominance)	Bilateral temporal (sphenoid/ subdural electrodes)	uk	uk	Bilateral anterior temporal (left predominance)
Ictal onset zone	uk	Not lateralized	Not lateralized	Right temporal (subdural electrodes)	Right frontal (depth electrodes)	Right frontal (depth electrodes)	Not lateralized

uk: unknown.

hippocampal region. Yet, according to the pre-surgical assessment and the majority of other reported cases of ictal singing *(table 1)*, full accordance could not be achieved between ictal-onset zone lateralization and other presurgical tests.

Because of the left-handedness, the dominant hemisphere in this patient is, with a high probability, the right one. Some of the ictal semiology, namely the ictal speech, and the absence of post-ictal aphasia, favoured, in fact, a non-dominant (in this case, the left) symptomatogenic zone, in agreement with the MRI findings and interictal SPECT. Furthermore, the predominance of left hand automatisms at the beginning of the event pointed to a left-side, ictal onset.

Scalp ictal EEG revealed a bilateral, temporal ictal-onset zone, with a late, right lateralization and as such, does not rule out a possible left hemisphere-onset with contralateral propagation. Intracranial recording could have been a way of clarifying this aspect, but the risks were thought to outweigh the benefits.

Ictal singing displaying song production during a seizure, should be distinguished from other disorders involving musical or melody function, such as musicogenic epilepsy (seizures triggered by music) (Wiser *et al.* 1997), aprosody (abnormalities involving the affective components of speech, including pitch, melody and intonation), and amusia (impaired capacity for musical activity not explained by damage to the articulatory apparatus [Bautista and Ciampetti 2003]), all three involving the right hemisphere, and musical focal seizures (musical hallucinations as the expression of a seizure) (Brust 2001). Music-provoked hallucinations are slightly more often evoked by electrical stimulation of the right rather than the left temporal regions (Penfield and Perot 1963). This selective elicitation of musical memories has been viewed as indicative of a brain specialization for music (Peretz 2002). Furthermore, most of the reported, spontaneous musical hallucinations refer to temporal lobe lesions or impaired frontal lobe modulation of temporal lobe structures (Keshavan *et al.* 1988). An ictal musical hallucination implies the presence of an auditory memory, but ictal singing also involves an expressive component. However, some data support an overlap in the perceptual and productive aspects of music, as well as a bihemispheric organization for musical tasks (Özdemir *et al.* 2006).

Temporal lobe involvement occurs in the great majority of the described cases of ictal singing (2, 3, 4 and 7), supporting the initial observations of Penfield and Perot (1963), who triggered musical experiences during electrical stimulation of this lobe. Furthermore, in the majority of previously reported cases, including the present one, all known epileptogenic lesions (cases 1, 3, 4 and 7) were localized in the left hemisphere, which was supposed to be the dominant one in two patients (cases 1 and 3) and the non-dominant in the other two (cases 4 and 7). This is in accordance with the previously reported evidence that singing production is only possible with an intact right hemisphere (Gordon and Bogen 1974), which is traditionally viewed as the musical hemisphere. However, the ictal involvement of the right hemisphere in cases 3, 4 and 7 is suggested by a bilateral, irritative zone, in cases 2, 3 and 7 by a non-lateralized ictal-onset zone, and in cases 4, 5 and 6 there was confirmed involvement as assessed by intracranial electrodes. Moreover, a very recent clinical report (Bartolomei *et al.* 2007) comparing five patients with ictal humming and two patients with ictal singing (*table* 1, case 5 and 6), suggests that humming is particularly observed in temporal lobe seizures and singing is more suggestive of seizures affecting the frontal lobe, in particular the right prefrontal cortex. The large network of regions involved in normal musical processing, as distinct from the epilepto-

genic network (Bartolomei *et al.* 2002), could support these different descriptions of the origin of singing.

Music is a specifically human trait and its production seems to require the orchestration of several components, *e.g.* rhythm, timbre, melody, pitch, lyrical content and expression, harmony (Doherty *et al.* 2002). Some of these seem to be predominantly a left hemisphere task (*e.g.* pitch and rhythm), while others (*e.g.* timbre) a right hemisphere one (Platel *et al.* 1997). In fact, the emerging evidence is that musical functions dynamically recruit several mechanisms/neuronal networks, involving regions in both hemispheres (Peretz 2002). In support of this statement, our patient had a clear left epileptogenic zone, and a definite involvement of the right hemisphere, during the ictal singing seizure, as demonstrated by the neurophysiological assessment.

Recordings using signal processing such as coherence and time-frequency analysis of temporal lobe seizures - stereoelectroencephalographic records - (Bartolomei *et al.* 2002), have shown that the occurrence of a discreet form of singing (humming) is associated with activity in a neuronal network involving the superior temporal gyrus (STG) and the inferior frontal gyrus (IFG), which are topographically distinct from the network implicated in the epileptic zone (amygdala-hippocampal and in some cases the middle temporal gyrus). Furthermore, this "humming network" was activated after ictal propagation out of the epileptogenic zone and was associated with the recruitment into theta synchrony of temporal-frontal networks. The existence of a neural network involving lateral temporal, inferior frontal and inferior parietal cortices, underlying melodious manifestations during seizures, has also been showed by SPECT studies (Guedj *et al.* 2006). In a similar way, our case disclosed a late, right temporal, theta rhythm (4.5 Hz) in association with ictal singing, occurring clearly after ictal onset, and not associated with the left amygdala-hippocampal epileptogenic zone. The existence of a temporal dissociation between seizure disorder-onset and the appearance of ictal singing, also support, in this case, the development of a distinct neuronal network.

