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PERCEFAL: an instrument to assess identification of phonological contrasts in Brazilian Portuguese

PERCEFAL: instrumento de avaliação da identificação de contrastes fonológicos

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ABSTRACT

Introduction: There is a growing interest of researchers in instruments designed for assessment of speech perception. **Purpose:** To develop an instrument to perceptual identification of phonemic contrasts in the Brazilian Portuguese for children over 4 years of age. **Methods:** The construction of the instrument involved four procedures: a) design of the experimental task; b) stimuli selection which constituted the instrument; c) operationalization of the test; and d) establishing the analysis criteria. It was used a computer attached to a headphone and PERCEVAL software. **Results:** The proposed instrument comprises a subset of four experiments that evaluate separately the identification of contrasts between vowel segments and between stops consonant segments, fricative and sonorant consonant segments. The test presents includes three stages: word recognition stage, training stage and testing stage, with an approximate 15-minute overall duration. The analysis of children's auditory perceptual performance is carried out based on three criteria: accuracy, reaction time and pattern of phonic contrasts identification, being recorded following a specific protocol. **Conclusion:** Studies that have used the PERCEFAL in their methodology have reported a low percentage of non-response by children (between 2 and 5%), which indicates that the task is appropriate for its purpose. It is encouraged the use of the instrument in different regions of the country in order to inquire not only its applicability, due to the existing linguistic diversity in the country; but also, to determine its sensitivity and specificity.

Keywords: Speech perception; Phonetic; Child

RESUMO

Introdução: Verifica-se um crescente interesse de pesquisadores por instrumentos designados para avaliação da percepção da fala. **Objetivo:** Construir um instrumento de identificação perceptual de contrastes fônicos do Português Brasileiro para crianças a partir de 4 anos de idade. **Métodos:** A construção do instrumento envolveu quatro procedimentos: a) delineamento da tarefa experimental; b) seleção dos estímulos que constituíram o instrumento; c) operacionalização do teste; d) estabelecimento dos critérios de análise. Foi utilizado um computador acoplado a um fone de ouvidos e o *software* PERCEVAL. **Resultados:** O instrumento proposto compreende um subconjunto de quatro experimentos que avaliam, separadamente, a identificação de contrastes entre segmentos vocálicos e entre segmentos consonantais oclusivos, fricativos e soantes. O teste envolve três etapas: fase de reconhecimento de palavras, fase treino e fase teste, com duração total de 15 minutos, aproximadamente. A análise do desempenho perceptivo-auditivo das crianças é feita a partir de três critérios: acurácia, tempo de reação e padrão de identificação dos contrastes fônicos, sendo registrada em um protocolo específico. **Conclusão:** Estudos que têm utilizado o PERCEFAL em sua metodologia reportam baixa porcentagem de não resposta por parte das crianças (entre 2% e 5%), o que indica que a tarefa mostra-se apropriada para a sua finalidade. Encoraja-se o uso do instrumento nas diversas regiões do país, para averiguar, não somente sua aplicabilidade, dada à diversidade linguística do país, como também para verificar sua sensibilidade e especificidade.

Palavras-chave: Percepção da fala; Fonética; Criança

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INTRODUCTION

Part of the phonological system of a language is composed of the distinction of sounds that the speakers perceive and produce. The distinctions of sounds of a language are marked by a series of acoustic properties (duration, intensity, spectral characteristics, etc.), which integrate to constitute a phonological contrast[1].

The acquisition of a phonological contrast involves, according to this perspective, the domain of relevant acoustic properties that differentiate two phonemes, using them contrastively in their production. Consequently, it is assumed that the construction of the phonological system of a language is directed, to some extent, by the detection of properties of the segments, used in a contrastive mode. In other words, as far as children begin to notice that two segments are used contrastively in their language, the acoustic properties that differentiate these two segments will also be integrated into their grammar.

