



The influence of musical practice in central auditory processing skills: a systematic review

Influência da prática musical em habilidades do processamento auditivo central: uma revisão sistemática

Influencia de la práctica musical en habilidades del procesamiento auditivo central: una revisión sistemática

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Abstract

Objective: To investigate what the literature reveals about the influence of the musical practice on Central Auditory Processing (CAP) skills, and whether the time of exposure to music acts in some way in these skills. **Method:** The collection of the articles was carried out from the databases PubMed, Science Direct and Lilacs, with the combination of indexed descriptors in the Medical Subject Headings (MeSH). Selection criteria: Articles were selected in English and Portuguese, published between 2010 and 2016, whose title, or abstract, or work content, were related to the objective of the present study, that is to verify the influence of music in the CAP. The repeated articles and those that did not have the abstract or full text, revision articles, dissertations and theses were excluded. Data analysis: After reading the articles in full, the data were extracted: title, year of publication, country of origin, age and characteristics of the examples, type of study, musicians' experience time, research objective, CAP skills assessed, results found

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and conclusion. **Results:** The research carried out generated a total of 1445 articles, 896 of them were contained in Pubmed, 518 in the base ScienceDirect and 31 in Lilacs. At the end of the analysis the judges selected 17 studies. **Conclusion:** The articles mentioned demonstrate that the musical practice positively influences the abilities of the CAP. There was no consensus regarding the performance of the exposure time on these skills, but it was shown a better result for individuals with greater musical experience.

Keywords: Music; Auditory Perception; Review; Hearing Tests; Auditory Cortex.

Resumo

Objetivo: Investigar o que a literatura revela sobre a influência da prática musical em habilidades do Processamento Auditivo Central (PAC), e se o tempo de exposição à música atua de alguma maneira nestas competências. **Método:** A coleta dos artigos foi realizada a partir das bases de dados PubMed, Science Direct e Lilacs, com a combinação de descritores indexados no *Medical Subject Headings* (MeSH). Critérios de seleção: Foram selecionados artigos em inglês e português, publicados entre os anos de 2010 e 2016, cujo título, ou resumo, ou corpo do trabalho, tivessem relação com o objetivo do presente estudo. Foram excluídos os artigos repetidos e os que não possuíam o resumo ou texto completo, artigos de revisão, dissertações e teses. Análise dos dados: Após a leitura dos artigos na íntegra, foram extraídos os seguintes dados: título, ano de publicação, país de origem, idade e características dos indivíduos da amostra, tipo de estudo, tempo de experiência dos músicos, objetivo da pesquisa, habilidades do PAC avaliadas, resultados encontrados e conclusão. **Resultados:** A pesquisa realizada gerou o total de 1445 artigos, sendo que 896 deles estavam contidos na Pubmed, 518 na base ScienceDirect e 31 na Lilacs. Ao final da análise, os juízes selecionaram 17 estudos. **Conclusão:** Os artigos mencionados demonstraram que a prática musical influencia positivamente as habilidades do PAC, não havendo um consenso quanto à atuação do tempo de exposição sobre essas competências, mas evidenciando um melhor resultado de indivíduos com maior experiência musical.

Palavras-chave: Música; Percepção Auditiva; Revisão; Testes Auditivos; Córtex Auditivo.

