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Exploration of the psychometric properties of the Montreal Battery of Evaluation of Amusia in a sample with temporal lobe epilepsy

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Original article

ABSTRACT

Background

The Montreal Battery of Evaluation of Amusia (MBEA) is a newly-developed instrument to assess music perception and memory, associated with temporal lobe functioning. Non-symptomatic temporal lobe epilepsy is a prevalent condition in Mexico, and it gives an opportunity to test the MBEA, considering the fact that epileptic seizures can cause neuropsychological impairment according to lobe localization and hemispherical lateralization of the epileptogenic focus.

Objective

To explore the psychometric and diagnostic properties of the MBEA.

Method

Two non-probabilistic samples of 31 control subjects and 22 cases with non-symptomatic temporal lobe epilepsy were assessed with the MBEA. Data from the original validation were used to compare with the control group.

Results

Analysis with the t test showed significantly lower performances in the case group relative to controls, and a general lower performance of controls compared to the norm. There was no significant difference in performance between cases with left epileptogenic focus and cases with right epileptogenic focus. ROC curve analysis showed questionable properties of sensitivity and specificity in the MBEA.

Discussion and Conclusion

Impairments in music perception were found in some cases, although theoretical inconsistencies with respect to relation between impaired functions were also detected. The performance of the control group relative to the norm indicated that the validation process should be continued, considering cultural differences. The MBEA seems to be a poor measure in terms of sensitivity and specificity for the detection of amusic impairments in subjects with non-symptomatic temporal lobe epilepsy, and its usefulness for determining hemispheric lateralization of epileptogenic focus remains uncertain.

Key words: Music cognition, amusia, temporal lobe epilepsy, lateralization of epileptic focus.

RESUMEN

Antecedentes

La Batería Montreal de Evaluación de Amusia (MBEA) es un instrumento de reciente creación, utilizado para evaluar percepción y memoria musical asociadas al funcionamiento de lóbulos temporales. La epilepsia de lóbulo temporal no sintomática (ELTns) es una condición de alta prevalencia en México; esto proporciona una oportunidad para evaluar la MBEA, considerando que las crisis epilépticas pueden producir alteraciones neuropsicológicas específicas según la localización lobular y la lateralización de foco epileptogénico (LFE).

Objetivo

Explorar las propiedades psicométricas y diagnósticas de la MBEA.

Método

Dos muestras no probabilística de 31 controles y 22 casos de epilepsia ELTns fueron evaluados con la MBEA. Se utilizaron asimismo los datos estandarizados originales de la MBEA para comparación de controles.

Resultados

El análisis con prueba *t* mostró desempeños significativamente menores de los casos en comparación con los controles y significativamente menores entre controles y la norma. No se encontraron diferencias significativas en los puntajes según LFE. El análisis por Curvas ROC mostró propiedades cuestionables de sensibilidad y especificidad en la MBEA utilizando la ELTns como variable de estado.

Discusión y conclusión

Se hallaron alteraciones en funciones de percepción musical en los casos; sin embargo, se detectaron inconsistencias teóricas con respecto a la relación de funciones afectadas. Las diferencias entre el grupo control y la norma apuntan a continuar evaluando la MBEA en población mexicana. La MBEA parece ser una medida poco precisa en términos de sensibilidad y especificidad para las alteraciones amúsicas en la ELTns, y su utilidad como medida de apoyo en la determinación de LFE permanece incierta.

Palabras clave: Cognición musical, amusia, epilepsia de lóbulo temporal, lateralidad de foco epileptogénico.

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BACKGROUND

The study of music as a neuropsychological phenomenon has gained relevance over the past two decades, as it provides valuable information with respect to a wide variety of attentional, mnemic, psychomotor, linguistic, and emotional response cognitive processes, as well as the cerebral structures associated with them.[1,2] The importance of music is highlighted when its association with autonomic nervous functioning and immunological and hormonal systems is understood.[3]

Musical cognition is a complex phenomenon, as just like other cognitive processes, it requires the correct functioning of various components for the analysis of perceived information. Recently, a model has been proposed[4] which describes the processing of music by means of these components, which correspond with the structural elements of Western music[5] and have been associated to specific cerebral structures, with varying evidence[6-13] (table 1).