However, the mere presence of phonic distinctions in the linguistic *input* is not enough for that they are acquired by children[2]. On the other hand, in order to detect that two sounds are used contrastively in his/her language, the learner must be able not only to discriminate between these two sounds, but also to identify or categorize them from a perceptual-auditory point of view.

The discrimination ability refers to the ability to perceive a difference between two sounds, in which the categorization of the sounds in question is not required from the listener, in other words, the comparison between sounds is made in *presentia*[3]. For example, from at least two stimuli presented, the subject must be able to detect whether they are the same or different. Already the ability to identify or categorize sound refers to the ability to organize sound patterns consistently into their appropriated phonic categories. The required comparison, therefore, is made *in absentia*[3]. An example of a task involving the identification or categorization of a sound refers to the presentation of a single acoustic stimulus (usually prototypical), followed by the association between the presented stimulus and a corresponding picture or letter, or even of the verbalization on which the stimulus it was presented.

It is emphasized that the identification or categorization ability presupposes that some form of symbolic representation is already established (because the comparison is *in absentia*, in other others, between the presented stimulus and what is supposedly represented), and it is not possible to test it, for example, in babies. Differently, the discrimination ability does not presuppose this condition because it involves the ability to detect differences between at least two presented stimuli.

Assessing discrimination and identification abilities in children is not an easy task since they do not always collaborate or are accessible and available to participate in research[4]. Although these difficulties, great advances have been achieved in the comprehension about the development of the perceptive-auditory abilities of children, due to the development of methods and techniques for this purpose[5].

Researches on very young children (usually babies) tested the perceptual-auditory abilities (especially the discrimination ability of sound patterns) from, fundamentally, the observation and/or measurement of rudimentary motor responses and physiological changes, such as non-nutritive sucking pattern, heart rate, cortical activation patterns and head movement change (this last one for children over 6 months). The most commonly used measure to assess the perceptual-auditory ability of babies up to the 6th month is the non-nutritive sucking rate and amplitude, whereas for babies above that age it is the attention directed to the stimulus presented, along with the control of the head movement[4,6].

According to the child is growing, he/she becomes able to control the movements of his /her own body, thus allowing the use of protocols involving volitional action.

Two protocols commonly used to assess speech perception in young children (up to 1 year of age) involve attention control or selective visual fixation, or control of head movement toward the targets associated with speech[7]. The improvement of these measures has occurred due to the technological advance, such as the use of the *Eye-Traking* system, which allows to evaluate the velocity, direction and duration of the visual fixation of the child, before the presentation of the sound stimulus[8].

In the assessment of abilities related to the speech perception of older children, over 2 or 3 years of age, it was not only tested the capacity to discriminate sound patterns, but also the ability to identify them in appropriate phonic categories, recording the reaction time used by the child in the presentation of the response. The most commonly used method in the assessment of identification refers to the identification task of minimal word pairs, also nominated forced choice task[9].

However, there is a lack of instruments or protocols available to researchers to assess the perceptual-auditory abilities of children.

The national literature has few instruments with the aim of assessing abilities related to speech perception. Among the existing instruments, there are those directed, more specifically, to the assessment of speech perception abilities, such as sentence, word and syllable recognition in hearing impaired children[10,11,12] and only three instruments aimed to assess the ability to discriminate phonological contrasts[13,14,15]. Furthermore, it is worth noting the lack of instruments that assess the identification ability of phonic contrasts of the Brazilian Portuguese (BP).

Therefore, the purpose of the present study was to create and make available an instrument that assesses, in children over 4 years of age, the ability to identify the phonological contrasts in the BP. The age chosen is justified by the fact that, at this age, children already have their phonological system practically acquired, especially with respect to fulfillment the simple syllable onset.

METHODS

The procedures used to elaborate the identification instrument of the phonemic contrasts in the BP comprised four distinct stages: delineation (design) of the experimental task; stimuli selection; operationalization of the identification test and establishment of the analysis criteria.