Resumen

Objetivo: Investigar lo que la literatura revela sobre la influencia de la práctica musical en habilidades del Procesamiento Auditivo Central (PAC), y si el tiempo de exposición a la música actúa de alguna manera en estas competencias. **Método:** La recolección de los artículos se realizó a partir de las bases de datos PubMed, ScienceDirect y Lilacs, con la combinación de descriptores indexados en el *Medical Subject Headings* (MeSH). Criterios de selección: Se seleccionaron artículos en inglés y portugués, publicados entre los años de 2010 a 2016, cuyo título, resumen, cuerpo del trabajo, tuvieran relación con el objetivo del presente estudio. Se excluyeron los artículos repetidos, los que no poseían el resumen o texto completo, artículos de revisión, disertaciones y tesis. Análisis de los datos: Después de la lectura de los artículos en su totalidad, se extrajeron los siguientes datos: título, año de publicación, país de origen, edad y características de los individuos de la muestra, tipo de estudio, tiempo de experiencia de los músicos, objetivo de la investigación, habilidades del PAC evaluadas, resultados encontrados y conclusión. **Resultados:** La encuesta realizada generó el total de 1445 artículos, 896 de ellos estaban en la base Pubmed, 518 en ScienceDirect y 31 en Lilacs. Al final del análisis, los jueces seleccionaron 17 estudios. **Conclusión:** Los artículos mencionados demostraron que la práctica musical influye positivamente en las habilidades del PAC, no habiendo un consenso cuanto a la actuación del tiempo de exposición sobre esas competencias, pero evidenciando un mejor resultado de individuos con mayor experiencia musical.

Palabras clave: Música; Percepción Auditiva; Revisión; Pruebas Auditivas; Corteza Auditiva.

Introduction

Central auditory processing (CAP) refers to how individuals analyze the acoustic information that is received via the sense of hearing, acting in the development of language and academic abilities as well as in the communication process¹. It can be conceptualized as a set of specific skills on which the individual depends to understand what he hears. It is a mental activity; therefore, it can not be studied as a distinct phenomenon, but as a complex response to the stimuli received through hearing².

In general, CAP can be defined as the ability to perceive sound stimuli around us by analyzing and memorizing what we hear. For this, it is necessary that the paths responsible for the path of sound, and for its interpretation, are intact. When there is some interference in this course we are facing a Central Auditory Processing Disorder (CAPD)³.

The APD refers to difficulties in the perceptual processing of auditory information in the Central Nervous System (CNS) and neurobiological activity that underlies the transformation. Difficulty in understanding speech in a noisy environment, although auditory thresholds are normal, is the hallmark of CAPD⁴. In addition, it causes difficulties in the interpretation of sound patterns, harming the individual when attending, discriminating, recognizing, remembering and / or understanding information presented to the auditory channels⁵.

Temporal Auditory Processing (TAP) can be defined as the perception of sound or the change of sound within a restricted or defined time domain, that is, it refers to the ability to perceive or differentiate stimuli that are presented in rapid succession⁶. TAP skills are extremely necessary for the ability to understand speech in noise and silence, as well as speech stimuli and other background sounds that vary over time. They can also be considered the basis for auditory processing, since many characteristics of auditory information are influenced by time⁶.

Perceptions of time information such as duration, range, and order of different stimulus patterns provide key information for the central nervous system. These clues govern temporal processing and are important for the perception of speech and music, since the structure of these events presents as rapid changes of the acoustic signal⁶. TAP is divided into four categories, all of which are important for CAP skills; they are: ordering or

temporal sequencing, which refers to the processing of multiple auditory stimuli in their order of occurrence. Integration, which results from the summation of neuronal activity, resulting from an additional duration of sound energy; in tests that assess temporal integration; subjects should detect weak signals in the midst of background noise or in silence. Temporal masking, which occurs when a stimulus is presented with duration and intensity sufficient to reduce the sensitivity of another stimulus presented before or after the initial stimulus. Resolution, discrimination or temporal acuity, which refers to the minimum time required to segregate or resolve acoustic events^{6,7,8}.

Apparently, it is in the right brain secondary area that environmental and musical sounds are processed, and on the left, the speech sounds. Thus, the left hemisphere is dominant for language and speech, and for the recognition and processing of sequential information. On the other hand, the right hemisphere is dominant to recognize contours, such as music⁹.

