

# Impact of the central auditory processing disorder on children with phonological deviation: a systematic review

Eduarda Anzolin Pereira<sup>1</sup> , Laura Faustino Gonçalves<sup>1</sup> , Ana Paula Blanco-Dutra<sup>1</sup> ,  
Karina Mary de Paiva<sup>1</sup> , Janaina Viana Stolz<sup>2</sup> , Patrícia Haas<sup>1\*</sup> 

## INTRODUCTION

The phonology acquisition process requires the acquisition and organization of sounds, in addition to the normal functioning of the structures of the oral myofunctional system as well as the auditory and central nervous systems. The correct sound production process occurs around the age of 5; however, this does not occur satisfactorily for some children, resulting in phonological deviations<sup>1</sup> in which the distinctive features of the sounds are not jointly achieved<sup>2</sup>.

Central auditory processing (CAP) refers to the capacity and efficiency of the central nervous system to use auditory information<sup>1</sup>. Its functions are noted by the ability to locate the sound source, focus, discriminate, recognize, and/or understand auditory stimuli. To fulfill these functions, it is necessary that the auditory structures, related to the central and peripheral auditory systems, are preserved. If this does not occur, alterations in auditory processing (AP) skills can be occur, causing problems in receiving, analyzing, and organizing auditory information<sup>3</sup>.

Difficulties in oral language may be associated with AP disorders, since hearing is an essential entry point for its acquisition. Central auditory processing disorder (CAPD) can be defined as a group of complex and heterogeneous alterations that are related to hearing and learning difficulties, with normal peripheral hearing<sup>2</sup>.

The present study aims to characterize, through a systematic literature review, the impact of CAPD in children with phonological disorders, in order to answer the following research question: What is the impact of central hearing processing disorder in children with phonological disorders?

## METHODS

### Protocol and registration

This systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses recommendations<sup>4</sup>. Searches for scientific articles were reported by two independent researchers in electronic databases (PubMed, CAPES, SciELO, LILACS, BIREME, MEDCARIB), between 2010 and 2020, without time and location restrictions. The search was conducted in December of 2020. The gray search used the same strategy and was performed using Google Scholar. The survey was structured and organized in the form PICOS, an acronym for the target population, intervention, comparison, outcome (outcomes), and study (Table 1).

**Table 1.** Description of the PICOS components.

Acronym	Definition
P	Children
I	Central auditory processing
C	Phonological disorder
O	Impact
S	Cross-sectional studies Observational studies Case reports Case-control studies Controlled clinical trials Cohort studies

Source: Developed by the authors.

<sup>1</sup>Universidade Federal de Santa Catarina – Florianópolis (SC), Brazil.

<sup>2</sup>Universidade Federal de Pelotas – Pelotas (RS), Brazil.

\*Corresponding author: [patricia.haas@ufsc.br](mailto:patricia.haas@ufsc.br)

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## Research strategy

The descriptors were selected from the medical subject heading terms dictionary. For the searches, the following descriptors and Boolean operators were used: (central auditory processing therapy) and (phonological disorder therapy).

## Eligibility criteria

Studies without language and location restrictions were included between 2010 and 2020. The admitted study obtained a score of 12 in the modified protocol by Pithon et al.<sup>5</sup> to assess their quality.

## Data analysis

Data extraction for the study eligibility process was performed using a specific form prepared by two researchers in Excel® Program, in which the extracted data were added by one of the researchers and then checked by another researcher. Initially, they were selected according to title; then, the abstracts were analyzed, and only those that were potentially eligible were selected. Based on the abstracts, articles were selected for full reading, those that met all the predetermined criteria designed for this research were admitted.

## Method of selection of the studies

Initially, the eligibility reviewers (LFG, EAP) were calibrated to carry out a systematic review by PH and KMV. Those that presented a title within the scope, but abstracts were not available, were also obtained and analyzed in full. Studies outside the preestablished scope, case reports, letters to the editor and/or editorial, literature reviews, indexes, abstracts, and studies on animals were excluded. Subsequently, the full texts of the preliminary eligible studies were obtained and evaluated.

