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Original Article

Artigo Original

Assessment of temporal aspects in popular singers

Avaliação dos aspectos temporais em cantores populares

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Keywords

Auditory Perception
Music
Hearing Tests
Hearing
Singing

ABSTRACT

Purpose: To evaluate the temporal processing of popular singers who do or do not play a musical instrument. **Methods:** The study population comprised 30 popular band singers. Of them, 15 play a musical instrument (G1) and 15 do them do not play a musical instrument (G2). All of them were submitted to basic audiological evaluation and temporal processing tests: test of frequency standard (TFS) and gaps in noise (GIN) detection. **Results:** Significant differences were observed in performance in the comparison between the groups with regard to the temporal acuity threshold and percentage of correct responses in the GIN, as well as the performance in the TFS. The results of the group of singers who play a musical instrument were found to be better than those of the group that only sings. **Conclusion:** Popular singers that play musical instruments have a better performance in resolution and temporal ordering auditory skills than singers who do not play an instrument.

Descritores

Percepção Auditiva
Música
Testes Auditivos
Audição
Canto

RESUMO

Objetivo: Avaliar o processamento temporal de cantores populares que tocam ou não instrumento musical. **Métodos:** O estudo foi composto por 30 cantores populares de bandas baile,15 dos quais cantam e tocam instrumento(s) musical(is) (G1) e 15 apenas cantam (G2). Todos os participantes foram submetidos à realização da avaliação audiológica básica e dos testes do processamento temporal: teste de padrão de frequência (TPF) e teste de detecção de *gaps* no ruído (GIN). **Resultados:** Houve diferença estatisticamente significante na comparação do desempenho entre os grupos no que se refere ao limiar de acuidade temporal e percentual de acertos do GIN, bem como no desempenho do TPF, sendo os resultados do grupo de cantores que tocam instrumento musical melhores do que os obtidos pelo grupo que só canta. **Conclusão:** Cantores populares que tocam instrumentos musicais apresentam melhor desempenho nas habilidades auditivas de resolução e ordenação temporal quando comparados àqueles que só cantam.

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INTRODUCTION

Many neurophysiological and cognitive mechanisms and processes are needed for a perfect decoding, perception, recognition, and interpretation of the audio signal. Thus, the act of "hearing" does not refer simply to the mere detection of the acoustic signal. Hearing plays an essential role in the proper recognition and discrimination of auditory events, from the simplest, such as nonverbal stimuli, to the more complex messages, such as speech and language[1].

Central auditory processing (CAP) is the domain from which the central nervous system uses auditory information[2] and includes auditory mechanisms that underlie the abilities of sound location and lateralization, auditory discrimination, recognition of auditory patterns, temporal aspects of hearing, including temporal integration, temporal resolution, temporal ordering, temporal masking, auditory performance with competing acoustic signals, and auditory performance with degraded acoustic signals[1,3].

Temporal processing refers to the processing of acoustic stimuli over time, necessary for the ability to understand speech in quiet and noisy environments, as well as speech stimuli and other background sounds that vary over time. It can also be considered as the basis for auditory processing, since many characteristics of auditory information are somehow influenced by time[4].

Temporal processing is divided into two main components: temporal ordering and temporal resolution. Temporal ordering refers to the processing of two or more auditory stimuli in their order of occurrence over time[5]. Temporal resolution is defined as the shortest time necessary for the central nervous system to discriminate two acoustic stimuli[6].

Music is the art of combining sounds either simultaneously or successively with order, balance, and proportion within a period. Studying musical perception allows the detailed analysis of sound and can profoundly influence the formation of the musician or other speaking and listening professionals, as it acts as a qualitative process of its development[7].

Studies conducted with musicians suggest that daily musical training, used by professional musicians, can functionally induce the reorganization of the cerebral cortex. Thus, the contact with music before the age of seven could contribute to the development of the CAP and, more precisely, of the temporal processing[8,9]. Another study conducted with professional and amateur singers, signing in and out of key, showed the superiority of musicians who have received proper music theory training over the years in the temporal ordering tests compared to those who did not receive any theoretical training in music, which showed that exposure to music theory is a contributing factor to the auditory temporal processing[10].

Other studies with musicians who played a musical instrument and non-musicians showed that those with the greatest musical aptitude show superiority in temporal processing when compared to non-musicians[9,11].