The CNS processes music differently from other auditory stimuli in the temporal cortex in three areas. The primary auditory area is responsible for recognition, analyzing each sound separately, but sequentially over time. In the secondary auditory area occurs the integration of the individual sounds into larger groups where new meanings such as rhythm, harmony and melody are valued. The tertiary auditory area integrates groups of musical notes into larger themes, hierarchizing, pondering and organizing in a temporal way, until obtaining a complete and diverse image of all music¹⁰. In addition to these, other brain areas are activated for the processing of musical information, such as areas of memory as the hippocampus, which recognizes the familiarity of thematic and rhythmic elements; the areas of motor and emotional regulation, such as the cerebellum and the amygdala, which attribute an emotional value to the sound experience, and a nucleus of gray substance (acumbens nucleus) related to the sense of pleasure and reward¹¹.

Thus, through a systematic review, the present study aims to investigate what the literature reveals about the influence of musical practice on Central Auditory Processing skills, and whether the time of exposure to music acts in some way in these skills.

Method

Research Strategies

For this systematic review, the Cochrane Handbook¹² precepts were followed, involving the formulation of the research question, the location, the selection of the scientific articles and the critical evaluation of them. Considering that the systematic review is carried out from the formulation of specific questions that guide the search of the publications involving the theme, the investigative question of the present study was: “What is the influence that the musical practice exerts in the abilities of the central auditory processing?”

The research was developed by three researchers, one of whom was blind and independent, while the other two were instituted as judges, being consulted in cases of doubt to establish a concordance between ideas.

The articles were collected from the PubMed, Science Direct and Lilacs databases. The search was performed in September, in a single day, from the intersection between the chosen descriptors. As a search strategy, the combination of indexed descriptors in the Medical Subject Headings (MeSH) was used. We used the following key words: Auditory Perception or Auditory Threshold or Auditory Fatigue or Loudness Perception or Perceptual Masking or Pitch Perception or Pitch Discrimination or Sound Localization or Speech Perception and Music or Singing and Hearing Test or Hearing or Tests, Hearing.

Selection Criteria

We selected articles in English and Portuguese published between 2010 and 2016, with human subjects, whose title, or abstract, or body of work, were related to the objective of the present study, which was to verify the influence of music in the central auditory processing. Repeated articles and those that did not have the abstract or full text, review articles, dissertations and theses were excluded. Beside the works in which individuals with experience in musical practice of non-musicians were not compared.

All the articles found were analyzed by two judges, who completed an eligibility form and, through it, included or excluded studies, according to the criteria described. Those who left doubts for eligibility were read in full. A third judge carried out the analysis of the agreement between the articles, deciding the cases in which there was disagreement.

Data analysis

The articles were analyzed qualitatively, according to the inclusion criteria and based on the guiding question of this study. For the analysis of the quantitative data, a descriptive analysis of frequency was performed in absolute and percentage numbers.

From the selection of the summaries of the studies found, pertinent to the proposed question, the retrieval of the articles in full text was performed. After reading the articles in full, the following data were extracted: title, year of publication, country of origin, age and characteristics of subjects in the sample, type of study, musicians' results found, and conclusion.

