STUDY OF THE AUDITORY PROCESSES OF TEMPORAL RESOLUTION AND AUDITORY FIGURE-GROUND IN DANCERS

Estudo das habilidades auditivas de resolução temporal e figura-fundo em dançarinos

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ABSTRACT

Purpose: to assess the auditory processes of temporal resolution and of the identifying sentences with competitive message in dancers. **Methods:** a perspective study in which 40 subjects were assessed distributed in two groups: group 1 (dancers) and group 2 (non-dancers). The instruments used in the auditory processing assessment were: Gaps-in-noise test (GIN) and Synthetic Sentence Identification test (SSI). **Results:** gap thresholds varied from 3 to 6 ms for both groups and did not display a statistical significant difference in the group comparison. There was a statistically significant difference when the percentage of gap identification of both groups was compared with the dancers group presenting a higher mean then the non-dancers group. The SSI test in ipsilateral competing message (rel -10dB) revealed results that varied from 50% to 100% to the dancers group and from 40% to 100% for the non-dancers. The age of beginning of dancing (before or after seven years of age) did not influence the performance in the studied tests. There was no correlation between variables of the obtained findings of the studied tests in the dancers group considering the time of dancing. **Conclusion:** the dance influenced positively the auditory perception of temporal resolution hence the dancers group presented a better performance than the non-dancers group. Dancing appears to have not influenced the auditory process of figure-ground.

KEYWORDS: Auditory Tests; Auditory Perception; Neuronal Plasticity; Dancing; Hearing; Neuropsychology

INTRODUCTION

The process of listening carefully occurs in the central auditory nervous system. The act of listening is not just a detection of the stimulus; there are many neurobiological processes in response to this stimulus that can be measured by the uptake of electrophysiological auditory potentials and observation of physiological mechanisms involved in auditory behaviors. Among these, we highlight the auditory discrimination, the location of the sound, the auditory pattern recognition, the auditory performance in the presence of competing acoustic signals and temporal aspects of hearing[1].

Recent studies suggest that formal musical training, and strengthen the specific musical knowledge, substantially affects the development of basic behaviors and neural processes in a number of areas and modalities, which is associated with higher verbal memory and enhances the linguistic cognitive processes. The ability to decode the language features that rely on acoustic information correlates with the ability of perceiving musical tone and rhythm, and early reading skills is correlated with musical pitch and / or rhythm[2,3].

In dance, the individual works with physical, spatial and temporal abilities, motor coordination, memory, and it is continually exposed to music. The implementation of the steps in the dance is often accompanied by music. The musical training influences brain electrical activity associated with the processing of linguistic frequency patterns and the

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effects on cortical neural networks can be observed in childhood[2,4].

Music training is a positive aspect in reading and writing, which improves discrimination in the field of speech. Increased musical ability correlates with the increase in capacity of phonological second language learning and teaching methods[4]. The music training facilitates the ability to extract temporal patterns for shorter periods or longer, considering sound sequences, which is necessary to identify the song melody [5].

Possibly, there is a sensitive period in childhood during the results of musical training promote changes in motor and auditory performance. Studies have shown that adult musicians who began training before the age of seven performed better in visual-motor tasks than those who began after seven years of age [6]. These results suggest that there may be a critical period for musical training, similar to what is observed for language acquisition.

The dance combines many features, besides being a physical activity, combines emotions, social interaction, sensory stimulation, motor coordination and the music, creating environmental conditions that improve the individuals. Dance promotes wide range of beneficial effects that are not limited to motor development, posture and balance, but also includes cognitive abilities [7].

There is a consensus in the literature about the positive influence of music in auditory processing. It is known that conscious operations performed from auditory sensation involve activities in the auditory pathways of the central nervous system. This study investigates whether the dance also influence the auditory processing. For this purpose, it has chosen two behavioral hearing tests, namely sentence recognition test in the presence of competing message and Gaps in Noise Test. These tests assess the hearing abilities of figure-ground for verbal and temporal resolution, respectively, thereby, the investigation of two important physiological mechanisms called auditory verbal sound recognition and temporal processing. The objective of this research was to investigate the auditory ability of temporal resolution and recognition of sentences with competitive message (figure background ability) in dancers.

METHODS

This study was conducted at the Department of Speech-Hearing Therapy, Federal University of São Paulo – UNIFESP approved by the Ethics Committee, n ° 0534/11. It was carried out after signing the informed consent of the volunteers of this research or the consent form. This is a cross-sectional prospective study.