There is a theoretical gap in the literature in relation to studies covering musicians and temporal processing. Knowing the temporal processing of singers contributes to science mainly due to a shortage of studies associating the practice of playing musical instruments and temporal skills and the influence of music in the performance of temporal skills.

Thus, this study aimed to evaluate the temporal processing of popular singers who do and do not play a musical instrument.

METHODS

The project of this study was submitted, reviewed, and approved by the Research Ethics Committee for Research with Human Beings of the institution where it was carried out, under protocol no. 711.422. All individuals invited to participate signed an informed consent authorizing their voluntary participation before the start of the assessments.

The study included 30 popular singers in ballroom bands from the city of Florianópolis, SC-Brazil, who do and do not play musical instruments, males and females, without age restrictions. Participants were divided into two groups: the G1 group, composed of 15 singers who also play musical instruments, and the G2 group, composed of 15 singers who only sing.

Inclusion criteria listed for the study population were the following: absence of middle ear diseases; no evidence of cognitive and neurological disorders; auditory thresholds within normal limits; logoaudiometry with result greater than or equal to 88%; type A tympanometric curve bilaterally and contralateral stapedial reflexes present at normal levels; having Brazilian Portuguese as a first language; acting only as a singer in a ballroom band from the city of Florianópolis, SC-Brazil; and being literate.

All participants underwent a battery of procedures consisting of anamnesis, basic audiologic evaluation and testing for the evaluation of the temporal processing, described below.

Speech-language/audiological anamnesis consisted of questions whose purpose was to know individual musical aspects of each participant, as well as sociodemographic characteristics, such as gender and age. Each participant individually filled an anamnesis instrument.

After that, there was a basic audiological evaluation comprised of meatoscopy, pure tone audiometry, speech audiometry, and immittance, to prove the normality of hearing.

The temporal processing evaluation was performed using the gaps in noise (GIN) test[12], in order to assess the temporal resolution ability, and through the frequency pattern test (FPT) [13,14],to assess the temporal ordering ability.

The GIN test consists of the presentation of six seconds of white noise segments, with a five-second interval. Inserted in white noise stimuli, there are gaps in different time positions and which can last 2, 3, 4, 5, 6, 10, 12, 15, and 20 ms. In the noise segments, there may be 1, 2, 3, or no gap[12]. This test was applied at 50 dBSL, based on the tritone average of 500, 1000, and 2000 Hz frequencies, as identified in the basic audiological evaluation, and participants were instructed to press the audiometer response button each time a gap inserted into the noise was detected. The test was applied to each ear separately and the lowest threshold sensed four times or more was considered the temporal acuity threshold obtained by the participant. It is noteworthy that thresholds lower or equal to 5 ms were considered within the normal range[15].

The FPT consists of sequences of three pure tones, two with the same frequency and the third with a different frequency. The version used in this study[14] consists in the presentation of tones of 880 Hz (low frequency) and 1122 Hz (high frequency), with intervals of 150 and 200 ms between them. The tones are presented in groups of three, with six possible sequences, as follows: HHL, GAG LHL, GAA LHH, AGA HLH, ABB HLL, AAG HHL, where A refers to the highest stimulation, the 1122 Hz tone, and G refers to the lowest, the 800 Hz tone. The proposal is to present 30 binaural sequences in an intensity level of 50 dBSL. The test was performed with an intensity of 50 dBNS, based on the tritone average of frequencies of 500, 1000, and 2000 Hz, as identified in the basic audiological evaluation, and participants were instructed to orally repeat the sequence heard. The test was presented to both ears simultaneously. As for the percentage of correct answers, were considered within normal limits those that were greater than or equal to 76%[16].

To perform the meatoscopy, the otoscope used was the mini 3000 model, by HEINE. The pure tone and speech audiometry were performed using the AC40 two-channel audiometer by Interacoustics and TDH39 earphones. For the impedance tests, the Interacoustic AT235h imitanciometer was used. The GIN and FPT tests were also conducted through the Interacoustic AC40 two-channel audiometer. The stimuli used were recorded on CD, which required insertion in a computer connected to the audiometer for the application of the tests.

The analysis of variance parametric test was used for the statistical analysis. The significance level was set at 0.05 (5%).

RESULTS

Table 1 shows the distribution of the participants' sociodemographic data according to their respective groups: G1 and G2.

Figure 1 outlines the types of musical instruments played by participants who constituted the G1. The guitar was the instrument with the higher incidence, used by 80% participants.