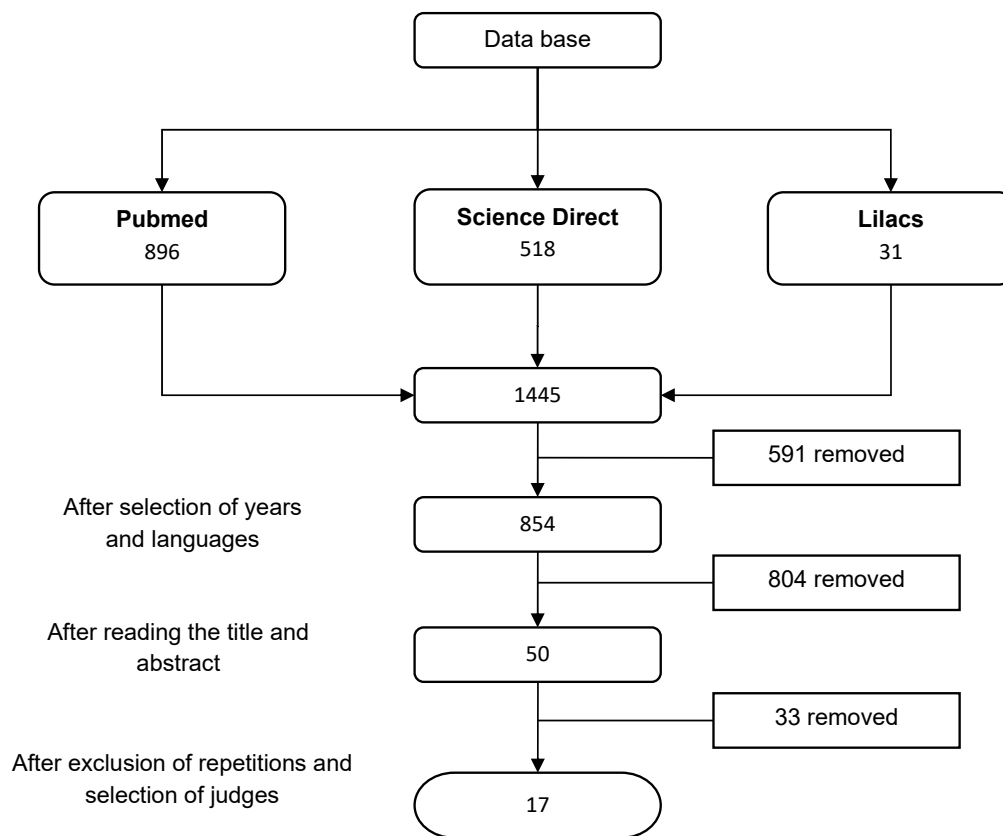


Figure 1. Number of articles found and selected after application of the inclusion and exclusion criteria according to descriptors and databases.

Results and discussion

The research conducted in the databases used, from the proposed descriptors, generated a total of 1445 articles. The quantitative references found and selected in the databases for this study show that 896 (62.1%) of them were contained in Pubmed, 518 (35.8%) in the ScienceDirect database and 31 (2.1%) in the Lilacs database. After being filtered by the selected languages, English and Portuguese, there were 854 articles, which, afterwards, went through an analysis of titles and abstracts based on the inclusion and exclusion criteria adopted. Of these, 804 were still excluded, leaving 50 articles for the analysis of the full text. From the reading of these and the exclusion of those who did not fit the inclusion criteria, the judges selected 17 studies for analysis (Figure 1).

In the articles selected for the present study, the following data were extracted for the analysis:

title, year of publication, country of origin, age and characteristics of subjects, type of study, musicians' results, and conclusion (Table 1).

The publication dates ranged between the years 2010 and 2016, previously selected for encompassing the most current works. Of the total, three publications occurred in the year 2010^{13,14,15}; two in the year 2011^{16,17}; six in the year 2012^{18,19,20,21,22,23}; one in the year 2014²⁴; four in the year 2015^{25,26,27,28}; and one in the year 2016²⁹; in the year of 2013 no publications were found that obeyed the criteria of inclusion proposed in this research. This statement leads to the conclusion that in the current period there was an increase in publications that deal with the subject of this study, since the area of Auditory Processing has gained greater repercussion in recent years. This fact may be related to the emergence of new studies that relate this area to music.

Of the published articles, six were developed in the United States of America (USA)^{13,19,23,24,26,27};

four in Brazil^{14,15,16,25}; two in Canada^{18,22}, in the United Kingdom^{28,29} and Italy^{20,21}; and one in Israel¹⁷. This result may be related to the tests that evaluate the TAP were created and commercialized, in the great majority, in the USA. In Brazil, we also count on the tests produced by the Speech Therapists Liliâne Desgualdo Pereira and Eliane Schochat. The only selected study that was not produced in the West, but rather in a country in the Middle East¹⁷, investigated the effects of the stimulus context and the musical experience on the auditory discrimination of temporal interval, concluded that in musicians the temporal resolution ability was more developed than in individuals without musical experience.

