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The impact of temporal lobe epilepsy on musical ability

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ABSTRACT

Purpose: Patients with temporal lobe epilepsy (TLE) often show impairment of cognitive processing in different domains. We aimed to evaluate whether also musical ability is impaired in TLE.
Methods: We enrolled patients with lesional TLE and without any other neurological or psychiatric disorder. The side and the etiology of the epilepsy were confirmed by EEG and by MRI. We applied a self-developed test of musical ability which evaluates the ability to identify melodies, pitch, rhythm, and emotional content of music. In addition, we compared the results of the patients to the results of age and sex matched healthy control subjects. All patients and subjects were without specific musical training.
Results: Patients with left TLE showed a significantly lower score in melody recognition, patients with right TLE showed a significantly lower score in identification of emotion in music. In all other aspects of music ability, no significant difference between left and right TLE could be found. We observed a significantly lower total score in patients with left TLE, but not with right TLE, as compared to healthy subjects. There were no differences with respect to sex.
Conclusion: Our data confirm that the recognition of melodies shows left hemisphere dominance whereas the identification of emotions in music shows right hemisphere dominance in patients without musical training. Furthermore, our data show that the impairment of cognitive processing in TLE is reflected even in higher cognitive functions such as music processing. However, this impairment was mild.

1. Introduction

Temporal lobe epilepsy (TLE) can have a significant impact on cognitive processing in many domains.[1] This has been evaluated by neuropsychological testing and other methods such as functional neuroimaging and electrophysiological measures.[2] In particular, the side of TLE has differential impact on the neuropsychological impairment with dysfunction of the dominant temporal lobe affecting verbal and non-dominant temporal lobe affecting primarily visuo-spatial cognitive function.[3–6] How TLE affects higher and more specialized cognitive functions remains unknown.

Lesional studies suggest impairment of music processing after epileptic surgery.[7–9] However, the specific cognitive processing of musical parameters has, to our knowledge, not yet been studied in TLE itself systematically. In one case report, right TLE caused amusia.[10] Since music can be of high importance for quality of life, even in those people without specific musical experience or training, we were interested in how the presence of TLE can affect basic musical perception. Therefore, we applied a standardized test of musical ability to patients with TLE which has been developed to measure musical ability in patients with neurological disorders. The test has a high ceiling effect and, thus, detects only relevant deficits of musical ability.

In this pilot study, we examined a strictly homogenous sample of patients with TLE and without specific musical training. TLE was used as a lesional model for the relevance of hippocampal structures for cognitive processing of music. In particular, the differential impact of left versus right hippocampal lesions on musical ability was analyzed.

2. Methods

2.1. Patients and subjects

We enrolled consecutive patients with TLE as proven by seizure semiology and EEG recording. In order to obtain a very

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homogenous sample, we only enrolled patients suffering from TLE with a lesion in hippocampal structures. Reflex epilepsies were excluded. Further inclusion criteria were

- seizures were controlled by medication (i.e., less than one psychomotor seizure per month or one generalized seizure per year);
- stable medication (no change within the last 3 months);
- hippocampal lesion proven by MRI scan without any other lesions in the brain and concordant EEG changes;
- no professional musical education but at least public high school degree;
- right handed;
- no history of substance abuse.

We also enrolled healthy control subjects without any history of epileptic seizures and with a normal EEG. These control subjects were enrolled during the evaluation of the test.[11] The data of 27 right-handed sex and age matched control subjects without musical education but at least public high school degree were included in the statistical analysis.

No medication with central nervous side effects was allowed. Prior to the testing, all participants were asked about graduation, profession, musical training, and hearing ability. All participants were native German speakers and gave written informed consent; they were all examined on the same time of day and asked to sit in a comfortable chair and to listen to music tests by headphone. The study was approved by the local Ethics committee.