In this model, the entering information is processed by two different perceptive routes: one for processing the melodic components of the acoustic flow, and another for processing its temporal characteristics. The melodic route interprets the flow through three components: *contour* (variations in the direction of height), *interval* (the distance between two successive notes), and *scale* (recognition of the tonal key in which the melody is structured). The temporal route analyzes the acoustic flow in terms of rhythm (the grouping of acoustic events according to closeness) and meter (acoustic events which occur at regular intervals of time, and which structure the pulse of the melody). The model also integrates a mnesic component in charge of the recognition of the melody in terms of the repertoire foreseen by previous experience. It is important to indicate that a hierarchical relationship has been described between the two components: Damage to the perception of contour invariably produces damage in the perception of interval, but not vice versa.[4] The alteration of one or more of these components produces some variation in the generic syndrome known as *amusia*,[6] which makes subjects who have the disorder incapable of recognizing, following, intoning, or remembering a certain melody in terms of the component affected. This deficiency cannot be explained by hypoacusia, cognitive deterioration or delay, or lack of exposure to music.[14]

Table 1. Association of components of musical cognition with hemispheric and lobe structures

Component	Hemisphere	Lobe structure	Reference
Contour	Right	Posterior region of superior temporal lobe	Liégeois-Chauvel *et al.* (1998); Peretz (2002); Zatorre *et al.* (2001); Zatorre *et al.* (2002); Peretz y Zatorre (2005); Peretz *et al.* (2003); Janata *et al.* (2002); Platel *et al.* (2013).
Interval	Left	Anterior region of superior temporal lobe	
Scale[a]	Bilateral	Superior temporal, prefrontal rostromedial cortex	
Rhythm	Left	Posterior region of superior temporal lobe	
Meter	Right	Anterior region of superior temporal lobe	
Memory	Left	Medial temporal gyrus, anterior temporal	Koeschl (2011); Platel *et al.* (2013).

[a] There is scarce evidence around the associated structures.

This model has been developed based on the study of causes of cerebral injury (due to apoplexy, surgical clipping of cerebral aneurysm, and resection of epileptogenic tissue), according to the principle of double dissociation, and a series of specially-designed tasks has been developed for the diagnosis of amusia, grouped together in the MBEA.[11] According to the authors, this battery has proven useful in detecting a variety of alterations in musical perception and memory which may derive from brain damage, as well as the identification of cerebral structures associated with the components of musical cognition.

Partial crises in epilepsy can alter neural populations in structures which are the focus origin of uncontrolled electric discharges.[15] These changes can derive from alterations in cognitive functions associated with these structures. Alterations are not expressed in defined neuropsychological profiles for different types of epilepsy,[16] nor are they completely differentiated for each cerebral structure; however, they show a tendency of lateralization according to assessment with neuropsychological tests.[17] For example, it has been found that in temporal lobe epilepsy (TLE) with left lateralization of epileptogenic focus (LEFl), there are more pronounced alterations in terms of verbal memory and language, while in TLE with right lateralization of epileptogenic focus (LEFr), more pronounced disorders in visuo-perceptive functions and visuo-spatial memory can be expected.[18-20]

Epilepsy is one of the most prevalent neurological illnesses in the Mexican population, suffered by 1-2 million people.[21] Of all types of epilepsy recognized by the International League Against Epilepsy, TLE is the most common,[19] which makes it a possible route for studying the role of this cerebral structure in processing the cognitive functions associated with it.

Following the paradigm of studying the alteration of specific neuropsychological functions in epilepsy, it is plausible to also investigate affectations on musical cognition, for which it is important to develop valid instruments which allow a more precise assessment of said phenomena.

Despite evidence which shows that musical cognition has been found to be markedly influenced by processes of acculturation,[22-24] there are very few studies carried out in

the Spanish-speaking population with tests expressly designed to assess and detect amusical alterations.