The observed theta synchrony in a temporal association with ictal singing is probably important in the mechanisms of singing production. This statement is supported by other studies showing that the timbre and pinch discrimination in musical sounds are associated with EEG activations within the alpha and theta bandwidths (Auzou *et al.* 1995).

Recent fMRI studies (Özdemir *et al.* 2006), showed a large overlap in activation regions associated with singing, humming and speaking, including the inferior pre- and postcentral gyrus, the STG and the superior temporal sulcus in both hemispheres. This pattern of activation may constitute a neuronal network for vocal production. However, in the singing paradigm, additional right side activation of the STG, inferior central operculum and IFG occurred. This pattern of differential laterality for singing has also been found by other imaging studies (Callan *et al.* 2006). The involvement of a larger network activation, reflects a greater bihemispheric organization for singing, and explains the clinical dissociation between singing and speaking in some patients.

The hypothesis is that ictal singing requires diffuse musical elements to be brought together and vocalized in such a way as to produce a recognisable tune (Doherty *et al.* 2002). Thus, the dynamic characteristics of the functioning and interactions of the music-specific neural networks, rather than their location, as previously posited, seem to be the basis of the brain specialization for music (Peretz 2002).

Conclusion

In conclusion, in the reported cases of ictal singing the ictal onset zone has not been consistent. Notwithstanding, there is an increasing body of evidence that brain specialization for music requires the involvement of both hemispheres and the dynamically recruitment of several neuronal networks, involving different cerebral lobes. Ictal singing is probably related to the recruitment of a "propagation network" mimicking musical activation of the brain that can be distinct from the epileptogenic zone. The neurophysiological evaluation of the case described, provides evidence for this statement. □

Legend for video sequence

Seizure characterized by discrete chewing and bilateral hand automatisms, followed by rhythmic bilateral hand clapping and singing of a Portuguese folksong. At the end, the patient sits on the bed, calls for her mother and looks around.

References

Bartolomei F, Wendling F, Vignal JP, *et al.* Neural Networks Underlying Epileptic Humming. *Epilepsia* 2002; 43: 1001-12.

Bartolomei F, McGonigal A, Guye M, *et al.* Clinical and anatomic characteristics of humming and singing in partial seizures. *Neurology* 2007; 69: 490-2.

Bautista RE, Ciampetti MZ. Expressive aprosody and amusia as a manifestation or right hemisphere seizures. *Epilepsia* 2003; 44: 466-7.

Brust JC. Music and the neurologist. A historical perspective. *Ann N Y Acad Sci* 2001; 930: 143-52.

Callan ED, Tsytsarev V, Hanakawa T, *et al.* Song and speech: Brain regions involved with perception and cover production. *Neuroimage* 2006; 31: 1327-42.

Doherty MJ, Wilensky AJ, Holmes MD, *et al.* Singing seizures. *Neurology* 2002; 59: 1435-8.

Gordon HW, Bogen JE. *J Neurol Neurosurg Psychiatry* 1974; 37: 727-38.

Guedj E, Guye M, Laforte C, *et al.* Neural Network Underlying Ictal Humming Demonstrated by Very Early SPECT: A case Report. *Epilepsia* 2006; 47: 1968-70.

Keshavan SM, Khan M, Jaspreet SB. Musical hallucinatins following removal of a right frontal meningioma. *J Neurol Neurosurg Psychiatry* 1988; 51: 1235-41.

Meierkord H, Shorvon S. Variations on a theme-singing as an epileptic automatism. *J Neurol Neurosurg Psychiatry* 1991; 54: 1114-6.

Özdemir E, Norton A, Schlaug G. Shared and distinct neural correlates of singing and speaking. *Neuroimage* 2006; 33: 628-35.

Penfield W, Perot P. The Brain record of auditory and visual experience. *Brain* 1963; 86: 595-696.

Peretz I. Brain specialization for music. *Neuroscientist* 2002; 8: 372-80.

Platel H, Price C, Baron J-C, *et al.* The structural components of music perception. A functional anatomical study. *Brain* 1997; 120: 229-43.

Theodore WH, Porter RJ, Penry JK. Complex partial seizures: clinical characteristics and differential diagnosis. *Neurology* 1983; 33: 1115-21.

Vidailhet M, Serdaru M, Agid Y. Singing in the brain: a new form of complex partial seizure? *J Neurol Neurosurg Psychiatry* 1989; 52: 1306-11.

Wieser HG, Hungerbuhler H, Siegel AM, *et al.* Musicogenic epilepsy: review of the literature and case report with ictal single photon emission computed tomography. *Epilepsia* 1997; 38: 200-7.