The sample consisted of two groups, the group of dancers consisted of 20 people and the group of non-dancers 20 people matched for gender, age and educational level. The dancers who participated in the sample came from a ballet school in São Caetano do Sul – São Paulo.

The sample selection criteria for the group of dancers were basic audiologic evaluation within normal without evidence of neurological alterations, without complaints of learning disability and training in the field of dance (minimum of eight years). The selection criteria for the group of non-dancers were basic audiologic evaluation within normal with no evidence of neurological, no complaint of learning difficulty and without any training in the field of dance and music. The age range for both groups between 16 and 39 years old, and the sample consisted of males and females.

Each individual underwent a hearing screening, cognitive assessment (NEUPSILIN) and a general questionnaire.

Hearing screening was composed of a pure tone audiometry by air in the sound frequencies from 500 Hz to 4000 Hz with intensity 0-110 dB, made in sound-treated booth and analyzed from the responses of the individual to sound stimuli presented. Overall questionnaire were investigated aspects of personal identification, preferred hand, learning difficulties complaints and aspects related to the dance and music education.

Two other hearing tests were the GIN test – Gaps-in-Noise and SSI Test – recognition of synthetic sentences test with contralateral and ipsilateral competitive message.

Musiek et al. [8] developed the Gaps-in-Noise test, in order to measure the temporal resolution ability in noise segments by determining the recognition of all gaps in the list of items that make up the test and measurement of the gap detection threshold.

The stimuli recorded on compact disc (CD) were presented through headphones and audiometer, single ear at 50dBSL based on the average value of hearing thresholds at 500, 1000 and 2000 Hz obtained in a sound-treated booth.

The list of stimuli contains several items, each segment six seconds of white noise, containing zero to three intervals of silence lasting from zero to 20ms. The “gaps” are included in the noise segment in random positions and lengths ranging from two, three, four, five, six, eight, ten, twelve, fifteen to 20ms. Each gap appears six times in total items in each of the lists that make up the test strip, totaling 60 gaps per test group. In each noise segment may occur up to three gaps and some segments do not contain gap. GIN has a list for training and four lists for testing, each of which is composed of several segments that have all kinds of Gaps (two to 20 ms).

To perform the test, the individual was instructed to raise the index finger to show that identified the silence (gap). The answers were recorded on a separate registration.

The results included the gap detection threshold, the total number of hits, number of false positives and percentage of correct answers. The threshold was defined as the least amount of time, in milliseconds, that was identified as an interruption of the sound stimulus [8]. The total number of correct answers was the total of all the gaps identified correctly. False positives occur when the individual reviews identified a gap when there was the presence of the same. Finally, the identification gap percentage was calculated using the total number of hits over the total number of gaps. If, however, the individual submit more than two false positives thereafter, each false positives were discounted from the total number of hits and hence identifying gaps percentage decreased [9]. It is called "recognition", the number of times that participants demonstrated to have identified the stimulus. It is called "threshold" of gap detection, the minimum value (in milliseconds) in which volunteer noticed the silent interval of at least four of the six stimuli presented, as proposed by Musiek et al. [8].

The SSI (Synthetic Sentence Identification) is a test in which the listener is asked to identify one of several alternatives of sentences and in the presence of a competing message, which has the role of background noise. SSI sentences are composed of seven to nine words classified as "artificial" once the sentences are not "real" and synthetic third order, because they have specific rules syntax, where there is a dependence every three words [10].

The SSI sentences are written in a frame, in very prominent lettering, which is placed in front of the patient. The test procedure includes the recognition of synthetic sentences in the presence of competing message against the tested ear and ipsilateral. In the contralateral evaluation was performed using the message / competition ratio of zero dB and 40 dB, using five sentences in each condition evaluated. In ipsilateral evaluation, the ratios used were zero dB and -10 dB, with the presentation of 10 sentences in each condition. The sentences were presented in the intensity of 40 dB SL, taking as a basis the average of pure tone hearing thresholds by air in the sound frequencies of 500 Hz, 1000 Hz and 2000 Hz.

The test was performed in a sound-treated booth, was presented via TDH – 39 by means of a GSI 61 audiometer, two-channel coupled to a CD player. The assessed subject was instructed to disregard the competitive message (recorded text) and point in the table, the graphical representation of sentences heard. The responses were recorded on a chart.

It was used the ANOVA – Analysis of variance- to compare the groups on the results of Gaps in Noise and sentence recognition tests with presence of competitive message (SSI); to compare the categories of dance early age on the test results Gaps in Noise and sentence recognition tests with presence of competing message and the use or not of musical instrument in the group of dancers.

