

CASE REPORT

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Is hemispheric language dominance relevant in musical hallucinations?**Two case reports**

Received: 16 July 2002 / Accepted: 2 December 2002

Abstract It has been suggested that musical hallucinations are often due to a focal brain lesion predominantly of right hemispheric pathologies. We report about two patients with musical hallucinations associated with a brain tumor of the right hemisphere. Although both patients were right-handed, one of them had a right hemispheric dominance for language as proven by the Wada test. The musical ability as measured by the Seashore test was not impaired. We conclude that the language dominance of the hemisphere is not primarily relevant for the development of musical hallucinations.

Key words musical hallucinations · brain tumor · seashore test

Introduction

Auditory hallucinosis consists of abnormal acoustic perception occurring in the absence of a corresponding acoustic stimulus while the patient is aware of its non-real nature (Berrios 1990). Beside unspecific abnormal perception such as tinnitus, voices as a more figured kind of acoustic hallucinations are frequent. In contrast, the prevalence rate of musical hallucinations is very low. Fukunishi et al. (1998) found it to be 0.16% of a large sample in a general hospital setting.

Musical hallucination is a very specific type of acoustic hallucinations. It constitutes a disorder of complex sound processing in which perception is formed by music, sounds, or songs (Cerrato et al. 2001). The etiol-

ogy of musical hallucinations is very heterogeneous. It is most commonly seen in subjects with moderate or severe acquired loss of hearing ability or deafness, and as such it may represent an auditory analogon of the Charles Bonnet syndrome (Griffiths 2000). Furthermore, it can be found as a manifestation of epilepsy, in particular in patients showing abnormal EEG pattern in temporal brain areas (Keshavan et al. 1992), and as a concomitant phenomenon in psychiatric illnesses such as severe depression or schizophrenia (Keshavan et al. 1992, Aizenberg et al. 1986, Baba and Hamada 1999). Focal brain lesions (Gordon 1997), in particular those involving the temporal cortex (Erkwoh et al. 1992), general brain atrophy (Aizenberg et al. 1986, Gilchrist and Kalucy 1983), and toxic states (Allen 1985) are further conditions found to be linked with musical hallucinations (for review see Berrios 1990 and 1991, Keshavan et al. 1992).

Regarding musical hallucinations after brain damage, only little is known about the influence of the involved hemisphere or hemispheric language dominance. In his synopsis, Berrios (1990 and 1991) suggested that with respect to laterality in patients with tumor, stroke, or epileptic focus, the right, i. e., the usually non-dominant, hemisphere seems to play a major role. This has recently been confirmed by neuroimaging methods (Kasai et al. 1999) and is considered to be consistent with the right hemisphere being dominant in music perception (Damasio and Damasio 1977, Zatorre 1984) at least in non-musicians (Bever and Chiarello 1974, Evers et al. 1999). In their review, Keshavan et al. (1992) pointed out, however, that right-sided lesions are only marginally more often associated with musical hallucinations among the patients with coarse brain disease.

Hemispheric language dominance had not been evaluated individually in the case reports published to date and dominance of the left hemisphere in right-handed patients was taken for granted. We recently showed that the relationship between handedness and language dominance is not a strict one (Knecht et al. 2000). For ex-

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ample, in strong right-handers, a right-hemispheric language dominance was found in 7.5 % of the subjects.

In this report, we describe two right-handed patients with musical hallucinations who suffered from brain tumors, both involving the right hemisphere. We evaluated hemispheric language dominance and found the right hemisphere to be dominant in one of the two patients and the left hemisphere to be dominant in the other one.

