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Revision articles

Language and auditory processing disorders: Literature review

Alterações de linguagem e processamento auditivo: revisão de literatura

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ABSTRACT

There is an interdependence between auditory and language process, and great performance of one of them contributes to proper operation of the other. The purpose of this article was to write a literature review based in national and international studies systematically. This review aimed to assess the relationship between auditory processing disorders and language disorders. The research used as databases PubMed and Web of Science, from May to June 2014. Inclusion criteria were: articles that responded to the guiding question and that met the theme established by the descriptors. We excluded studies with animals, laboratory, opinion articles / authority, case series and case report. The selection of articles was made through an established protocol for the preparation of this study. For this, we used the following: author, year, location, design, sample, age, used tests and results. The search performed by descriptors and free terms revealed 259 articles in pre-established database. In Pubmed search resulted in 187 studies and 67 in Web of Science. Of the total, 161 were excluded by the title and abstract and 36 by reading the full text. This allowed the analysis of 11 articles. It was observed that children with impairments in language development showed lower performance in auditory tests, compared to those with typical development.

Keywords: Auditory Perception; Hearing Tests; Language Development Disorders; Language; Language Tests

RESUMO

Há interdependência entre os processos auditivos e de linguagem, e o bom desempenho de um deles contribui para o adequado funcionamento do outro. O objetivo do presente artigo foi realizar uma revisão de literatura baseada em estudos nacionais e internacionais de forma sistemática. Tal revisão buscou verificar a relação entre alterações do processamento auditivo e alterações de linguagem. A pesquisa bibliográfica utilizou como bases de dados Pubmed e *Web of Science*, no período de maio a junho de 2014. Os critérios de inclusão utilizados foram: artigos que respondiam à pergunta norteadora e atendiam à temática estabelecida pelos descritores. Excluíram-se os estudos com animais, laboratoriais, artigos de opinião/autoridade, série de caso e relato de caso. A escolha dos artigos se deu por meio de um protocolo criado para a elaboração do presente estudo. Para isto, utilizaram-se os seguintes aspectos: autor, ano, local, delineamento, amostra, faixa etária, testes utilizados e resultados. A busca realizada por meio de descritores e termos livres revelou 259 artigos nas bases de dados pré-estabelecidas. Na Pubmed a pesquisa resultou em 187 estudos e 67 na *Web of Science*. Do total, 161 foram excluídos pelo título e resumo e 36 pela leitura do texto completo. Isso possibilitou a análise de 11 artigos. Foi observado que crianças com prejuízos no desenvolvimento linguístico apresentaram desempenho inferior nos testes auditivos, quando comparadas àquelas com desenvolvimento típico.

Descritores: Percepção Auditiva; Testes Auditivos; Transtornos do Desenvolvimento da Linguagem; Linguagem; Testes de Linguagem

INTRODUCTION

Auditory processing is the ability of the Central Nervous System to receive, process and interpret sounds[1]. The proper development of this ability depends on factors such as the preservation of the peripheral hearing, the neurobiological maturation, environmental stimuli and cognitive skills, such as attention, memory and language[1-3]. The impairment of some of these aspects (or several of them together) can impair the physiological processing of sounds and lead to disorders of the auditory skills such as attention, discrimination, recognition and comprehension of the information[4].

On the other side, language constitutes the human ability to combine conventional symbols in order to transmit and understand information[5]. For that, the interaction of the environmental influence, biological processes and various cognitive and auditory skills is also decisive[4,6,7]. Otherwise, the language development will occur in an atypical way.

According to these considerations, it can be concluded that there is a relationship between the auditory and the language processes, and that the good performance of one of them contributes to the proper functioning of the other[4,8]. Therefore, the study of these aspects is of utmost importance for the understanding of their relationship. In addition, as the present study intends to raise studies that verify the relationship between language and auditory processing disorders, support is provided for health promotion strategies, guidance of family members and treatment planning.

The purpose of this study was to make a literature review based on national and international studies in a systematic way. Such review was made to verify the relationship between language and auditory processing disorders.

METHODS

This is a systematic literature review based on national[9,10] and international[11] recommendations, which sought to answer the following question: "Which is the relationship between language and auditory processing disorders?".