As far as the subjects of the research were concerned, the samples were quite varied and involved children, adults and the elderly. The sample size ranged from 21 to 163 participants. The article containing the sample with 163 participants was developed with a very heterogeneous population, with individuals of both genders, between 18 and 91 years of age, and with different characteristics²².

Regarding the age group of the studies, 15 investigated adult individuals, 11 of whom reported the participants' mean age^{13,17,18,20,21,23,24,25,26,28,29} and four did not include this information^{14,15,19,22}. The mean age of the sample was 25.2 years. Only two studies were carried out with school-age children, in one of them the mean age was 5.5 years¹⁶ and in the other 8 years²⁷.

As to the design of the studies, it was verified that the majority had a cross-sectional design^{14,15,16,17,18,19,20,21,23,24,25,26,28}, and consisted basically of a comparison between two groups, one composed of musicians and another by non-musicians, in the performance of tests that evaluated CAP skills. The highest level of scientific evidence found in the selected studies was the cohort study^{13,22,27}, present in only three articles, all international. Regarding the method used in the articles included in the present study, we highlight two that used specific groups of violinist musicians to perform tests that evaluate temporal ordering and temporal resolution abilities^{13,14}. In the other studies, there was no specification as to the instrument practiced by the musicians.

Concerning the minimum amount of musical practice required for the musicians in the selected studies, the shortest period was only four months¹⁶ and the largest was the average of 12 years²⁰, and

in this same study there were individuals with musical experience much larger than the required. The overall mean of the studies was 7.6 years of practical engagement with music, either by playing an instrument or singing. The literature argues that in order to achieve high levels of performance, at least ten years of orderly practice in the field of the chosen instrument is required; they also affirm that activities related to informal practice, such as participating in exploratory and pleasurable musical activities, encourage development of musical expressiveness and contribute to the musician's formation, although to a lesser extent than the practice of scales and repertoire³⁰.

All the studies used musicians with experience prior to the experiment in the study group, except for only two^{16,27} in which the individuals did not have musical training in a period prior to the study. In the first one¹⁶, the objective was to investigate the relationships between musical experience, auditory processing and phonological awareness skills of 5-year-old children, in which group 1 began to attend children's music classes for at least one hour per week, for at least four months, and it was concluded that the group that underwent this training had better results when compared to the group that did not undergo this experiment, in the results of the temporal ordering ability. In the second study²⁷, conducted with children who had the mean age of eight years, and whose objective was to conduct an investigation of the effect of group music instruction on performance in a measure of speech perception in noise, the population with the highest time of musical training obtained the best results in the tests performed that evaluate the ability of figure-background, concluding that such training causes beneficial effects on this competence.

In the selected articles, four competences were evaluated and tested in the CAP, most of them corresponding to the TAP. This data reveals a greater tendency on the part of researchers to correlate such abilities with musical practice, taking into account that music uses different forms of duration, interval and sequence of different patterns of stimulus, important for the perception of speech and music, since the structure of these two events presents itself as rapid changes of acoustic signals¹⁴. The investigation of temporal resolution ability was the most approached, corresponding to seven studies^{15,17,19,20,22,24,25}; in five studies the figure-background ability was evaluated^{22,23,26,27,28};

in four, the temporal ordering^{14,16,21,25}; and, in three articles, the tests involved the ability of auditory discrimination^{13,18,29}.

A variety of tests were used to carry out the evaluations. The use of the Gap in Noise (GIN) for the evaluation of the temporal resolution ability is highly emphasized^{15,25}; the Frequency Pattern Test (TPF), for evaluation of temporal ordering^{14,25}; the use of melodies that ended in an expected or unexpected note paired with prosodic statements for the evaluation of auditory discrimination²⁹; and measures of speech perception in the noise, to evaluate the ability of the deep figure^{26,27,28}.