## RESULTS

The results obtained in this research and presented in Figure 1 highlight that exclusions were carried out due to duplicity, title, abstract, and complete reading. At the end of the selection process, the study was considered adequate for all eligibility criteria. The type of study included in this analysis was a clinical experimental study.

## Study characteristics

The study included<sup>6</sup> 21 patients (both sexes) diagnosed with phonological disorder, aged between 7.0 and 9.11 years. According to the results of the CAP assessment, 10 subjects without CAPD were allocated to the control group (CG) and 11 subjects with CAPD to the study group (SG). All participants were Brazilian Portuguese speakers. As inclusion criteria, the child needed to have speech errors in the phonological test

and adequate performance for age in the vocabulary, fluency, and pragmatic assessments of the ABFW Child Language Test.

Severity indices were calculated from percentage of correct consonant (PCC) and corrected-revised consonant percentage index (PCC-R); the number of different types of phonological processes; and the occurrence of each process. The phonological processes analyzed were Syllable Reduction (RS), Consonant Harmony (HC), Fricative Plosive (PF), Posteriorization to Velar (PV), Posteriorization to Palatal (PP), Velar Frontalization (FV), Palatal Fronting (FP), Liquid Simplification (SL), Simplification of the Consonant Meeting (SEC), Final Consonant Simplification (SCF), Sound of Plosiva (SP), Fricative Sound (SF), Plosive Deafening (EP), and Fricative Deafening (EF). For the evaluation of the CAP, identification tests of figures with white noise, dichotic digits test, frequency pattern test, and duration pattern test were used. The criterion for identifying CAPD in the tested subjects was the presence of alterations in at least two of the four tests administered<sup>6</sup>.

## Auditory processing, phonological processes, and deviation severity

In the analysis performed by sex in both groups, it was noted that most subjects were male, both in the CG (7) and SG (8). Regarding the number of different types of phonological processes in the phonological tests, the results showed that the SG participants used, on average, four types of phonological processes in each test. On the other hand, CG participants used an average

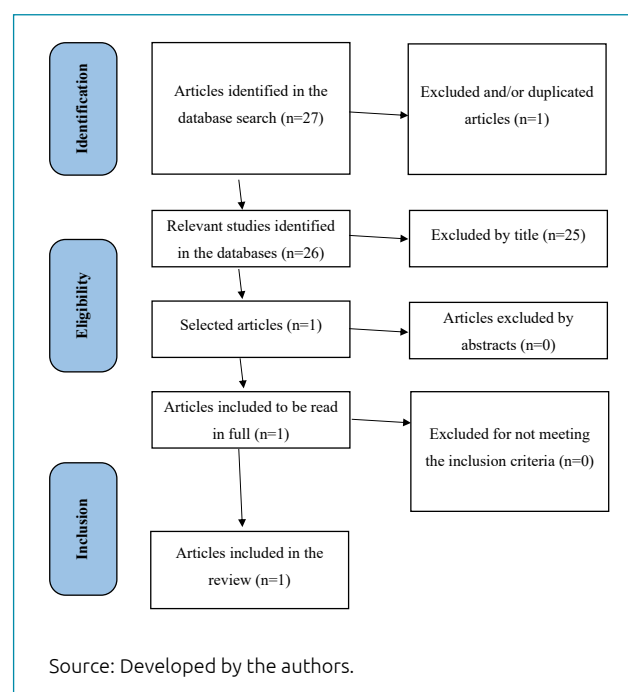


Figure 1. Flowchart of the article search and analysis process.

of three types of phonological processes. Although the SG had a higher mean number of phonological processes regardless of the phonological test, this difference was not significant in relation to word imitation or picture naming. The phonological processes that presented the highest occurrence were EP, EF, SL, and SEC. The distributions of these processes were compared between the two groups (CG and SG), with a difference only found for SEC in the word imitation test, indicating a higher occurrence of this process in the SG. Thus, the group with AP disorder (SG) had a greater severity of phonological disorders<sup>6</sup>. The information regarding the selected studies is presented in Table 2.