Considering the possibility that non-symptomatic TLE (nsTLE) could alter the functions for musical cognition in a general way, and following lateralization of epileptogenic focus (LEF), this study was carried out with the aim of exploring the psychometric properties of the MBEA, comparing cases with the condition with a control sample.

METHOD

Participants

A non-probabilistic, intentional sample was made for both groups. The case group was made up of 22 patients diagnosed with nsTLE (idiopathic, cryptogenic, or not attributed to brain injury) from a highly-specialized medical center in Mexico City. The controls were 31 subjects who were not patients. For both groups, the exclusion criteria were as follows: hypoacusia, diagnosis of a psychiatric disorder that could compromise the auditory perception (e.g. schizophrenia), cognitive deterioration (according to the MINI Mental State Examination)[25] or intellectual disability judged by the researcher, a history of neurosurgical intervention, brain damage corroborated by neuroimaging, and formal instruction in music (this criteria was based on the findings of cerebral asymmetry in musicians *vs*. non-musicians).[26]

Furthermore, because of the difficulty in recruiting cases, the groups were compared by pairs method by sex, age, level of education, and manual laterality. Within the group of cases, subgroups were formed according to LEF.

Furthermore, average scores by test and overall (average of six tests) of the original sample of standardization[11] were used to compare them to the control group.

Instruments

The MBEA consists of six tests (Scale, Interval, Contour, Rhythm, Meter, Memory) which correspond to the model of musical cognition and are based on a paradigm of discrimination. For the first four tests (30 questions in each, plus a non-computable validation question), the subjects listens to two melodies which may vary in one note; in the fifth test (30 questions), the subject must determine if the melodies correspond to a metric pulse of a waltz or a march. Finally, the sixth test (30 questions) assesses the incidental memory through presenting melodies which the subject must identify (or not) from among the melodies of the preceding tests.[11]

The overall score of the MBEA as a measure of normal functioning does not present evidence of the ceiling and floor effect. In the process of standardization, a reliability of 0.75 was obtained, based on a later assessment at four months of 28 subjects from the total sample. A validation was carried out with the Gordon *Musical Aptitude Profile* using the results of 68 subjects from the total sample, with a final correlation of 82% and 89%.[11]

Procedure

The process of recruiting and assessing the cases was done in the neurological outpatients' area of a highly-specialized medical center in Mexico City. The group of cases was recruited during their routine neurological appointments. For the case selection phase, an assessment by a specialist doctor of neurology was used, which determined the diagnosis of nsTLE with a review of the clinical report and the neurological exam. Once a possible candidate had been detected, they were invited to participate in the study. The assessment procedure for both groups consisted of three stages: (1) brief assessment of neurological and psychiatric background; (2) application of the Mini Mental State Examination; (3) administration of the MBEA.

For the application of the MBEA, .wav for Windows support files and Sony MDR-XB400 headphones were used. Each subject was provided with a notebook and a pencil with an eraser for their responses. Each test was preceded by two examples (four for the Meter test) which were used to check that the subject had understood the instructions on how to complete the battery. Each subject was advised that they could take as many rests as they liked between tests, but not while they were being carried out.

Ethical considerations included obtaining the approval of a committee of experts from the medical center's headquarters, as well as the written informed consent of each patient, which detailed the aims of the study, the characteristics of their participation, and the report of the results.

As part of the statistical analysis, criteria validity was determined by means of the contrasted groups' method, through the comparison of the *t* test for non-related samples between cases, controls, and the norm. Differences in the means by LEF were also estimated. Pearson's correlations were carried out between the subtests, with the aim of estimating possible dependence/independence of the components of the construct. Later, an analysis of ROC curves was conducted with the total score and of each one of the subscales, taking the diagnosis of TLE as a reference. The SPSS 22 software package was used for this analysis, and R Version 3.0.2 was used to generate graphs.