Delineation of the experimental task

Considering that the identification ability involves the comparison in absentia, in other words, after the presentation of a single sound stimulus it is expected that the individual compares it, supposedly with its respective representation, indicating or verbalizing its appropriate category, sought an experimental task involving such ability.

Based on a classic study[16], it was decided to use an identification task involving minimal pairs (also known forced choice task) to assess the identification of phonemic contrasts in the BP.

The identification task of minimal pairs involves the concomitant or almost concomitant presentation of two types of stimuli: visual and auditory.

In addition to the type of stimulus used in the development of the experiment, two very important aspects to be considered in the delineation of the experimental task are: the inclusion of demonstration items and the investigation of lexical knowledge of the stimuli by the children[15,17].

In the proposed instrument, it was included, not just the denominated "training" phase - demonstration items, in order to guarantee the comprehension of the task to be performed by the child - as well as a first stage, designated "recognition", to ascertain the lexical knowledge of stimuli.

Stimuli selection

In order to define the visual and auditory stimuli that would constitute the instrument, first, minimal word pairs (minimum pairs of words) that were contrasted to the phonemes of BP were listed.

The selection of the words was performed according to the following criteria: contrast the phonemes of BP, in order to compose minimal word pairs (minimum pairs of words), preferably in accented syllables; be represented by means of picture; be preferably paroxytone nouns and belong to children vocabulary.

Instead of combining all vowel and consonantal phonemes with each other, it was chosen to separate the possibilities of combination of the phonemes into four major classes: contrasts between vowel segments and between stops consonantal segments, fricative, and sonorants segments, resulting in a subset of four experiments.

Once the words of the experiments were defined, recordings were made with high fidelity equipment inside an acoustic booth with a typical adult speaker of BP.

The adult was requested to produce the target words within a vehicle phrase ("Speak *target word* to him") in order to avoid the characteristic upward curve of the production obtained by means of isolated repetition of words.

At the end of the recordings, with the use of PRAAT software[18], the minimal pairs were extracted from the vehicle phrase.

The recordings were judged by three judges, who should to perform the phonetic transcription of each one of them. All words obtained 100% accuracy in the judges' judgment, constituting the auditory stimuli of the experiments.

Concurrently to the edition of the audio files, it was selected pictures corresponding to each word, from the site http://images.google.com.br/, in the public domain. With the support of the Paint software, the pictures were cut and edited in order to standardize them, resulting, in this way, in the visual inputs of the experiments.

Operationalization of the Identification Test

Once defined the type of task (identification of minimal pairs, or forced choice), the nature of the stimuli, the inclusion of demonstration items (test training phase) and inspection of the lexical items of the experiment (recognition phase), it was defined the operationalization of the task, in other words, the presentation form of both the visual and auditory stimuli, as well as the presentation interval between each of them.

Due to the technological advances, the methods and techniques used in the speech perception experiments have also advanced, resulting in the availability of free software, with a user-friendly interface, for the execution of speech perception experiments.

In the literature, three software are used for this purpose: *Perception Evaluation Auditive&Visuelle* (PERCEVAL)[19], PRAAT (*Praat: doing phonetics by computer*)[18] and, more recently, *Testes/treinamentos de Percepção* (TP)[20].

It was decided to use PERCEVAL software[19] to perform the identification task, since it presents the following characteristics: it is free, with no cost to use; presents a user-friendly interface, allowing that the responses to be given by remote control, or computer keyboard, such as computer games widely used by children; enables to program a training phase before the test phase itself, in the attempt to guarantee the understanding of the task by children; allows the standardized control of the presentation time of the visual and auditory stimuli; measures the response-time of participants' responses; allows to program the random presentation of the stimuli to be tested; provides automatic storage of responses in individual files; allows the cancellation and restart of the experiment, if there is any intercurrence during the task.