The "Pearson Correlation" was also used to measure the degree of dance time relationship in sentence recognition in competitive message and Gaps in Noise tests, only between dancers.

It also used the "correlation test" to validate the correlations made by "Pearson Correlation" in which measured the degree of dance time relationship with the sentence recognition in competing message and Gaps in Noise tests, the dancers group.

The significance level was 0.05 (5%). Data were presented using descriptive statistics.

RESULTS

In the present study, most of subjects of dancers group was in the age group of 16-39 years and the majority were women; the non-dancers group also showed the same because individuals were matched by sex, age and education.

The individuals in the group of dancers and non-dancers were considered cognitively normal, according to the NEUPSILIN.

In Table 1, we observed that there was no statistically significant mean difference between groups for SSI Test (Synthetic Sentence Identification) with contralateral competitive message in the relationship – 40 dB. However, with ipsilateral competitive message in the relationship – 10 dB, as shown in Table 2, it was found that the left ear in the dancers group had underperformed the group of non-dancers in this task.

Table 1 – Decriptive statistics in percentage of hits for SSI test (*Synthetic Sentence Identification*) – contralateral message – relation -40 by right and left ears and dancers and non-dancers groups

SSI contra lateral message relation -40	Right Ear		Left Ear	
	Dancers	Non-Dancers	Dancers	Non-Dancers
Mean	99.5%	99.5%	98.5%	98.5%
Median	100%	100%	100%	100%
Standard Deviation	2.2%	2.2%	3.7%	3.7%
CV	2.2%	2.2%	3.7%	3.7%
Min	90%	90%	90%	90%
Max	100%	100%	100%	100%
N	20	20	20	20
CI	1.0%	1.0%	1.6%	1.6%
P-value (Mann-Whitney)	1,000		1,000	

Legend: CV = Coefficient of Variation
CI = Confidence Interval, * statistically significant,
Min = Minimum
Max= Maximum
N = Number of Occurrences

Table 2 – Decriptive statistics in percentage of hits for SSI test (*Synthetic Sentence Identification*) – ipsilateral message – relation-10 by right and left ears and dancers and non-dancers groups

SSI IPSILATERAL message relation -10	Right Ear		Left Ear	
	Dancers	Non-Dancers	Dancers	Non-Dancers
Mean	74%	81.5%	76.5%	87.0%
Median	75%	80%	80%	85%
Standard Deviation	14.7%	16.0%	12.5%	10.3%
CV	19.8%	19.6%	16.6%	11.9%
Min	50%	40%	50%	70%
Max	100%	100%	100%	100%
N	20	20	20	20
CI	6.4%	7.0%	5.6%	4.5%
P-value	0.130		0.007*	

Legend: CV = Coefficient of Variation
CI = Confidence Interval, * statistically significant,
Min = Minimum
Max= Maximum
N = Number of Occurrences
ANOVA Test- Analysis of Variance" and "Pearson Correlation".

Regarding the results of the GIN test, there was no statistically significant difference between groups as the gap detection threshold – GIN_Li (Table 3).

There were significant differences between the groups, about the extent of the recognition of gaps in the GIN test (GIN %). The dancers had better percentage of gaps recognition in noise test, the left ear, than the group of non-dancers (Table 4).

Data from hearing tests SSI (Synthetic Sentence Identification) and Gaps in Noise by right and left ears in hit percentage values in the dancers group were not statistically significant when compared by age of onset of dance, before and after seven years.

In the group of dancers, only three individuals played a musical instrument and no differences were found in the results of hearing tests among those who played and not played musical instruments.

Regarding the dance time, the group of dancers, there was no significant correlation between the years of dance time and the results of hearing tests.

Table 3 – Decriptive statistics of thresholds gap in milliseconds by right and lef ears and dancers and non-dancers groups

Gaps in Noise threshold	Right Ear		Left Ear	
	Dancers	Non-Dancers	Dancers	Non-Dancers
Mean	3.90	4.15	4.20	4.60
Median	4.0	4.0	4.0	5.0
Standard Deviation	0.79	0.67	0.77	0.88
CV	20,0	16	18	19
Min	3.0	3.0	3.0	3.0
Max	6.0	5.0	5.0	6.0
N	20	20	20	20
CI	0.35	0.29	0.34	0.39
P-value	0.287		0.134	

Legend: CV = Coefficient of Variation
CI = Confidence Interval, * statistically significant,
Min = Minimum
Max= Maximum
N = Number of Occurrences
ANOVA Test- Analysis of Variance” and “Pearson Correlation”.