Berrios (1990) supposed that the level of the sufferer's musical training might influence the general reporting of musical hallucinations. He suggested a connection between the damaged hemisphere and musical skills due to findings of Bever and Chiarello (1974) that representation of musical information shifts with training from the non-dominant to the dominant hemisphere. This was confirmed in a recent study (Evers et al. 1999). In order to evaluate the musical ability of both patients in an objective way, we performed the Seashore test (Lewis and Sæviest 1960). This test contains six measurements as follows:

- Sense of pitch (50 pairs of tones differing in frequency from 17 Hz to 2 Hz; the subject is asked whether the second tone is higher or lower than the first).
- Sense of loudness (50 pairs of tones differing in intensity from 4.0 to 0.5 decibels; the subject is asked whether the second tone is stronger or weaker than the first).
- Sense of rhythm (30 pairs of rhythmic patterns; the subject is asked whether they are the same or different).
- Sense of time (50 pairs of tones differing in duration by 0.3 to 0.5 second; the subject is asked whether the second is longer or shorter than the first).
- Sense of timbre (50 pairs of tones, each of which is made up of the fundamental first five harmonic intervals with the intensities of the third and fourth harmonies being varied; the subject is asked whether they are the same or different.)
- Tonal memory (30 pairs of tone sequences with one tone different in the second sequence as compared to the first; the subject is asked which tone is different).

Age-related normal values have been evaluated for the Seashore test (Butsch and Fischer 1966). They are presented with the individual results of the two patients described in this report in Table 1.

Case reports

■ Patient 1

Patient 1 was a 23 year old Turkish man who was referred to our inpatient department with a 3-month history of episodes with receptive and productive aphasia, alexia, and agraphia. He was tested to be right-handed by the Edinburgh inventory (Oldfield 1971). The deficits occurred suddenly, lasted two to three hours, and vanished completely again. This happened four times during the last three months. Otherwise, no history of previous diseases, neither neurological nor internal could be recorded. He was suspected of having transient ischemic attacks.

At the time of admission, the clinical findings were regular. However, EEG revealed a pathologic 2 Hz delta focus on the right parietofrontal side. MRI including perfusion studies showed a 3 x 4 cm signal intense lesion in the right temporal lobe with abnormally reduced perfusion, suspicious to be tumorous. This was verified by stereotactic biopsy. The patient was diagnosed with right temporal glioblastoma grade IV of the WHO classification.

The Wada test (Wada and Rasmussen 1960) clearly demonstrated right hemispheric language dominance with deficits both in articulation and comprehension. This is why a complete resection of the tumor was not considered and chemotherapy was initiated instead. Since growing of the tumor proceeded, it was partly resected half a year later. Two months afterwards, the patient reported for the first time about musical hallucinations. He was not under medication at that time. Music of all kinds was perceived for several hours a day, two or three times a week. He described it as either English pop music or modern Turkish folk music like a radio program. The hallucinations did not occur ictally but had a character of background music. The patient did not have any musical experience except the common music education in primary and secondary school. He indicated that his father was very fond of Turkish folk music. Before onset of symptoms, he himself liked to hear a lot of music being together with friends, on parties or family events. Since being diagnosed with cancer, he had rarely listened to music. Our patient

Table 1 Results of the Seashore test of the two reported patients and comparison to normal values

	Patient 1	Patient 2	Score range for 87 % of the normal population ^a	Arithmetic mean of normal population ^b
Pitch	41	45	34–49	40 ± 7
Loudness	43	38	35–49	43 ± 5
Rhythm	29	28	23–29	27 ± 3
Time	36	42	32–46	40 ± 5
Timbre	46	39	29–43	39 ± 5
Tonal memory	30	30	21–29	25 ± 5

^a according to Butsch and Fischer (1966); ^b according to Henson and Wyke (1982)

was aware of the fact that no external stimuli for his perception existed. He described the sound as 'emerging in his head itself'. The perceptions neither frightened nor pleased him; he described them as affectively neutral.

For objective evaluation of his musical ability, the patient underwent the Seashore test. He showed average to good results as presented in Table 1.

■ Patient 2

Patient 2 was a 53-year-old woman who was right-handed according to the Edinburgh inventory (Oldfield 1971). At the age of 40, she was diagnosed with astrocytoma grade II according to the WHO classification in her right hemisphere, and the tumor was removed. Despite taking antiepileptic medication (phenytoin), she developed left-sided epileptic Jackson seizures with clonic cramps of her facial muscles, dizziness, and impaired consciousness nine years later. At this time, no relapse of the tumor could be observed. Antiepileptic medication was increased. Another three years later, i. e., 12 years after the first diagnosis, she had her first generalized seizure. MRI was performed and showed a relapse of the tumor in the right frontotemporal hemisphere with a size of 4 x 5 cm. The patient underwent radiotherapy, and the progression of the tumor was stopped.