In order that the identification experiment could be executed by the PERCEVAL software, it was necessary the elaboration of a script* (in programming language), defining each command/ stage of the experiment. The scripts of the experiments can be obtained by requesting the author of the study, by e-mail.

Analysis criteria

Once the experiments have been performed, it is proposed that the results obtained in the identification test are analyzed according to the following criteria: perceptual-auditory accuracy; mean of reaction time of the errors and correct answers and identification pattern of the contrasts, from the confusion matrix.

RESULTS

The proposed instrument – PERCEFAL - is an identification test, also known as forced choice test, involving minimal word pairs, which contrast the phonemes in stressed position, preferably.

The PERCEFAL is composed of a subset of four experiments: PERCivogais (evaluates the identification of the phonic contrast between the stressed vowels); PERCocl (evaluates the identification of the phonic contrast between the stops); PERCifric (evaluates the identification of the phonic contrast between the fricatives); PERCison (evaluates the identification of the phonic contrast between the sonorants).

Charts 1 and 2 present the set of words selected to compose each proposed experiment.

Auditory stimuli are natural stimuli, corresponding to the recordings of a typical adult speaker and judged with 100% accuracy by three judges. The visual stimuli correspond to the pictures edited from the site http://images.google.com.br/, in the public domain.

The test involves three stages: recognition, training phase and test phase, properly said.

The recognition stage consists in the presentation of the visual and auditory *inputs* to the child. For this purpose, all stimuli corresponding to words are presented using PowerPoint®, asking the child about his/her knowledge. After the child's familiarization with the inputs of the experiment, an inspection, in other words, a verification of the percentage of correct answers, in relation to the knowledge of the words, is performed. A criterion of 80% correct answers is adopted so that the children are taken to the training phase and, later, to the identification test, properly said.

The second stage of the instrument refers to the training phase. At this stage, the stimuli of the experiment are

Chart 1. Minimal word pairs in the PERCivogais and PERCoson

Contrasts between vowels	Minimal pairs	Contrasts between sonorant	Minimal pairs
/i/ - /e/	*bico – beco*	/m/-/n/	*mata-nata*
/i/ - /ɛ/	*vila – vela*	/m/-/ɲ/	*uma-unha*
/i/ - /a/	*pipa – papa*	/m/-/l/	*mata-lata*
/i/ - /ɔ/	*chique – choque*	/m/-/ʎ/	*comer-colher*
/i/ - /o/	*figo – fogo*	/m/-/r/	*fumo-furo*
/i/ - /u/	*lixo – luxo*	/m/-/R/	*mata-rata*
/e/ - /ɛ/	*feira– fera*	/n/-/ɲ/	*sono-sonho*
/e/ - /a/	*pera – para*	/n/-/l/	*nata-lata*
/e/ - /ɔ/	*feira – fora*	/n/-/ʎ/	*fina-filha*
/e/ - /o/	*seco – soco*	/n/-/r/	*caneta-careta*
/e/ - /u/	*seco – suco*	/n/-/R/	*nata-rata*
/ɛ/ - /a/	*berro – barro*	/ɲ/-/l/	*punho-pulo*
/ɛ/ - /ɔ/	*cheque – choque*	/ɲ/-/ʎ/	*pinha-pilha*
/ɛ/ - /o/	*beca – boca*	/ɲ/-/r/	*sonho-soro*
/ɛ/ - /u/	*fera – fura*	/ɲ/-/R/	*unha-urra*
/a/ - /ɔ/	*bala – bola*	/l/-/ʎ/	*vela-velha*
/a/ - /o/	*saco – soco*	/l/-/r/	*pulo-puro*
/a/ - /u/	*lava – luva*	/l/-/R/	*lata-rata*
/ɔ/ - /o/	*toca – touca*	/ʎ/-/r/	*alho-aro*
/ɔ/ - /u/	*coca – cuca*	/ʎ/-/R/	*colher-correr*
/o/ - /u/	*soco – suco*	/r/-/R/	*caro-carro*