The bibliographic search used as databases: Pubmed and Web of Science, from May to June 2014. DeCS (Descriptors in Health Sciences), and terms of the MeSH (Medical Subject Headings) of the National Library of Medicine were combined by the Boolean operators AND and OR. Thus, the following cross checks in English, Portuguese and Spanish were made: ("Auditory Perception" OR "Percepción Auditiva" OR "Percepção Auditiva" OR "Hearing Tests" OR "Pruebas Auditivas" OR "Testes Auditivos" OR "Processamento Auditivo" OR "Auditory Processing") AND ("Language Development Disorders" OR "Trastornos del Desarrollo del Lenguaje" OR "Transtornos do Desenvolvimento da Linguagem) and ("Auditory Processing" and "Phonological Awareness"); descriptors and free terms, respectively.

Regarding the selection criteria, two researchers independently searched for articles according to the inclusion and exclusion criteria. The texts with different answers of the researchers were grouped in a table presented later to a third appraiser in order to resolve the points of disagreement. Articles published in the last five years, i.e., from 2010 to 2014, were selected.

The inclusion criteria were: articles that answered the guiding question and were found through the descriptors used. Studies with animals, laboratory studies, opinion/authority articles, case series and reports, and cross-sectional studies were excluded[11].

In the Pubmed database, filters related to species (humans), language (English, Portuguese and Spanish) and year (2010-2014) were used. No filters were used in the Web of Science.

The data analysis was initially made through titles and abstracts of articles. Then, the full text of the selected articles was read. Only studies within the established criteria were used for the review.

The selection of articles was made through a protocol created for the elaboration of this study. For that, the following aspects were used: author, year, place, design, sample, age group, used tests and results. The data were summarized in a table in order to better visualize the results.

LITERATURE REVIEW

The search through free descriptors and terms revealed 254 articles in the pre-established database, 187 from Pubmed and 67 from Web of Science. Of the total, 156 were excluded by the title and abstract and 87 by the reading of the full text. This enabled the analysis of 10 articles.

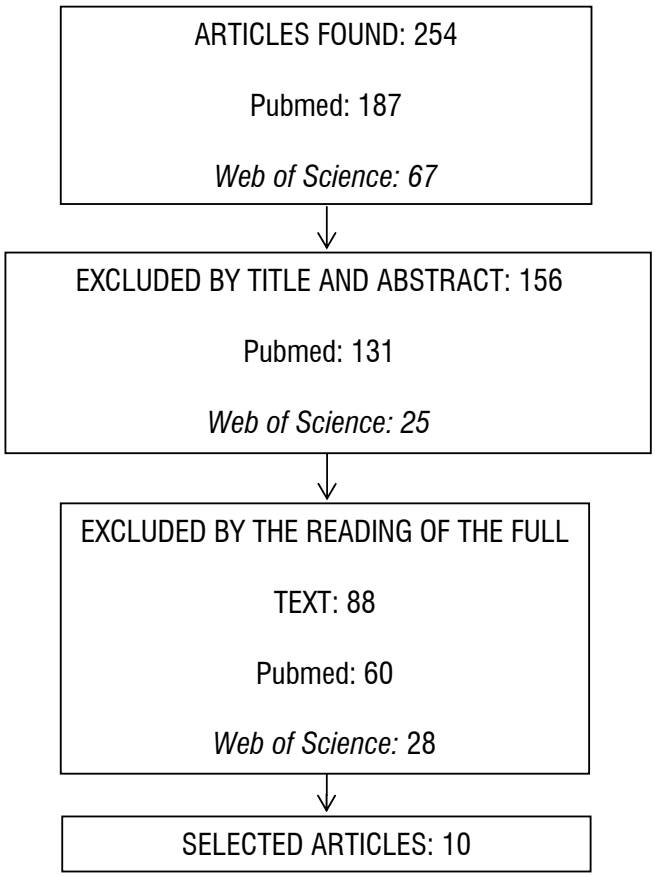

Figure 1. Flowchart with articles found and selected after analysis and application of inclusion and exclusion criteria

As a wide variety of designs and criteria used for the elaboration of the results was found in the selected studies, such as sample, age group and used tests, it was not possible to make a statistical analysis. However, valid reflections can be drawn from this review.