2.2. Testing musical ability

The clinical test of musical ability is supposed to examine basic musical perception and processing not presuming that participants had any special musical training in the past. For it can be expected that even musically untrained people should acquire basic musical competence because of just being exposed to music. This test was developed for application to cerebral stroke patients as well as healthy controls demonstrating that it indicates impairment of cerebral functions concerning musical perception and processing.[11]

Short rhythmic or melodic tracks on CD (played by instruments) were presented to the participants via headphone. Participants were informed that once the audio samples were heard they could not be repeated, so decision should be made straight after the single tracks. Before starting each subtest, the upcoming task was explained in detail until, and it was made sure by the examiner that the subject had fully understood the task. To allow the participants to focus just on hearing they gave verbal answers which were noted immediately by the examiner on a response sheet. The musical testing is subdivided into five parts:

(1) *Rhythm and meter*: The participant had to reproduce 16 (1–3: 2/4 time; 4–10: 4/4 time; 11–16: 3/4 time) short rhythmic sequences by tapping with a pen on a table. For each of the samples correctness of rhythm and meter was evaluated separately and noted, resulting in a maximum score of 16 points for rhythm and 16 point for metrum.
(2) *Comparing melodies*: A first melodic sequence serving as a standard melody was shortly followed by a second melody. The latter should be compared to the standard melody. The 16 samples included four different standard melodies. Participants should just tell if the second melody was identical (7×) or different (9×). It was not necessary to specify the location of the interval changes (minor or major second, third, fourth, fifth, octave). Each correct comparison produced one point, overall 16.
(3) *Emotions*: This subtest consisted of 12 improvisational short pieces of 3–4 bars duration. Each sample should represent one of these emotions: anger (3×), fear (3×), sadness (4×), happiness (2×). Before the actual testing, the four emotions were written down and placed in front of the participant so he could concentrate on listening without memorizing them continuously. After each track, participants were advised to choose which of the named emotions would reflect the heard sample best. Participants were not informed about the total number each emotion would occur during the testing. A full score of 12 points could be reached in this task.
(4) *Pitch discrimination*: A piano played 12 different tone pairs on which the first tone should be compared to the second. The participant had to judge whether the second tone was higher or lower than the first (7 higher, 5 lower). The intervals ranged from minor second to minor seventh (minor second 3×, major second 1×, minor third 3×, major third 1×, perfect fourth 2×, perfect fifth 1×, minor seventh 1×). Each correct pitch discrimination was given one point resulting in a total score of 12 points for this subtest.
(5) *Melody recognition*: The patients listened to 14 short tracks consisting of either the beginning of a common well known German or international song (10×) or an improvisation (4×). The songs were: "Te Deum" by Charpentier; "Frère Jacques" (folk song); "Der Mond ist aufgegangen" (German lullaby); "Kommt ein Vogel geflogen" (German folk song); "Eine kleine Nachtmusik" by Mozart; "Yesterday" by The Beatles; "Love me tender" by Elvis Presley; "Oh Tannenbaum" (German Christmas carol); "Air" by Bach; "Schneewalzer" by Koschat. All were played by various instruments not using commercial recordings but ensuring that familiar melodies would be clearly recognizable through these samples. At the end of each track, participants should tell if they identified the melody as a familiar song or not. Concerning the scoring it was not necessary to explicit name the song title. For each correct answer, participants received one point (14 points maximum).

2.3. Statistics

Data are presented as arithmetic mean and standard deviation. Comparison between groups (left versus right TLE versus control group; male versus female) was made by Kruskal–Wallis-analysis with Mann–Whitney *U*-test as post hoc test and by X^2-test. Significance level was set at $p = 0.05$.

3. Results

We enrolled 27 patients (14 with left-sided lesion; 10 male patients). In all patients, the EEG showed a regional dysfunction of the respective temporal lobe. All patients had hippocampal sclerosis on MRI. The patients were either treated with one ($n = 18$) or two ($n = 9$) anticonvulsant drugs; no patient was without medication. The mean duration of TLE was 9.1 ± 3.4 years. The demographic data of the patients and of the healthy control subjects are shown in Table 1. We included the mean number of antiepileptic drugs (AED) including the range in this table. No patient was on carbamazepine, and one patient in each group was on topiramate. The most commonly taken AED in the left and right TLE patients were levetiracetam ($n = 8$ and $n = 7$, respectively) and lamotrigine ($n = 6$ and $n = 7$, respectively).

In Table 2, the results of the different subtests and the total score are presented separately for the left and right TLE patients. There was a significantly lower score for musical emotion identification in right TLE patients and a significantly lower score for melody recognition (but not comparison) in left TLE patients. In

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