Table 4 – Decriptive statistics in regard to performance subjects to gaps recognition of percentage, obtained in the gap in noise test by right and left ears and dancers and non-dancers groups

Gaps in Noise % recognition	Right Ear		Left Ear	
	Dancers	Non-Dancers	Dancers	Non-Dancers
Mean	82.4%	77.8%	81.8%	75.4%
Median	83%	80%	83%	77%
Standard deviation	6.4%	8.5%	6.5%	8.7%
CV	7.8%	10.9%	8.0%	11.5%
Min	67%	52%	67%	53%
Max	92%	88%	93%	88%
N	20	20	20	20
CI	2.8%	3.7%	2.9%	3.8%
P-value	0.058		0.013*	

Legend: CV = Coefficient of Variation
CI = Confidence Interval, * statistically significant,
Min = Minimum
Max= Maximum
N = Number of Occurrences
ANOVA Test- Analysis of Variance” and “Pearson Correlation”.

DISCUSSION

In the literature, there are no studies that references to dance relationship with a better performance in auditory processing tests for the hearing abilities of temporal resolution and selective attention or figure-ground.

Studies were found where there is relationship between music and perform better in central auditory processing tests. The studies are unanimous in noting that the music is beneficial to humans. It was chosen to highlight the studies on the relationship between music and auditory processing since music is a constant element and very important in the formation of the dancers.

Individuals with musical practice perform better in math assignments [11], reading [4], vocabulary, auditory discrimination, fine motor abilities, and nonverbal reasoning [12]. It was observed that the phonological ability, understanding speech, cognitive structures, patterns of action and increased level of intelligence in children who underwent music therapy [13].

The study by Moreno et al. [4] mentions that are needed at least six months of formal study of music so there is brain plasticity modification, demonstrated with electrophysiological tests. The study by Forgeard et al. [12] that took into account the hours of practice music at home, showed that the greater the study during the time, the better the performance in cognitive and motor tasks.

Studies have reported statistically significant relationship between music and the improvement of auditory processing [14-16]. The study of Eugênio, Escalda and Lemos [17] reports that music education is of great importance for children with auditory processing disorders. Amatucci and Lupion [14] reported a statistically significant relationship between music and improvement of auditory processing. Zaidan et al. [18] applied the GIN and RGDT in music therapy students and they performed better on both tests.

In contrast to these studies, Monteiro et al. [19] applied the GIN test violinists and fiddlers not and did not find statistically significant difference between the results of groups.

In the test, SSI (Synthetic Sentence Identification) contralateral message ratio – 40 dB, all evaluated subjects performed better than normal criteria established for this test in normal subjects [20]. In the test, SSI (Synthetic Sentence Identification) message ipsilateral ratio -10 dB, most subjects also showed responses above 70%, it was found those seven individuals in the group of dancers and two individuals non-dancers group presented a poor performance, which is, below 70% correct.

Groups of dancers and non-dancers showed similar results in the SSI (Synthetic Sentence Identification) with contralateral message ratio – 40 dB. In the literature, there are no studies comparing dancers and non-dancers on SSI (Synthetic Sentence Identification) contralateral message ratio – 40 dB and SSI (Synthetic Sentence Identification) ipsilateral message ratio -10 dB, involving selective attention.

When comparing the performance of individuals in the test SSI (Synthetic Sentence Identification) with ipsilateral message ratio -10 dB to the right ear, the group of dancers and non-dancers group had no significant mean difference. However, on the left ear, it was observed that the group of dancers had a mean of 76.5% and the group of non-dancers had a mean of 87.0% correct, so there was a statistically significant mean difference in better performance test on the left ear, and the group of non-dancers superior performance to the group of dancers.

The temporal acuity thresholds found in the GIN test for this study are similar to those found in national and international literature [8,9,18,20-22] who described values ranging from 3.98 ms to 5.05 ms.

In this study, it was found that the dancers performed better than non-dancers as related to the percentage of correct identification of gaps. This shows that the dancers correctly identify more gaps than non-dancers do. The values obtained for identifying gaps percentage in the GIN test, are similar to those found in the literature [23,24].

The cerebellum and basal ganglia structures are responsible for many types of functions, such as motor coordination, maintaining balance and muscle tone, emotions and cognition. Furthermore, it is also considered very important aspects for processing time. Specifically, the basal ganglia have been recognized as a neural structure involved in temporal question, and of point of view both perceptual and motor [25,26.]

It can be hypothesized that because dance is an activity that combines hearing and movement, dance practice could have positively changed important neural substrates for temporal processing, which could be demonstrated by test results GIN.