Chart 2. Minimal word pairs in the PERCocl e PERCifric

Contrasts between stops	Minimal pairs	Contrasts between fricatives	Minimal pairs
/b/ x /t/	*berço-terço*	/f/-/v/	*faca-vaca*
/b/ x /k/	*bola-cola*	/f/-/s/	*fanta-santa*
/g/ x /b/	*gola-bola*	/f/-/z/	*forro- zorro*
/b/ x /p/	*bote-pote*	/f/-/l/	*fora-chora*
/b/ x /d/	*bucha-ducha*	/f/-/ʒ/	*faca-jaca*
/d/ x /g/	*danço-ganso*	/v/-/s/	*vela-sela*
/g/ x /t/	*guerra-terra*	/v/-/z/	*cavar-casar*
/p/ x /g/	*pato-gato*	/v/-/ʃ/	*veia-cheia*
/p/ x /d/	*pente-dente*	/v/-/ʒ/	*vaca-jaca*
/p/ x /k/	*porta-corta*	/s/-/z/	*caçar-casar*
/t/ x /d/	*tia-dia*	/s/-/ʃ/	*sapa-chapa*
/t/ x /p/	*torta-porta*	/s/-/ʒ/	*selo-gelo*
/k/ x /g/	*cola-gola*	/z/-/ʃ/	*rosa-rocha*
/k/ x /t/	*couro-touro*	/z/-/ʒ/	*zangada-jangada*
/d/ x /f/	*fada-faca*	/ʃ/-/ʒ/	*xis-giz*

*In this stage, we counted on the valuable contribution of the researcher Dr. Antônio Carlos Silvano Pessotti (UNICAMP), besides the availability of the manual (in Portuguese) elaborated by the researcher Dr. Rui Rhote-Neves (UFMG).

randomized and 10 presentations are selected, but the responses are not recorded by the software in a response file. The auditory stimulus is presented to the child through the headphone, and then, two pictures appear on the computer screen. The child should indicate what is the picture corresponding to the word presented.

Following the training phase, the test phase starts, properly said. At the test phase, all presentations of the stimuli are used, in a random mode, and the responses are recorded automatically by the software, in a response file.

Both phases are performed by PERCEVAL software. Both the presentation time of the auditory and visual stimuli, as well as the response time, are controlled and measured automatically by the software. The presentation time of the stimulus is approximately 6,000 ms, while the interval time stipulated for the child's response is 4,000 ms. If the child does not present a response pattern within the interval of 4,000 ms, it is considered absence of response. In contrast, when the child presents a response pattern, either correct answer or error, the time taken for decision making in the identification task is computed automatically by the software, and can vary from 0 ms to 4,000 ms.

The total duration of each one of the experiments, comprising the three stages, is approximately 15 minutes per child.

Application procedures

The materials required for the application of the instrument are: a connected computer, coupled to a headphone; The PERCEVAL software installed, and the PERCEFAL files (script, stimuli folder, and responses folder) saved in a directory.

In order for the experiments can be performed, firstly the interested persons (researchers and/or clinicians) must download the PERCEVAL software (following the software installation instructions). In addition, they should save in a directory, for each one of the experiments, three distinct folders: the first, named as *stimuli*, in which all the auditory and visual stimuli must be saved; The second, named as a *script*, containing the script corresponding to the experiment and the instruction file, and finally a third folder, called *response*, so that the response files are saved automatically.

Before beginning the stages of the instrument to assess the identification of phonological contrasts with the child, it is recommended to leave the experiment exposed on the computer screen. Therefore, it must open the PERCEVAL software and select the option: *configure and run an experiment*. In the sequence, a screen will appear where the user should choose the corresponding folders. In addition, the name and surname of the subject to be assessed and/or other information considered relevant, such as age, medical record number, group to which him/her belongs (in the case of research), among other should be included.

After preparation of the experiment to be performed, the child is placed comfortably in front of the computer screen, inside a silent room or an acoustic booth.