RESULTS

General characteristics of the groups

In the study were included a total of 53 participants (table 2). The control group was made up of 31 subjects between the ages of 19 and 64, with an average of 13.4 years of edu-

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Table 2. General characteristics of the groups

	Cases	Controls	*chi*² o *t*(gl)
Sex			0.004(1)
Men	9	12	
Women	13	19	
Age			–0.32(51)
Mean	38.2	39.4	
[95% CI]	[–32.63–43.82]	[–34.48–44.36]	
SD	12.6	13.4	
Mín–máx	19–61	19–64	
Education			0.488(51)
Mean	13.4	12.9	
[95% CI]	[11.91–15.00]	[11.63–14.30]	
SD	3.4	3.6	
Mín–max	9–25	6–18	
ML			0.829(1)
Right	20	30	
Left	2	1	
LEF			
Right	6		
Left	7		
Unknown	9		

Note. ML = Manual laterality; LEF = Laterality of epileptogenic focus.
*p<0.05.

cation. The group of cases was made up of 22 subjects aged between 19 and 61 with an average of 12.9 years of education. Of these cases, a LEF was identified in 13 subjects. According to the *chi*² and *t* tests, no significant differences were found in the distribution of variables of sex, age, education, and manual laterality between groups.

Comparison between the groups

The t test was used to compare the means between the case groups and the control group (table 3, figure 1); significant differences were found in the Scale and Contour tests and in the overall scores. Significant differences were also found in all tests and the overall score in the control group when compared to the norm (table 3, figure 1). None of the average scores of the controls was lower than the cutoff score for the norm (mean = 21), whereas for the cases, the average scores of the Scale and Contour tests, as well as overall scores, were placed below the corresponding cutoff points.

Figure 1 shows that the distribution of this data tended towards a mild symmetry. For the case group, this was more pronounced in the Memory test, and to a lesser extent, in the overall score with more dispersed values between quartiles two and three. The same trend appears markedly in the control group for the Contour and Interval tests. In both groups, the data was distributed more symmetrically in the overall score. Atypical cases were only found in the control group. Except for the marked difference in sample size, the scores for the control group in this study tended to be distributed differently to those in the normative group, in which most of the subjects were distributed according to the floor effect for all of the tests.

In terms of LEF (table 4), no significant differences were found in the scores of the epileptic subgroups. It should be noted that notwithstanding the absence of statistical differences, the epileptic subgroup with LEFl scored up to two standard deviations lower than the control groups in the Scale and Contour tests respectively, and also in comparison with the epileptic group with LEFr.

Inter-test correlations

The inter-correlations analysis (table 5) through the Pearson test was carried out on the total of the participants in the study (n = 53), to understand the behavior of the battery applied. With the exception of Meter, which was the only test

Table 3. Means (M), standard deviation (SD), and differences between the groups

Test	Cases M [95% CI]	SD	Control M [95% CI]	SD	*t*	Norm[a] M [95% CI]	SD	*t*
Scale	20.3 [18.03 – 22.70]	5.2	23.0 [21.69 – 24.44]	3.7	–2.18(51)*	27 [26.46 – 27.21]	2.3	–5.39(34.9)*
Contour	20.9 [19.21 – 22.70]	3.9	23.0 [21.76 – 24.37]	3.5	–2.03(51)*	27 [26.20 – 26.91]	2.2	–5.27(34.9)*
Interval	21.0 [18.98 – 23.02]	4.5	21.9 [20.60 – 23.34]	3.7	–0.84(51)	26 [25.77 – 26.52]	2.4	–6.04(34.8)*
Rhythm	25.2 [24.10 – 26.44]	2.6	25.1 [24.04 – 26.35]	3.1	–0.09(51)	27 [26.85 – 27.50]	2.1	–3.36(35.3)*
Meter	20.7 [18.88 – 22.66]	4.2	22.9 [21.12 – 24.81]	5.0	–1.66(51)	26 [25.23 – 26.24]	2.9	–2.94(34.9)*
Memorry	23.9 [22.44 – 25.38]	3.3	25.3 [24.10 – 26.61]	3.4	–1.53(51)	27 [26.45 – 27.20]	2.3	–2.29(35.8)*
Overall	21.9 [20.73 – 23.21]	2.7	23.6 [22.66 – 24.55]	2.5	–2.19(51)*	27 [26.29 – 26.80]	1.6	–6.13(34.8)*

[a] n = 160.
*p < 0.05.