Most of the selected articles were published in 2010, 2012 and 2013. No publications were found in 2011 and 2014.

Brazil and the United States were the countries with the largest number of selected studies related to the question of the review. The researches carried out in these countries, along with those of Mexico, highlight the predominance of studies that address this theme in the American continent. The other countries are located in Europe.

Regarding the design, the authors of the articles used in this review showed the need to make a comparison between typical and atypical development. It was made through the distribution of the population in groups of individuals with typical development and those with language or auditory processing disorders, or language and auditory processing disorders. Therefore, the most commonly used design was control case. In addition, cohort, literature review and experimental type studies were found.

The samples of the selected studies had at least 20 and at most 88 individuals, and all selected studies were conducted with children and adolescents aged 3 to 13 years. The fact that these samples are composed of such age group suggests the importance of considering the maturation of the Central Nervous System in language and auditory processing studies. Most language and auditory processing disorders are identified in the childhood, as it is during this phase that the maturation of the Central Nervous System occurs[2,22,23] .

In addition, this age group comprises the inclusion of the children in school, when linguistic and auditory demands increase. Thus, the difficulties become more evident, both for the professionals involved in the educational institution as for the health professionals[24,25].

The selected articles presented a wide range of tests that assess language and auditory processing, and their selection was done according to the purpose of the study. Regarding the auditory processing tests, it was observed that the Staggered Spondaic Word – SSW[20,21] and Speech in Noise[15,19] were the most used tests. The Pediatrics Speech Intelligibility – PSI[19], Dichotic Digit[18,19], Frequency Standard[12] and Simplified Evaluation of Auditory Processing – ASPA[18,19] tests were also frequently used. Regarding the language tests, the Phonological Awareness Test[20] was the most used.

The predominant use of SSW and Speech in Noise tests demonstrates the interest of the authors in the further investigation of the binaural integration and auditory closure skills, respectively. Both are extremely important in the language development, especially with regard to reading and writing learning. It occurs in the school, frequently with a noisy environment that requires the proper functioning of these skills[4].

The fact that the Phonological Awareness Test is the most widely used may be related to its importance to the development of language. The acquisition of phonological awareness enables the development of oral language, communication, reading and writing[26]. A deficit in the mental organization and representation of speech sounds leads to alterations in the processes of perception, analysis and conscious manipulation of syllables[27].

The results varied according to the objectives and selected variables of the studies, but most of them showed the relationship between language and