The first phase of the instrument is started, concerning the stage of stimulus recognition. The stimuli corresponding to the words are presented to child, using PowerPoint®, asking the child about his/her knowledge. Phrases such as "what is this?", "Do you know this picture?" can be used at the moment of word recognition. In case the child does not demonstrate knowledge, or even presents any doubt, it is suggested that the evaluator teaches the meaning of the word in a contextualized manner. After the child's familiarization with the inputs of the experiment, an inspection is performed in order to verify the percentage of word recognition. A criterion of 80% correct answers is adopted so that the child is conduct to the training phase and, later, to the identification test itself. If the child does not reach this criterion, a more extensive work of word recognition is recommended.

The second stage of the instrument refers to the training phase. Before beginning this phase, it is necessary to explain the task to the child. After attaching the headphones to his/her ears, it is explained that he/she will listen a word through the earphone, and then two pictures will appear on the computer screen. He /she should indicate which the picture is corresponding to the word presented. After the explanation, the button that represents the "thumb up" signal is selected, so that the software starts the training phase.

Following the training phase, the test phase itself starts, with an interval of approximately 2 minutes of the training phase. At this stage, the child should listen to one of the words of the minimal pair through the earphones (with a binaural presentation at an intensity of 50 dB) and then decide and indicate which is the picture corresponding to the word presented aurally, between two possibilities of pictures arranged on the computer screen.

For example, in identification of the stops contrast between /p/ vs. /g/, it is presented aurally, at first, the word "pato", and immediately afterwards the pictures corresponding to the words "pato" and "gato" will be placed on the computer screen, so that the participant decides and indicates by pressing the corresponding *joystick* button or by pointing on the *touchscreen*, which of the pictures represents the presented auditory stimulus. At other moment in the round of the experiment, the word "gato" is presented aurally and, in the sequence, the pictures corresponding to the words "pato" and "gato" are again placed on the computer screen.

The stimuli selection relative to the analyzed contrasts is done in a random mode, by the PERCEVAL software itself.

Once the identification experiment of phonological contrasts with the child has been performed, its responses are automatically stored in individual files, in the txt extension. It is suggested to import the results arranged in the txt file into the Excel® file, in order to provide the quantification of the results, as well as the completion of the register protocol.

Register protocol

Initially, information about the participant and assessment date of each PERCEFAL experiment (PERCivogais, PERCocl; PERCifric and PERCison) (Appendix 1) is filled in, since the user can choose to perform the assessment of each phonic class in different days.

In the sequence, the child's performance is recorded in the first stage of the instrument, word recognition phase.

Finally, information concerning the third stage of the instrument is recorded - test phase itself, based on the following performance analysis criteria in the identification task: perceptual-auditory accuracy; mean of errors and correct answers at reaction- time; identification pattern of the contrasts, from the confusion matrix.

In PERCivogais, for example, 42 vowel contrasts (21 pairs) are evaluated, which corresponds to 100%. With the use of a rule of three, the respective percentages are identified, from the absolute number of correct answers, errors and non-answers.

In order to record the reaction time, it is suggested the extraction of the arithmetic mean of the errors and the correct answers at the reaction time (for example, sum of all the correct answers at reaction time are divided by the number of correct answers).

It is also proposed to analyze the identification pattern of the contrasts evaluated, based on the construction of a confusion matrix.

The first column of the matrix refers to the presented stimuli, while the other columns refer to the subject's responses.

Considering the PERCivogais, the decreasing diagonal line of the matrix refers to the perceptual-auditory accuracy of each one of the stressed vowels of BP, in other words, how many times a determined vowel was assertively recognized by the child, while the last line of the confusion matrix shows the information about the tendency of the child's response pattern.

In the PERCEFAL register protocol, the information about perceptual-auditory performance in the identification of phonic contrasts is recorded according to each experiment: PERCivogais, PERCocl; PERCifric and PERCison.