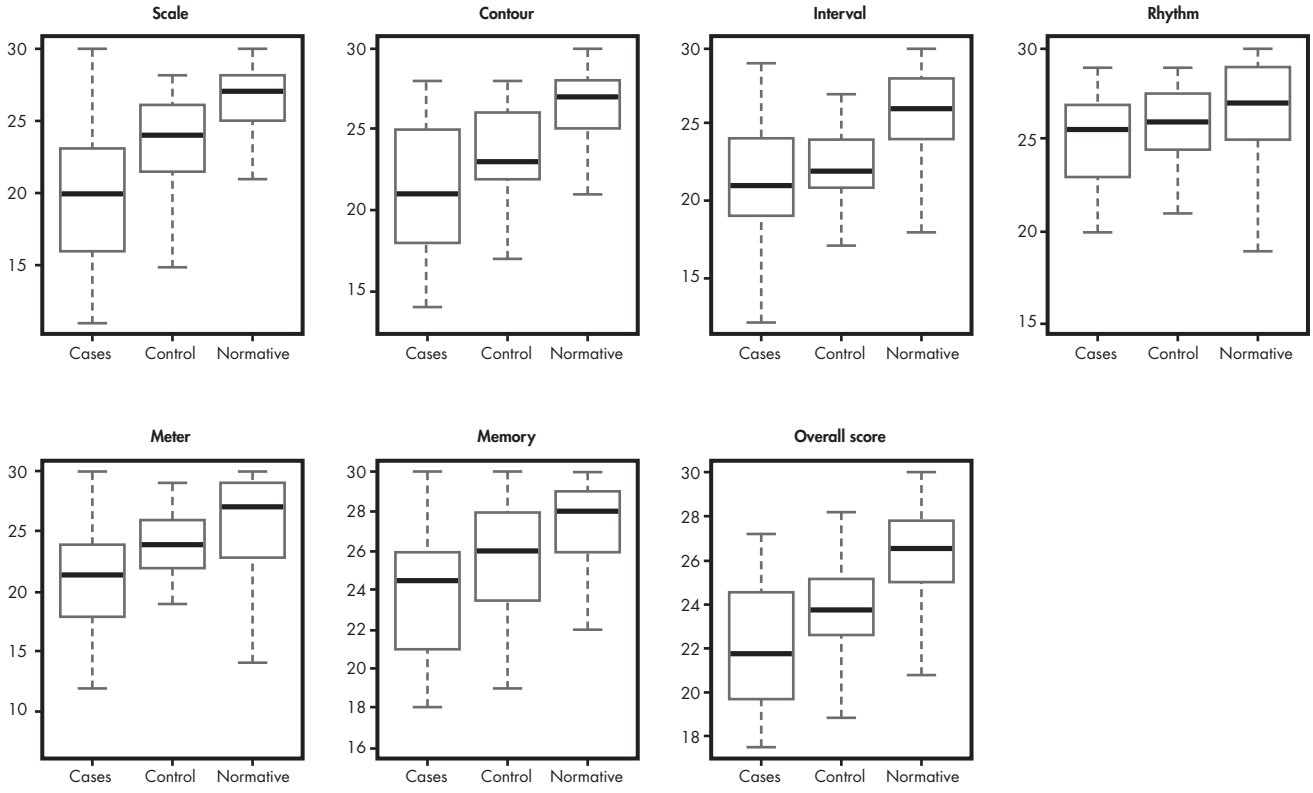

Figure 1. Box graphs of the groups' scores by test and overall.

with no significant correlation with the rest of the battery, all of the scores were correlated with moderate to strong strength, and significantly so with the overall score. Moderate and significant correlations were also found between the tests corresponding to the melodic dimension of the theoretical model of the MBEA, and of the Rhythm test with the rest of the scores. The significance and strength of these correlations suggest that the tests have a sufficient construct relationship without necessarily measuring the same variables.