Table 1. Results of the selected studies according to the variables analyzed

Author	Year	Place	Design	Sample	Age group	Used tests	Results
Murphy PC-Ruiz, Penaloza YR-Lopez et al.[12]	2013	Mexico	Control Case	40 children. 20 with typical development and 20 with developmental dyslexia.	Children aged between 7 and 11 years.	Informal assessment of reading and writing, Frequency Standard, Duration Standard, Environmental Sound and Music Test.	Children with developmental dyslexia showed lower performance than children of the control group in all auditory processing subtests.
Schwartz RG, Scheffeler FLV, Lopez K.[13]	2013	USA	Control Case	25 children. 12 with specific language disorder and 13 with typical development.	Children aged between 6 and 9 years.	Questionnaire for the parents, auditory screening and Nonverbal Intelligence	Perceptual deficits related to language disorders suggest alteration in cognitive-linguistic factors and not in auditory processing.
Heim S, Keil A, Choudhury N et al.[14]	2013	USA	Experimental	33 children. 21 with language learning disabilities and 12 with typical development.	Children aged between 6 and 9 years.	Electroencephalogram, Electrophysiological Assessment of Hearing Events.	Aspects of ineffective sensory cortical processing in children with language learning disabilities are improved after treatment.
Vandewalle E, Boets B, Ghesquière P, Zink I.[15]	2012	Belgium	Control Case	32 children. Group case 1: 8 with specific language disorder and literacy delay. Group case 2: 10 with specific language disorder and normal literacy. Control group: 14 with typical development and literacy.	6 years	Frequency modulation, Gap Detection Channels, Test Method for Auditory Processing Tasks, Speech in Noise, Categorical perception, Phonological Awareness, Short-term Verbal Memory, Rapid Automatized Naming, Reading, Standard Orthographic Realization, Productive and Receptive Oral Language.	Group case 1: worst performance in speech perception, but not in temporal auditory processing. Group case 2 and Control group: no difference regarding speech perception and auditory processing.
Vandermosten M, Boets B, Luts H et al.[16]	2010	Belgium	Control case	38 children. Group case: 13 dyslexic. Control group: 25 with typical development	11 years	Temporal and non-temporal contrasted speech and temporal and non-temporal non-contrasted speech	Group case: children with less consistent sound classification (of speech or not).
Muluk NB, Yalçinkaya F, Keith RW.[17]	2010	Turkey	Control case	22 children. Group case: 12 with early language delay and speech sound distortion. Control group: 10 with typical hearing, phonological development and language.	5 to 13 years	Scale-4 of Preschool Language, CELF-4, SSDT, RGDT.	Group case: highest average with statistical significance, of Gap Detection Thresholds in all frequencies: 500Hz, 1000Hz, 2000Hz e 4000Hz.
Attoni TM, Quintas VG, Mota HB.[18]	2010	Brazil	Control case	46 children. Group case: 22 with phonological disorders. Control group: 24 with typical speech development.	5 to 7 years	SSW, Dichotic Digit, Simplified Evaluation of Auditory Processing and Phonemic Discrimination Test with Figures.	Group case: lower results in all tests performed.
Attoni TM, Quintas VG, Mota HB.[19]	2010	Brazil	Control case	46 children. Group case: 22 with phonological disorders. Control group: 24 with typical speech development.	5 to 7 years	Simplified evaluation of auditory processing, Digit dichotic, Speech in noise, SSW, PSI, Phonological Evaluation of Children and evaluation of the acoustic reflex.	SSW - Group case: high levels of exchanges and omissions and longer time to respond in the SSW. Digit dichotic – Group case: values outside the normal range. Relationship between acoustic reflex and severity of the phonological disorders: values with significance.
KH Corriveau, U Goswami, JM Thomson.[20]	2010	USA	Coorte	88 children	3 to 6 years	Auditory processing, Phonological awareness, Reading skills and General skills.	There is a relationship between early acquisition of auditory sensitivity and development of phonological awareness skills, especially rhyme.
Loo JHY, Bamiou DE, Campbell N et al.[21]	2010	England	Literature review	16 articles	–		Auditory training programs: little effect on language, spelling and reading skills. Relationship with phonological awareness skills.

auditory processing disorders. Children with language disorders presented lower performance in the auditory tests compared to those with typical development. This finding may be explained by the fact that language and hearing development occurs simultaneously and they are interdependent[2,28].

The study of Murphy-Ruiz, Penaloza-López et. al[12] showed that children with developmental dyslexia presented lower performance than children with typical development in all auditory processing tests. Such evidence corroborates the literature, as children with language disorders present alterations in the phonological processing related to an auditory processing disorder, in other words, children with dyslexia present changes in auditory skills[29].

In addition to original articles, a literature review with a sample of 16 articles, published in England in 2010 was found. The research reveals that the auditory training used in the studies had little effect on the language skills, therefore a strong relationship between language and auditory processing disorders could not be established. Although the language skills depend on the integrity and maturation of the Central Nervous System, the establishment of a relationship with auditory processing disorders requires studies with strong scientific designs, i.e., that enable higher level of scientific evidence, such as randomized clinical trials.

Through the analysis of the results of each article included in the review, in children with language disorders, the occurrence of changes in auditory tests involving temporal processing, dichotic hearing and speech perception can be verified. In addition, there was an association between auditory processing disorders with cognitive-linguistic factors and tasks involving phonological awareness.

CONCLUSION

This study showed that most of the research conducted in the last five years, published in the PubMed and Web of Science databases, revealed an association between language and auditory processing disorders. It was observed that children with language development disorders have lower performance in the auditory test compared to those with typical development.

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