The time of professional activity for participants in G1 varies from 2 to 30 years, while in G2, this time ranged from 1 to 30 years.

The results of temporal acuity thresholds in the GIN test, obtained by ear and by group studied, are shown in Table 2 and Figure 2. In the right ear, there was a trend toward statistical significance (p=0.055) for individuals in G1, because they had a lower temporal acuity threshold than individuals in G2. For the left ear, the results were statistically significant (p=0.02), that is, the singers who play musical instruments had a lower temporal acuity threshold in the GIN test, which means they have a better temporal resolution ability compared to those who just sing.

The percentage performance of gap recognition in the GIN test was also evaluated by ear and study group. As can be seen in Table 3 and Figure 3, there were statistically significant differences between the two groups in both ears, which means singers who play a musical instrument (G1) showed better percentages of gap recognition than singers who do not play any instrument (G2).

As for the FPT test, the comparison between the performances of G1 and G2 is shown in Table 4 and Figure 4.

There was a statistically significant difference when comparing the groups, and once again, G1 had the best performance in the recognition of tones in different frequencies than G2.

Table 1. Distribution of sociodemographic data of subjects according to their respective groups: G1 and G2

Group	Mean	Age (years)			
Sex		n	Mean	Minimum	Maximum
G1					
F	33.3 (%)	5	31.93	19	50
M	66.6 (%)	10			
G2					
F	60.0 (%)	9	29.86	19	55
M	40.0 (%)	6			

Caption: G1 = Group 1; G2 = Group 2; Min = minimum; Max = maximum; F = female; M = male

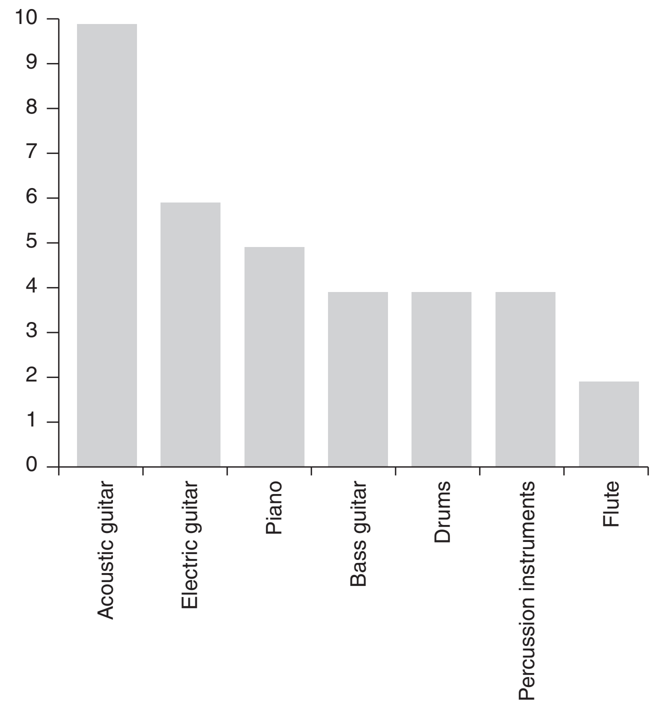


Figure 1. Distribution in absolute values of the types of musical instruments played by participants who formed Group 1

Table 2. Description of the gap in noise test regarding the temporal acuity threshold in milliseconds (ms) obtained by ear and by study group

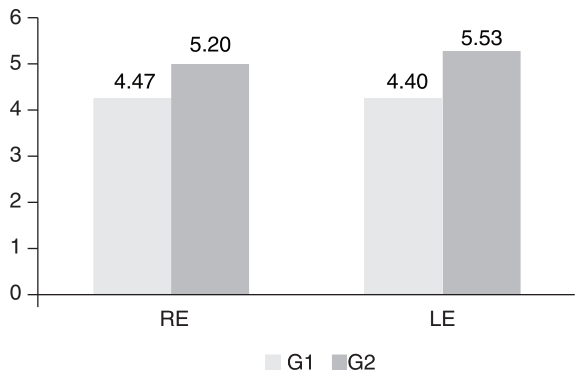
Groups	Mean	Median	SD	CV	Min	Max	n	CI	p-value
GIN TAT- RE									
G1	4.47	4	0.52	12	4	5	15	0.26	0.055
G2	5.20	5	1.32	25	4	8	15	0.67	
GIN TAT- LE									
G1	4.40	4	0.63	14	3	5	15	0.32	0.002*
G2	5.53	5	1.13	20	4	8	15	0.57	