Sensitivity and specificity

The ROC curve analysis (figure 2) shows that the MBEA does not present sufficient properties for detecting alter-

Table 4. Means, standard deviation, and case group differences according to LEF

Test	Right[a] M [95% CI]	SD	Left[b] M [95% CI]	SD	*t*(gl)
Scale	22.1 [17.23 – 27.11]	4.7	17.8 [12.10 – 23.62]	6.2	1.38(11)
Contour	22.1 [16.72 – 27.62]	5.1	19.8 [16.68 – 23.04]	3.4	0.96(11)
Interval	20.6 [15.58 – 25.75]	4.8	20.1 [14.95 – 25.33]	5.6	0.17(11)
Rhythm	25.3 [22.17 – 28.49]	3.0	23.8 [21.11 – 26.60]	2.9	0.88(11)
Meter	20.5 [16.42 – 24.58]	3.8	20.2 [18.10 – 22.47]	2.3	0.12(11)
Memory	24.3 [21.39 – 27.28]	2.8	23.2 [20.74 – 25.83]	2.7	0.67(11)
Overall	22.5 [19.91 – 25.15]	2.4	20.8 [18.27 – 23.49]	2.8	1.10(11)

[a] $n = 6$; [b] $n = 7$.
* $p < 0.05$.

Table 5. Inter-test Pearson correlations

	Scale	Contour	Interval	Rhythm	Meter	Memory
Scale	1					
Contour	0.668**	1				
Interval	0.656**	0.604**	1			
Rhythm	0.448**	0.534**	0.512**	1		
Meter	0.108	0.083	0.106	–0.112	1	
Memory	0.669**	0.614**	0.566**	0.384**	0.153	1
Overall	0.841**	0.818**	0.784**	0.593**	0.388**	0.784**

**$p < 0.01$.

ations in nsTLE according to the evaluation of the functions of musical perception associated to this cerebral structure. This is because the cutoff points that obtain high sensitivity also obtain specificity much lower than expected. This is the case with an overall score of 17.6, which obtains a sensitivity of 1.0 but with specificity of 0.045 (table 6).

It should also be noted that although all of the tests passed the area below the major curve at 0.5 (table 6), none of them reached a capacity of satisfactory classification. This is especially relevant if it is observed that the overall score obtained the highest rank (0.6377), just above random.

DISCUSSION AND CONCLUSION

The primary objective of this research was to explore the psychometric properties of the MBEA with a group of subjects with nsTLE, assuming alteration in the functions of musical cognition in these cases, and according to LEF. It was found that only those scores in the Scale and Contour tests, as well as overall scores, were significantly lower in the case groups compared to the control group. These findings are coherent with the paradigm of neuropsychological alterations commonly associated with partial epilepsies,[15-20] and are specif-