DISCUSSION

Delineation of the experimental task

The experimental task consisted of a minimal pair identification test, comprising three stages: recognition phase, training phase and test phase.

The word recognition phase was included in the experimental task, in order to verify and guarantee the knowledge and/or familiarization of lexical items by the children, in an attempt to avoid "errors" motivated by a lexical question, given the narrow relationship between perceptual-auditory performance and word knowledge[21].

Likewise, the inclusion of demonstration items - denominated training phase - was inserted to guarantee an understanding of the task to be performed by the child. Many tests make use of demonstration items before the test itself, to explain to children how they should proceed during the requested task[15,17].

The test phase consists of an identification task involving minimal pairs. This type of task was first used in a classic study[16], with 1-year-old children, to identify Russian phonological contrasts. The child was requested to point out what is the corresponding member, from a pair of objects arranged in front of him/her, to a presented auditory stimulus. For example, the child could point to "бак" ([ʻbak]) or "мак" ([ʻmak]) after having heard [ʻ bak].

Subsequent researches[22,23,24,25] do not only adapted the task proposed in this classic study, but also showed the validity of this experimental paradigm to assess the identification ability. Studies[24,25] that have used PERCEFAL in their methodology, report a low percentage of non-response by children (between 2% and 5%), which indicates that the task is appropriate for its purpose.

It is also worth noting that for the child to be able to perform a task that involves minimal pairs, he/she must not only be able to discriminate the distinctions of acoustic properties, but also to correlate these acoustic distinctions with a difference of meaning. It can be comprehended that, in terms of linguistic levels of *standard* representation, the identification task of minimal pairs accesses the phonological representation, while the discrimination task of sound patterns accesses phonetic representation[9].

Stimuli selection

Both auditory stimuli and visual stimuli were selected for the performance of the proposed instrument.

Regarding the choice of auditory stimulus, similarly to the classic study mentioned above[16], natural stimuli of speech production (recorded by a human speaker) were chosen instead of synthetic stimuli or acoustically manipulated stimuli (stimuli generated by a machine), since these can influence the performance of the categorization task, in other words, the more natural the stimulus the more categorically they are perceived [26]. It should also be highlighted that the three existing instruments for assessing auditory discrimination also use natural stimuli[13,14,15].

Regarding the visual stimuli, the pioneer study (16) used, as visual stimuli, pairs of objects (corresponding to the minimal word pairs), rather than pictures. However, as the proposed instrument aims at assessing the identification ability in older children, over 4 years of age, it was decided to use pictures corresponding to the minimal word pairs, rather than objects, such as in the two instruments of Auditory Discrimination: Auditory Discrimination Test, adapted from *The Boston*

University Speech Sound Discrimination Picture Test[14] and Test of Figures for Phonemic Discrimination[15].

The auditory and visual stimuli were listed according to the minimal word pairs that contrast the BP phonemes. Instead of combining all the vowel and consonantal phonemes among themselves, the possibilities of combination were divided into four major classes: contrasts between stressed vowels; contrasts between stops; contrasts between fricatives and contrasts between sonorants.

The separation in classes was motivated, fundamentally, by two aspects.

The first aspect refers to the fact that researches have consistently reported that perceptual-auditory accuracy in discrimination and identification depends on the phonic class[9,16,22,27]. In the pioneer study[16], for example, the author found that the performance of Russian-speaking children to identify certain contrasts tended to be better than others, proposing a perceptual-auditory acquisition order similar to that described for speech production.

The second aspect refers to the execution time of the experiment. If the 19 consonant phonemes in the BP were combined in syllabic onset, there would be 342 words in the experiment, or 121 contrastive pairs, by combinatorial analysis (19x18 = 342). This means that, it would be a time-consuming experiment to be carried out by children over 4 years of age.