*ANOVA test

Caption: G1 = Group 1; G2 = Group 2; GIN TAT = temporal acuity threshold; RE = right ear; LE = left ear; CV = coefficient of variation; Min = minimum; Max = maximum; CI = confidence interval; GIN = gap in noise test

DISCUSSION

It is known that the auditory temporal processing is defined as the perception of sound or modification of a sound within a restricted period of time. In musical practice, singers need to follow musical melodies with harmony and represent them through the voice, and a good performance of the temporal resolution ability is fundamental to make it happen[10]. Furthermore, the sensory encoding of the temporal information, such as duration, interval, and order of different stimulus patterns, is the clue that guides temporal processing, being important for the perception of music[18].



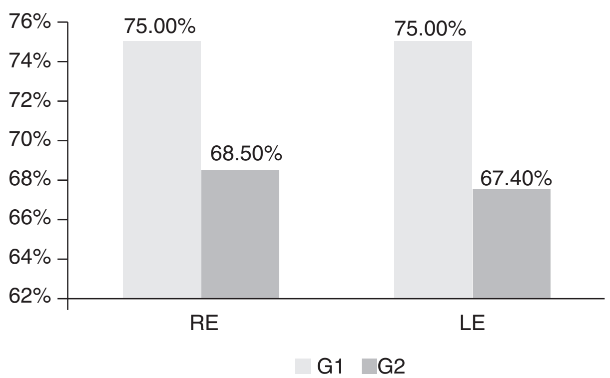
Caption: RE = right ear; LE = left ear; G1 = Group 1; G2 = Group 2; GIN = gap in noise test

Figure 2. Average values of temporal acuity threshold, in milliseconds, obtained through the gap in noise test, by ear and study group

Table 3. Description of the percentage of gap recognition in the gap in noise test, obtained by ear and by study group

Groups	Mean (%)	Median (%)	SD (%)	CV (%)	Min (%)	Max (%)	n	CI (%)	p-value
Gin % – RE									
G1	75.5	75	4.4	5.8	70	85	15	2.2	0.002*
G2	67.5	68	8.3	12.2	55	80	15	4.2	
Gin % – LE									
G1	75.9	75	5.5	7.2	66	88	15	2.8	0.001*
G2	67.4	68	6.6	9.8	56	78	15	3.3	

Caption: G1 = Group 1; G2 = Group 2; GIN% = percentage of correct responses in the GIN test; SD = standard deviation; RE = right ear; LE = left ear; CV = coefficient of variation; Min = minimum; Max = maximum; CI = confidence interval; GIN = gap in noise test; *ANOVA test



Caption: RE = right ear; LE = left ear; G1 = Group 1; G2 = Group 2; GIN = gap in noise test

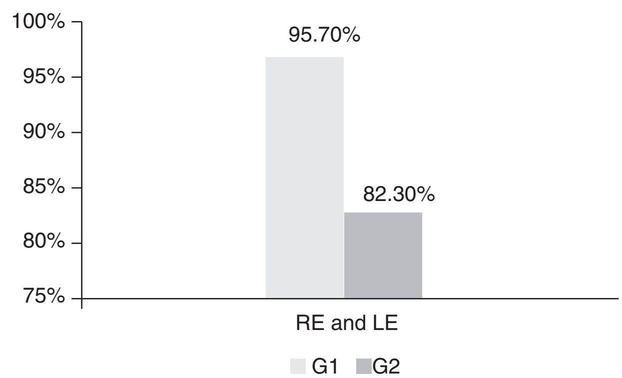
Figure 3. Average values of gap recognition percentages obtained in the gap in noise test, by ear and study group

Table 4. Comparison between the performances of G1 and G2 in the frequency pattern test

Groups	Mean (%)	Median (%)	Standard Deviation (%)	CV (%)	Min (%)	Max (%)	n	CI (%)	p-value
FPT – Binaural									
G1	95.7	100	8.2	8.6	73	100	15	4.1	0.028*
G2	82.3	90	20.8	25.3	44	100	15	10.6	

*ANOVA test

Caption: G1 = Group 1; G2 = Group 2; FPT – binaural = frequency pattern test in both ears simultaneously; CV = coefficient of variation; Min = minimum; Max = maximum; CI = confidence interval



Caption: RE = right ear; LE = left ear; G1 = Group 1; G2 = Group 2

Figure 4. Average values of the percentage of correct responses obtained in the frequency pattern test, by study group

The musical practice stimulates the development of melodic and harmonic auditory perception through the perceptive training of intervals, rhythm, and other acoustic parameters[19].