In all the studies the hypothesis tested was that the musical experience would have advantages over the abilities of the sound processing by the brain, in relation to the individuals with no or restricted practical contact with music. The results found in most of the articles brought as an outcome what was expected: music contributed positively on these competencies. However, in the research performed with violinist musicians, there was no difference in the GIN test results, neither in performance, nor in the time of daily exposure to music¹⁵. Already in the experiment performed between popular singers who play or not instruments, the same test revealed that popular singers who play musical instruments

have better performance in hearing abilities when compared to those who only sing²⁵. In the study that aimed to estimate if, and in what way, experienced musicians differ from nonmusicians in their perception of masked speech, no advantage was found for masked speech perception of musicians over nonmusicians, and this did not vary as to the noise type²⁸.

The present study sought to verify the influence of the musical practice and the time of exposure to the music act in the abilities of the CAP; however, it is believed that further studies are necessary in order to consider other important points, such as the differences between people who have studied fundamentally melodic instruments and those who have devoted themselves to essentially percussive and rhythmic instruments, difference in brain dominance for specific auditory abilities (melodic, harmonic and rhythmic perception). It would also be worth considering studies with a group of children with exposure and musical experiences during early childhood, a fundamental period for the development of auditory abilities, both for language acquisition and development, and for the development of musical abilities.

Table 1. Results of selected studies following the analyzed variables

Author (s), year and country	Sample	Kind of study	Skill (s) tested	Objectives	Results and conclusion
Wayland et al. (2010) ⁽¹³⁾ United States of America	Group 1: 15 musicians with at least 6 years of experience Group 2: 15 non musicians Average age: 22.5 years.	Cohort	Hearing discrimination	To examine the effects of musical experience and training on the perception of tonal contour.	The results suggest that the musical experience sharpened the perception of tuning among musicians, but that the auditory systems of both groups are experience dependent and comparatively malleable.
Nascimento et al. (2010) ⁽¹⁴⁾ Brazil	Group 1: 20 musicians all with musical training Group 2: 20 non musicians Average age: not informed	Transversal	Temporal ordering	Compare the sorting ability between musicians and non-musicians from the frequency pattern test.	The results of the Frequency Pattern Test (TPF) were correlated with the mean of the bass frequencies, mean tritonal and average of the acute frequencies obtaining a statistically significant relation only for OD. The performance of the group of musicians in the TPF was superior to the group of non musicians. The relevance of the auditory thresholds for the severe, acute and tritonal frequencies in the performance of TPF in the right ear is highlighted.
Monteiro et al. (2010) ⁽¹⁵⁾ Brazil	Group 1: 20 musicians all with musical training Group 2: 20 non musicians Average age: not informed	Transversal	Temporal resolution	To identify the temporal resolution performance between groups and to correlate it with the mean of the thresholds of the high and low frequencies, as well as the time of daily exposure to music.	The mean of the bass frequencies for both ears in the group of musicians was statistically significant, with the highest values for OD ($p = 0.001$). There was no difference between the performance of the Gap in Noise (GIN) test for both groups as well as the correlation between the time of daily exposure to music and GIN. The audiometric threshold of the acute frequencies was shown to be relevant in the GIN test.
Escalda et al. (2011) ⁽¹⁶⁾ Brazil	Group 1: 30 with 4 months of musical experience Group 2: 26 without musical experience Average age: 5.5 years	Transversal	Temporal ordering	To investigate the relationships between musical experience, auditory processing and phonological awareness skills of 5-year-old children with and without musical experience.	We observed a difference between the results obtained in verbal sequential memory tests and non-verbal sequential memory with four instruments, tasks of rhyme identification, synthesis and phonemic exclusion. The musical experience promotes the improvement of the auditory and metalinguistic abilities of children of 5 years.