On the contrary, when separating by classes, we have 42 words in the identification experiment of the stressed vowels (7x6); 30 words in the stops experiment (6x5); 30 words in the experiment involving the fricative contrasts and 42 words in the sonorant experiment (7x6). Thus, the time of each task is considerably diminished, thus avoiding fatigue and tiredness by the children.

Operationalization of the Identification test

Regarding the presentation of the stimuli in the existing national tests, some differences were observed in relation to the instrument proposed here. In the Auditory Discrimination Test[13], syllabic pairs are presented to the children through a tape recorder, without use of headphones, to standardize the presentations and avoid the use of visual cues resulting from the moment of speech production. In the Test of Figures for Hearing Discrimination[14] and Test of Figures for Phonemic Discrimination[15] the presentations of the minimal pairs are made in the speakerphone, and the evaluator must hide his /her mouth at the moment of speaking, to avoid the use of visual cues from the speech production process.

In relation to the presentation of visual stimuli, two of the existing instruments in the national literature that evaluate the discrimination ability of minimal pairs[14,15] present the pictures arranged in cards.

In relation to the time interval between the presentation of the visual and auditory stimuli, in none of the existing instruments who assesses the auditory discrimination there is any mention about the control of the presentation time or the reaction time of the children to respond to the proposed task.

Differently, in the international literature, the great majority of the studies on the phonological contrasts perception use some software, not only to standardize the time and the presentation form of the stimuli, but also to measure the reaction time of the subjects, thus evidencing the importance of considering this measure in the performance analysis of perceptual-auditory tasks[28,29].

Criteria for analysis

The perceptual-auditory accuracy refers to the response patterns accepted in the test: correct answer (when the child correctly identifies the stimulus), errors (when he/she does not correctly identify the auditory stimulus), and no response (when no response occurs during the time). Previous studies[22,27] have also used the accuracy to describe the child performance.

The reaction time used by the child refers to the time that she/he presents a response pattern. The reaction time may indicate the degree of similarity between phonological contrasts, as far as the higher the degree of similarity of phonological contrast, the longer the reaction time and vice versa, as described in a previous study[28]. Additionally, from the reaction time, it can be inferred whether the child is responding randomly or not. In previous studies[24,25], it was verified that the reaction time presented by the children in the errors is always greater than the reaction time in the correct answers, which led the authors to consider the non-randomness of the answers.

Finally, the confusion matrix, proposed in a previous study[30], aims to catalog quantitatively and qualitatively the perceptual-auditory performance of the children, providing information related to the more difficult and less difficult contrasts in the identification task, as well as the more frequent error pattern recurrent.

CONCLUSION

The use of the PERCEFAL instrument is encouraged in the various regions of the country, not only its applicability, given the linguistic diversity existing in the country, but also in order to verify its sensitivity and specificity.

It is believed that the proposed instrument can support researchers and clinicians in the investigation of the phonological contrasts perception in children, regarding the identification task, an ability of great importance in the phonological system acquisition and development.

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Appendix 1. PERCEFAL Protocol (PERCivogais)

I - Identification

Name: _____ Medical records:_____D.B (date of birth).: _____
Date of experiment: _____ Experiment: _____

II - Recognition phase – Inspection

Date: __/___/____

Experiments	Correct answers	%	Errors	%	Non-response	%
Stressed vowels						
Sonorants						
Stops						
Fricatives						

III - Test phase

3.1. Vowels Date: __/___/____

Perceptual accuracy		
Perceptual accuracy	nº	%
Number of errors		
Número de correct anwers		
Non-response		

Reaction Time		
Values	RT Correct answers	RT Errors
Mean (ms)		
Standard deviation		

Confusion matrix – Stressed vowels

Presented stimuli vs Responses	**/i/**	**/e/**	**/ɛ/**	**/a/**	**/ɔ/**	**/o/**	**/u/**	**Total**
/i/								6
/e/								6
/ɛ/								6
/a/								6
/ɔ/								6
/o/								6
/u/								6
Total								42