In the group of 14 individuals dancers started to dance before the age of seven, five individuals began after the age of seven and one started at seven years of age.

The values of the SSI tests (Synthetic Sentence Identification) and GIN (Gaps in Noise) were not statistically significant when compared by age of onset of dance. Not found in the literature articles that asserted the correlation between the age of onset of dance and performance on central auditory processing tests. There are articles that are correlated with musicians [6,27,28].

The study of Bailey, Penhume [6] said that there is a sensitive period for the development of the individual, for musical training, it occurs before the age of seven, this could contribute to the development of the central auditory processing, specifically the temporal processing. The study of Ohnishi et al. [27] highlighted that to be a better development in the timetable, the musical stimulus should begin before the age of nine, which is important for the temporal processing. The authors also claim that contact with the music before the age of seven could contribute to the development of the central auditory processing, specifically the temporal processing. The authors, Pantev et al. [28], confirmed the improvement of temporal processing in individuals who were exposed to early music stimulus.

The studies of Ishii C, Arashiro PM, Desgualdo L. [29] and Rammsayer, Altenmüller [30] considered the time of initiation and / or musical training as relevant to performance in tests involving auditory processing.

It was found in this study that the beginning of the dance did not influence the results of auditory processing tests.

Studies performed with musicians indicate that the daily musical training, used by professional musicians, can induce functional reorganization of the cerebral cortex [27]. The study of Schön, Besson [31], Cioqueta e Costa[32], showed that the group has musical experience has better answers in auditory processing tests.

Regarding the dance time for the individuals in the group of dancers, the average was 17.8 years of dancing, ranging from eight years of dance (younger individual of this study- 16 years) and 31 years of dance (older individual of this study-39 years).

There was no correlation between the dance-time variables and better results in hearing tests. There was no found in the literature studies comparing the time dancing in years with central auditory processing. The authors are unanimous in state that musical training time is correlated with better performance on central auditory processing tests. In this study, there was no such correlation.

The author Schalaug [33], concluded that musicians have better neural activation due to the long-term musical training. The study of Moreno et al. [4], mentions that it takes at least six months of formal study of music so there is brain plasticity modification, demonstrated with electrophysiological tests.

The studies of Ishii, Arashiro and Pereira [29] as well as the Monteiro et al. [19], found that the increase of musical training is correlated with improved performance in RGDT.

CONCLUSION

In this study, the dance seems to have positively influenced the auditory ability of temporal resolution, since the group of dancers presented a better performance than the group of non-dancers, as assessed by the GIN test. It is likely that the dance influence the ability of the individual to deal with acoustic signal timing aspects (temporal processing).

The dance did not influence the auditory ability of figure-ground, as assessed by SSI.

To future studies increasing the number of subjects and the physiological auditory mechanisms to be evaluated as well as the number of applied auditory tests would be interesting.

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RESUMO

Objetivo: avaliar a habilidade auditiva de resolução temporal e de identificação de sentenças com mensagem competitiva em dançarinos. **Métodos:** trata-se de um estudo prospectivo em que foram avaliados 40 indivíduos distribuídos em dois grupos: grupo 1 (dançarinos) e grupo 2 (não-dançarinos). Os instrumentos de avaliação do processamento auditivo utilizados foram: teste Gaps-in-noise (GIN) e teste de reconhecimento de sentenças na presença de mensagem competitiva (SSI). **Resultados:** os limiares de gap de ambos os grupos variaram de 3 a 6 ms e não demostraram diferença estatisticamente significante na comparação entre os grupos. Houve diferença estatisticamente significante ao comparar a porcentagem de identificação de gaps entre os dois grupos, sendo que o grupo de dançarinos apresentou média maior que o grupo de não dançarinos.O teste de reconhecimento de frases em escuta monótica (rel -10dB) mostrou resultados que variaram de 50% até 100% para o grupo de dançarinos e de 40% até 100% para o de não – dançarinos. A idade de início da dança (antes ou depois dos sete anos) não influenciou no desempenho dos testes estudados. Não houve correlação entre as variáveis dos achados obtidos nos testes estudados no grupo de dançarinos considerando o tempo de dança. **Conclusão:** a dança influenciou positivamente a habilidade auditiva de resolução temporal, pois o grupo de dançarinos apresentou desempenho melhor do que o grupo de não-dançarinos. A dança parece não ter influenciado a habilidade auditiva de figura-fundo.

DESCRITORES: Testes Auditivos; Percepção Auditiva; Plasticidade Neuronal; Dança; Audição; Neuropsicologia

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