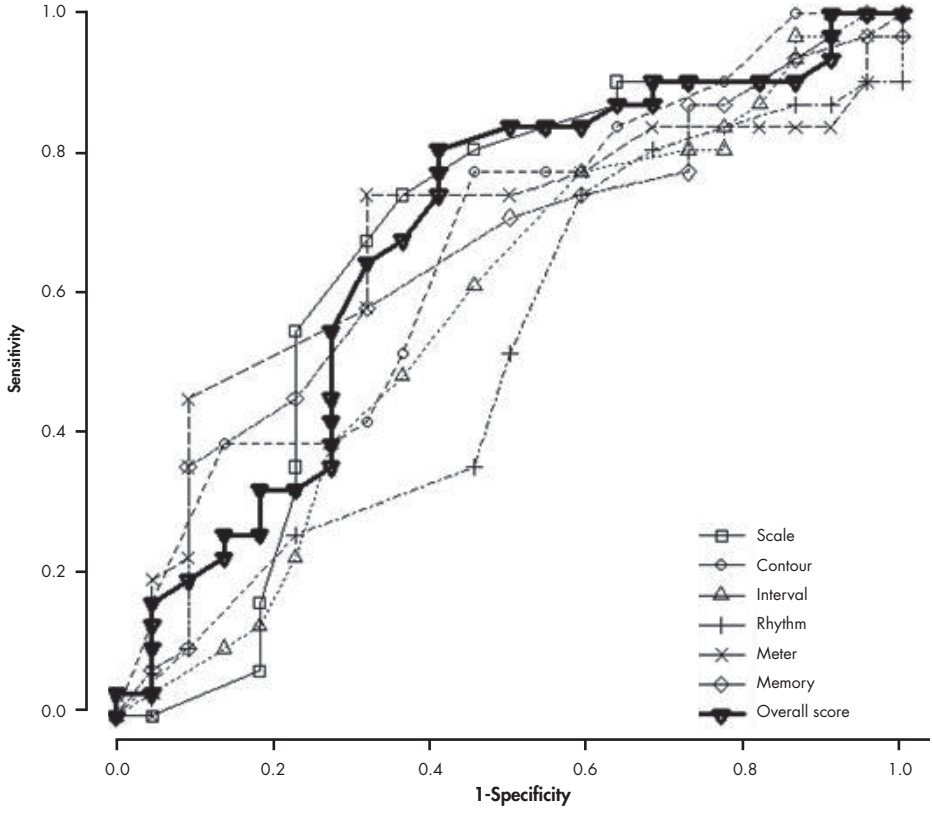

Figure 2. ROC curves for each one of the tests and the overall score of the MBEA in the groups, considering as gold standard a diagnosis of temporal lobe epilepsy according to the case groups' clinical reports.

ically congruent with the knowledge that TLE produces alterations in specific functions associated with these cerebral lobes; in this case, functions of musical cognition.

It is important to note that none of the case scores were lower than the sample of congenital amusical cases [*n*=19; *mean*=21] of the original standardization of the MBEA. This would suggest that in spite of it not being possible to place these deficiencies in a diagnostic entity of amusia, it is plausible to consider them a general alteration in musical cognition, analogous to the neuropsychological deficiencies frequently found in patients with TLE in terms of language or memory,[18-20] which are not necessarily qualified as clearly distinguishable aphasia or amnesia.

According to current knowledge about the absence of clear neuropsychological profiles for the different types of epilepsy,[16] no alterations were found in the components of musical cognition specifically differentiated in relation to LEF. In this respect, lower scores were found for the Scale and Contour tests and for the overall score in epileptics with LEFl compared to the cutoff points for the normative group and in the subgroup of subjects with LEFr. However, these differences were not statistically significant in terms of this latter subgroup. Furthermore, these deficiencies in perception of the properties of musical scale and contour, observed according to LEFl, do not seem to be congruent with the mode of musical perception and memory maintained by the MBEA, which says: (1) that the alteration in the musical contour component is directly involved in the perception of intervals, which was not observed in the case groups when compared to the controls and with the cutoff scores for the norm; and (2) that alteration in the perception of musical contour is associated with damage to the right superior temporal lobe, which was not identified at a hemispheric level when compared to the LEF subgroups. Furthermore, and although this is not covered in the musical cognition model, it would be expected that alterations in the perceptual components of scale and particularly contour would have a considerable impact on the mnesic module of recognition, as it is involved in the initial registration of auditory information. However, this was not observed in the average scores for Memory (with no significant differences between cases and controls), in inter-test correlations, or in the observations of differences between the LEFl and LEFr.