Author (s), year and country	Sample	Kind of study	Skill (s) tested	Objectives	Results and conclusion
Banai et al. (2011) ⁽¹⁷⁾ Israel	<p>Group 1: 24 musicians with minimum experience of 10 years</p> <p>Group 2: 50 non musicians</p> <p>Average age: 31 years old</p>	Transversal	Temporal resolution	To investigate the effects of the stimulus context and the musical experience on the auditory discrimination of time interval.	Musical experience, while improving performance, did not alter the context effect, suggesting that the best discriminating skills among musicians are probably not the result of more sensitive contextual facilitation or predictive coding mechanisms.
Ouimet et al. (2012) ⁽¹⁸⁾ Canada	<p>Group 1: 16 musicians with at least 7 years of experience</p> <p>Group 2: 16 non musicians</p> <p>Average age: 20 years</p>	Transversal	Hearing discrimination	Investigate global-local auditory processing using improved material based on standard stimuli used in global-local visual processing studies.	The musical experience had an effect on global-local auditory processing, with musicians presenting better overall performance compared to non-musicians. Specifically, non-musicians showed a greater overall advantage over musicians, driven by the fact that musicians improved local processing compared to non-musicians.
Zarate et al. (2012) ⁽¹⁹⁾ United States of America	<p>Group 1: 13 musicians with at least 3 years of experience</p> <p>Group 2: 8 non musicians</p> <p>Average age: not informed</p>	Transversal	Temporal resolution	To investigate the effects of musical experience on the discrimination of time intervals.	Although exposure to Western music and speech can help establish a basic threshold of interval discrimination between 1 and 2 semitones, music training presumably improves auditory processing and reduces that limit to one semitone. As the musical skill does not decrease this threshold beyond 1 semitone, the semitone may represent an interval musical limit induced by musical training for acoustic processing.
Agrillo and Piffer (2012) ⁽²⁰⁾ Italy	<p>Group 1: 13 musicians with at least 12 years of experience</p> <p>Group 2: 14 non musicians</p> <p>Average age: 28.1 years</p>	Transversal	Temporal resolution	Observe musicians and non-musicians performing three different tasks: temporal, spatial and numerical discrimination.	As expected, musicians were more accurate in relation to time discrimination. They also performed better on spatial and numerical tasks, but only out of the range of sublimations. Our data are in agreement with the existence of a system of common magnitude. We suggest, however, that this mechanism can not involve the whole range of numbers.
Deguchi et al. (2012) ⁽²¹⁾ Italy	<p>Group 1: 14 musicians with at least 8 years of experience</p> <p>Group 2: 14 non musicians</p> <p>Average age: 25.9 years</p>	Transversal	Temporal ordering	Investigate the differences between musicians and non musicians in the processing of tuning changes in spoken phrases.	Overall results have confirmed musicians' advantage in detecting subtle tone changes, not only with tones, but also with phrases in native and unfamiliar languages. This effect seems to emerge from a more efficient tone analysis, trained by musical experience.