At the time of admission to our department, which was two months after radiotherapy had started, the neurological examination was normal except for slightly increased muscle tendon reflexes on the left side. She still had been taking carbamazepine as an antiepileptic medication. No more generalized seizures occurred; frequency of focal seizures declined. EEG showed a dysrhythmic focus in the right frontotemporal hemisphere but no epileptic pattern. Testing aphasic symptoms by the Aachen Aphasia Test (AAT) did not reveal any abnormalities although at least mild disturbances could have been expected because of the size and localization of the lesion if the right hemisphere had been dominant. Thus, the patient was regarded to have left hemispheric dominance for language.

It was at this time that, the patient mentioned the first acoustic hallucinations lasting one to three days. She perceived German folk music of simple rhythm and foreign melodies. Perceptions appeared spontaneously, frequently after excessive strain, and used to stay in the background of her head for days without interruption. Even stopping carbamazepine for two weeks did not influence the occurrence of these musical hallucinations which were associated with feelings of anxiety, although the mood of the music was neutral. The patient was not educated in music except lessons in primary school; she did not play any instrument and was not able to read notes. She rarely listened to music; if she did, she preferred traditional folk music and music from the local radio.

This patient also underwent the Seashore test. We ob-

tained average to good results in the different categories of the test (see Table 1).

Discussion

We add a further case to the large sample of reports on musical hallucinations associated with a focal brain lesion of the right non-dominant hemisphere. Furthermore, we add a second case with musical hallucinations due to a lesion of the right hemisphere with this hemisphere proven to be dominant for language. Both patients showed average to good musical ability as measured by the Seashore test but neither was a skilled musician or an experienced analytical listener to music. Therefore, their musical perception is most probably processed in the non-dominant hemisphere (Bever and Chiarello 1974, Evers et al. 1999). As proven by functional testing with the Wada test and the AAT, this was the right hemisphere for patient 1 and the left hemisphere for patient 2.

A malignant process of the right hemisphere possibly caused the musical hallucinations in both of them. Therefore, it is the dominant hemisphere in one patient and the non-dominant hemisphere in the other patient that is responsible for the phenomenon. Even the type of music the patients perceived and the feelings the perception evoked were very similar in both. In the patients reviewed and described in the literature, right hemispheric lesions have been suggested to be the underlying pathology of musical hallucinations more often than left hemispheric lesions (Berrios 1990 and 1991). Many authors conclude that lesions of the right, i. e., non-dominant, hemisphere cause musical hallucinations because of interruption (i. e., deafferentiation) of information processing in the brain areas important for perception of music.

The two patients reported here indicate that language dominance of a hemisphere per se is not of importance for the development of musical hallucinations. This supports the observation by Keshavan et al. (1992) that right hemispheric lesions are only marginally more often involved in musical hallucinations than left hemispheric lesions. Furthermore, malfunction of brain areas important for the processing of musical stimuli does not seem to be a prerequisite for or the decisive trigger of musical hallucinations in general. This corresponds with a case report on a composer showing that lateralization of music processing is not as stable and predictable as that of language (Luria et al. 1965).

The basic musical skills were unimpaired in our patients. Therefore, we cannot conclude whether the level of basic musical ability is of importance for the development of musical hallucinations. Presumably other factors are more important for the initiation of musical hallucinations.

Functional and morphometric brain imaging may provide an even better understanding of complex cognitive processing. Still, we are far from understanding

one of the most sophisticated human abilities – music perception. One fundamental question is whether musical processing resembles other higher cognitive functions such as language in that the underlying neural network is lateralized to one hemisphere. In addition, we do not yet know whether there is a consistent relationship between lateralized linguistic and musical processing. Observations of musical hallucinations in patients with hemispheric brain lesions can be informative about this question.

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