Table 6. Sensitivity, Specificity, and Area Below the Curve by Test and Overall Score of the MBEA

Cutoff points	Sensitivity	Specificity	Area below the curve
Scale			0.666
12.0	1.000	0.045	
27.5	0.065	0.818	
29.0	0.000	0.955	
Contour			0.663
15.0	1.000	0.045	
23.5	0.419	0.682	
27.5	0.129	0.955	
Interval			0.576
12.5	1.000	0.955	
18.5	0.806	0.227	
26.5	0.097	0.864	
Rhythm			0.519
19.0	0.903	0.000	
26.5	0.355	0.545	
28.5	0.097	0.909	
Meter			0.679
13.5	0.903	0.045	
17.5	0.839	0.182	
29.5	0.000	0.955	
Memory			0.646
17.0	0.968	0.000	
22.5	0.774	0.273	
28.5	0.097	0.909	
Overall score			0.677
17.6	1.000	0.045	
18.4	0.935	0.091	
25.1	0.258	0.818	
27.1	0.032	0.955	

On the other hand, when observing the components of the temporal dimension, Rhythm and Meter, a correspondence can be seen with other studies which indicate a total dissociation between them,[5,6] although a differentiation according to LEF was not seen.

It should be noted that the average scores of the control group were also significantly lower than the norm. Despite the possible influence of lack of precision derived from sample size and other potential confusing elements which were not analyzed (e.g. intrinsic cultural differences, level of education, exposure to any musical training), these differences may suggest routes for future studies around the influence of acculturation processes on musical cognition, which were not considered in this first approach.

On the other hand, according to the results obtained from the COR curve analysis, it is plausible to put forward for critique the pertinence of the MBEA for detecting anomalies in musical perception and memory in patients with nsTLE. The results lead to questioning the usefulness of the cutoff point proposed by Peretz et al. (2003), especially considering that said points were obtained by means of a statistical analysis that was not expressly designed to rate clinical sensitivity and specificity. The battery seems to be sensitive to a general alteration in cognitive functioning which secondarily involves the processing of musical stimuli; however, it fails to homogeneously detect the absence of alterations in healthy subjects. This critical point is even more important when considering that in fact, the scores for amusical people are, on average, two standard deviations removed from the scores of the normative group, while the differences between the groups formed here were not expressed in this way. This makes the diagnostic precision of the MBEA ambiguous for cases of nsTLE. Alternative ex-

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planations for these results could be: (1) the number of subjects which made up the sample; (2) the unspecific nature of cognitive alterations in epilepsy (Tracy and Shah, 2008); and (3) the lack of specificity of many neuropsychological tests, affected by many variables that are theoretically separate from the constructs they seek to measure (e.g. attentional functions). If we accept the second of these explanations, the results of the ROC curve analysis could have their cause in the population studied, and not in the qualities of the battery, in which case this data may have been expected. This is encapsulated if it is noted that the area below the curve for the overall score is above the random identification of the data. Interpreted carefully, the MBEA scores could be clinically useful in the identification of general deficiencies in the cognitive processing of music as a consequence of epileptic crises. However, crises would not be reliably attributable to the same specific causes which lead to amusia in injury cases (Peretz et al. 2003). On the other hand, the results lead to seriously questioning the value of the MBEA as a measure of support in determining the lateralization of EF, as originally considered in the justification of this study.

Limitations

As well as the reduced sample size (which it was attempted to control by the pairing of inter-group variables) there were other limitations of this study, which must be considered in order to extract conclusions. Among these are the following: anti-epileptic medication (although this does not seem to have a direct repercussion on the perception of musical stimuli[27] or the execution of the MBEA[6]), the frequency and onset age of the crises,[16,19] and other cognitive alterations which could be involved in the subjects' performance. On the other hand, there were also limitations related to the design and the means of obtaining data, for example, obtaining the characteristics of the diagnosis of nsTLE for making up the case group based on reviewing the clinical report, as well as the absence of a comparison group with a diagnosis of partial epilepsy with the epileptogenic focus in another lobe region. This would have allowed associations to be established between the localization of the focus and the execution of the MBEA.

Despite the limitations of the study, potential findings were made in three areas: (1) evidence of alterations in musical cognition in nsTLE; (2) significant differences between the control sample for this study and the normative group; (3) a critique of the psychometric properties and diagnostic precision of the MBEA for these cases.

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Conflict of Interest

The authors do not declare any conflicts of interest.

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