In the GIN test, the singers in G1 obtained a lower temporal acuity threshold (Table 1), as well as a higher percentage of gap recognition (Table 2) than individuals in G2, meaning that popular singers who play musical instruments have better temporal resolution ability when compared to those who just sing.

Mishra, Panda and Herbert[20]compared the auditory ability of temporal resolution in musicians and non-musicians through the gap detection threshold test. The authors found that the group of musicians performed better, that is, had lower temporal acuity thresholds. Thus, musicians showed greater sensitivity to detect the presence of gaps between two markers, confirming the findings in this study.

In contrast, in another study[10], professional and amateur singers, who sing in and out of key, had the temporal resolution auditory skills assessed by the RGDT test and statistically significant differences were detected between the groups formed. The authors also concluded that singing out of key was not associated with lack of efficiency in temporal resolution, contrary to the conclusion reached in this study, which demonstrated the fact that playing musical instruments contributes to the good performance in the temporal resolution ability of musicians.

Other authors claim that musical training, as well as the musical experiences, greatly increase the cortical and subcortical processing of sounds, which may have a direct influence on the superior temporal perception obtained by musicians that was also found in this study[21,22].

By analyzing Table 2, it was found that the average of the temporal acuity thresholds obtained from the group consisting of singers that do not play any instrument is outside the normal range in both the left and the right ear. Results outside of the normal range were detected in five singers who do not play instruments. The GIN test was sensitive to detect problems in the temporal resolution ability of singers. In other studies evaluating this skill through the RGDT for singers and musicians, this did not occur[10,23]. The comparison between GIN and RGDT was not the subject of this study. However, it was noted in the literature that other authors[24–26],in doing this comparison, detected GIN to be the most sensitive to assess the aforementioned ability.

The standardization of the GIN test started in 2005, in order to verify the diagnostic value of the test as a tool to assess the temporal resolution ability. The first studies[27] assessed normal and neurological patients in whom it was found that the temporal resolution ability was affected by injuries in the (central) auditory nervous system.

In the control group, comprised of patients with neurological disorders, detection thresholds found were 4.8 ms for the left ear and 4.9 ms for the right ear. In Brazil, Samelli, in 2005[15] studied the test in normal-hearing young adults and found that the overall average for the temporal acuity thresholds was 3.98 ms bilaterally. In 2008[24], the average of the thresholds in adults with normal hearing were found, with 5.38 ms for the right ear and 4.88 ms for the left ear, which explains the results outside the normal ranges obtained by singers who do not play musical instruments.

The gap recognition percentage in G1 approaches that obtained in a study with normal-hearing adults[15], while in G2 is lower, different from the comparison carried out with another study, carried out with teenagers[28], in which the percentage of correct responses is close to that obtained by the two groups in this study.

Just as in the GIN test, in the FPT, the group of popular singers who play musical instruments performed better and thus showed a better temporal ordering ability than those who only sing (Table 3). These findings corroborate those obtained in previous studies[9,10].

A study compared the temporal ordering ability among violinists and a control group using the FPT and found that the performance of the group of musicians was better, with a statistically significant difference[9].

In another study[10], the FPT was applied to professional and amateur singers singing in and out of key, and statistically significant differences were also detected regarding the performance of the groups in that test, and the group of professional singers had the best performance (96.5%), followed by the groups of amateur singers (82.3%). The percentage of correct responses found by the authors mentioned is quite close to that found in this study, and the values for the groups composed of singers who do not play instruments was identical to those for amateur singers.

The findings of this study have shown that auditory training (referred to here as the practice of playing musical instruments) contributes significantly to the performance of the temporal processing abilities. Thus, playing musical instruments might be used as a practical possibility for the rehabilitation of skills involved in temporal processing.

We suggest further research addressing the temporal aspects of musicians playing different musical instruments to assess whether there is an instrument that has greater influence on the development of temporal ordering and resolution skills.

CONCLUSION

Singers who play a musical instrument perform better on tests that evaluate temporal processing than singers who do not play any instruments. In this way, auditory abilities of temporal resolution and ordering are more developed in popular singers who play musical instruments.

ACMR was responsible for data collecting and preparation of the article; RCS and MMCP were in charge for drafting and preparation of the article.

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