## DISCUSSION

Individuals with CAPD) have some characteristic behaviors, such as alterations in oral communication or in the use of grammatical rules; inversions of graphemes; alterations in the notion of laterality, agitation, hyperactivity, or apathy; impaired auditory memory; and difficulty in understanding an acoustic message in noisy environments<sup>7</sup>. Furthermore, substitutions in oral production involving the phonemes /r/ and /l/ and difficulties in understanding reading are also manifestations found in individuals with CAPD, which may be related to phonological, learning, and language problems resulting from problems in the processing of acoustic stimuli<sup>8</sup>.

For the evaluation of the CAP, identification tests of figures with white noise, dichotic digits test, frequency pattern test, and duration pattern test were used. The criterion for identifying CAPD in the tested subjects was the change observed in at least two of the four tests administered<sup>6</sup>. One study<sup>9</sup> compared a group of children with and without speech sound disorder (SSD) who underwent a temporal processing test and found altered results in most children with SSD. Regarding the group

without DF (phonological deviation), the results were within the normal range in most individuals<sup>9</sup>.

Individuals who have language disorders may have deficits in temporal processing, manifested by limited abilities to identify brief phonetic elements in specific speech contexts and poor performance in identifying or sequencing short-term stimuli presented quickly<sup>10</sup>. Regarding the analysis by gender, it was observed that most individuals were male, both in the CG (7) and SG (8)<sup>6</sup>. Some studies<sup>11-14</sup> have confirmed the prevalence of phonological disorders or other speech and/or language disorders in men. Regarding age, the admitted study<sup>6</sup> included individuals aged between 7 and 9 years, and four phonological processes were found for each SG and CG. One study<sup>15</sup> sought to analyze the occurrence, types, and average of phonological processes in subjects with phonological disorder, with and without a history of otitis media, and found that, on average, three phonological processes were found for each group.

Another study<sup>7</sup> pointed out the interference of neural maturation in the performance of AP tests, which included individuals from 8 to 10 years of age, and indicated that they can perform better in the 10-year-old range. As in a study<sup>16</sup> carried out with children aged 7–12 years, the authors observed that the performance on the tests was better according to the increase in age of the individuals. According to the study of Simon and Rossi<sup>17</sup>, who carried out a survey with individuals aged 8–10 years, the difference in their performance in AP tests was statistically significant and was considered positive, as it indicates the test's ability to assess the maturation of the central auditory nervous system.

Regarding DF and CAP abilities, the authors<sup>18</sup> pointed out that children with deviant speech show poor performance in relation to children without DF, with the main deviant abilities being temporal resolution, location, memory for sounds in sequence, figure-background, and auditory closure. Furthermore,

Table 2. Síntese dos artigos incluídos.

Author/year/ Place of publication	Objective	n	Method	Results	Conclusion
Barrozo et al. <sup>6</sup> , 2016 Brazil	To study phonological measures and auditory processing in children with phonological disorders.	21	Clinical and experimental study with 21 subjects with phonological disorder, between 7.0 and 9.11 years old, separated into two groups: with and without auditory processing disorder. Phonology, speech inconsistency, and metalinguistic skills tests were evaluated.	The group with auditory processing disorder showed greater severity of phonological disorder.	The comparison of the performance of the tests evaluated in the two groups showed differences regarding some phonological and metalinguistic aspects. Children with an index value above 0.54 showed a strong tendency to present alterations in the auditory processing, and this measure was effective in indicating the need for evaluation of children with phonological disorders.

studies<sup>19,20</sup> indicate that conductive hearing loss caused by recurrent otitis media can be a risk factor for the development of CAPD, which will consequently have negative impacts on language acquisition and development.

## CONCLUSION

It can be concluded that CAPDs have an impact on children with phonological disorders, as the studies found in this study corroborate the idea that these individuals have greater losses in AP tests, indicating a close correlation between the two,

demanding greater attention for this population, and highlighting the need for assessments in children with phonological disorders and subsequent auditory training.

## AUTHORS' CONTRIBUTIONS

**EAP:** Conceptualization, Data curation. **LFG:** Formal analysis, Investigation, Methodology. **PH:** Methodology, Visualization. **APBD:** Project administration, Writing – review & editing. **KMP:** Supervision, Writing – original draft. **JVS:** Validation.

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