Author (s), year and country	Sample	Kind of study	Skill (s) tested	Objectives	Results and conclusion
Zendel and Alain (2012) ⁽²²⁾ Canada	<p>Group 1: 74 musicians with at least 6 years of experience</p> <p>Group 2: 89 non-musicians</p> <p>Age: between 18 and 91 years.</p>	Cohort	Background Figure and Time Resolution	Investigate the possibility that musicians experience less age-related decline in auditory perception.	Musicians showed lower age-related declines in gap detection and noise speech and temporal resolution tests. It is important to note that the rate of age-related decline in auditory sensitivity as measured by pure tone thresholds was similar between the two groups, demonstrating that musicians experience less age-related decline in central auditory processing.
Parbery-Clark et al. (2012) ⁽²³⁾ United States of America	<p>Group 1: 23 musicians with at least 12 years of experience</p> <p>Group 2: 27 non-musicians</p> <p>Average age: 22.0 years</p>	Transversal	Figure Background	To measure the degree to which subcortical response time differs from the speech syllables / ba /, / da / and / ga / in adult and non-musician musicians.	We show that musicians show greater neural distinction between speech syllables than non-musicians and that the extent of this neural differentiation correlates with the ability to perceive speech in noise. This musical enhancement may result from his extensive experience distinguishing closely related sounds from timbre.
Mishra et al. (2014) ⁽²⁴⁾ United States of America	<p>Group 1: 16 musicians with at least 10 years of experience</p> <p>Group 2: 28 non-musicians</p> <p>Average age: 25 years old</p>	Transversal	Temporal resolution	To compare the temporal resolution, tested by gap detection thresholds between channels, between musicians and non-musicians.	These results indicate that musical training has a significant impact on gap detection thresholds. Specifically, musicians have lower gap detection thresholds compared to non-musicians.
Ribeiro et al. (2015) ⁽²⁵⁾ Brazil	<p>Group 1: 15 musicians who only sing without the minimum experience required</p> <p>Group 2: 15 musicians who sing and play some instrument with minimal experience required</p> <p>Average age: 30.9 years</p>	Transversal	Resolution and temporal ordering	To evaluate the temporal processing of popular singers who play or not a musical instrument.	There was a statistically significant difference in the comparison of the performance between the groups regarding the temporal acuity threshold and percentage of correct GIN. Popular singers who play musical instruments have better performance in the auditory skills of resolution and temporal ordering when compared to those who only sing.
Swaminathan et al. (2015) ⁽²⁶⁾ United States of America	<p>Group 1: 12 musicians with at least 10 years of musical training</p> <p>Group 2: 12 non-musicians</p> <p>Average age: 21.6 years</p>	Transversal	Figure Background	To determine through intelligible and spatial speech as the key stimulus, if musicians show advantages for speech perception in noise in more ecologically valid situations.	These results suggest that the characteristics of speech masks and the amount of information masking can influence the magnitude of the differences found between musicians and non-musicians in multi-partner environments.

Author (s), year and country	Sample	Kind of study	Skill (s) tested	Objectives	Results and conclusion
Slater et al. (2015) ⁽²⁷⁾ United States of America	<p>Group 1: 19 w / 1 year of music training</p> <p>Group 2: 19 w / 2 years of musical training</p> <p>Average age: 8 years</p>	Cohort	Figure Background	Conduct a longitudinal investigation of the effect of group music instruction on performance in a classical measure of speech perception in noise.	The results provide the first longitudinal evidence that noise perception in noise improves after two years of group musical training. The children were enrolled in an established and successful community-based music program and followed the standard curriculum so these findings provide an important link between laboratory research and real-world assessment of the impact of music training on daily communication skills .
Boebinger et al. (2015) ⁽²⁸⁾ United Kingdom	<p>Group 1: 25 musicians with at least 10 years of musical training</p> <p>Group 2: 25 non musicians</p> <p>Average age: 27.2 years</p>	Transversal	Figure Background	To estimate if, and in what way, experienced musicians differ from non-musicians in their perception of masked speech.	The results of this experiment demonstrate the need to account for general cognitive abilities before attributing group differences observed to musical training. We found no advantage to masked speech perception of musicians over that of non-musician musicians, and this did not vary in the type of noise.
Zioga et al. (2016) ⁽²⁹⁾ United Kingdom	<p>Group 1: 22 musicians w / musical experience time not informed</p> <p>Group 2: 20 non musicians</p> <p>Average age: 23.7 years</p>	Transversal	Hearing discrimination	To investigate how music and language interact in the dimension of tone and whether musical training plays a role in this interaction.	Participants were faster for simultaneous breaches of expectation in melodic and linguistic stimuli. In addition, musicians performed better than non-musicians, which may be related to increased tracking capacity. The beneficial aspect of the experience could be attributed to its effect of strengthening general executive functions.

Conclusion

The articles referred to in the present study demonstrate that the musical practice positively influences the abilities of the CAP. There was no consensus regarding the performance of the exposure time on these skills, but, evidencing in several studies, a better result of individuals with greater musical experience on those who did not have, or for less time, practical contact with music.

The review in question showed that there is a possibility and need for deepening studies in order to stabilize and standardize evaluation and comparative instruments to elucidate the involvement of musical practice with the improvement of CAP skills.

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