Original Article

Artigo Original

Perceptual-auditory and orthographic performance of fricative consonants in writing acquisition

Desempenho perceptual-auditivo e ortográfico de consoantes fricativas na aquisição da escrita

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Keywords

Auditory perception
Handwriting
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ABSTRACT

Purpose: To investigate the perceptual-auditory and orthographic performances of students regarding identification of contrasts among the fricatives of Brazilian Portuguese, and to investigate the extent to which these two types of performances are related. **Methods:** Data from perceptual-auditory and orthographic performances of 20 children attending the two first grades of elementary education at a public school in Mallet (PR), Brazil, were analyzed. Data collection regarding auditory perception was based on the Assessment Tool in Speech Perception (PERCEFAL), using the software Perceval. Data collection regarding orthography was carried out through dictation of the same words used in the assessment tool PERCEFAL. **Results:** We observed: more accuracy in perceptual-auditory than in orthographic skills; tendency of shorter response time and lesser variability in the perceptual-auditory hits than in the errors; mismatch of errors in orthographic and auditory perception, since, in perception, the highest percentage of errors involved the point of articulation of fricatives, while in orthography the highest percentage involved voicing. **Conclusion:** Although related to each other, perceptual-auditory and orthographic performances do not match term by term. Therefore, in clinical practice, attention should focus not only on the aspects that bring these two performances together, but also on the aspects that differentiate them.

Descritores

Percepção auditiva
Escrita manual
Avaliação
Fonética
Criança

RESUMO

Objetivo: Verificar os desempenhos perceptual-auditivo e ortográfico de escolares no que se refere à identificação de contrastes entre as fricativas do Português Brasileiro, e investigar em que medida esses dois tipos de desempenhos se relacionam. **Métodos:** Foram analisados dados de desempenho perceptual-auditivo e de desempenho ortográfico extraídos de 20 crianças das duas primeiras séries do ensino fundamental de uma escola pública do município de Mallet (PR). A coleta de dados de percepção auditiva foi feita com base no Instrumento de Avaliação da Percepção de Fala (PERCEFAL), com o uso do *software* Perceval. Já a coleta de dados de ortografia foi feita por meio de um ditado das mesmas palavras que compõem o instrumento PERCEFAL. **Resultados:** Foram observadas: maior acurácia perceptual-auditiva do que ortográfica; tendência de menor tempo de resposta e de menor variabilidade nos acertos perceptuais-auditivos do que nos erros; não correspondência de erros de percepção-auditiva e ortografia, já que, na percepção, o maior percentual de erros envolveu o ponto de articulação das fricativas, enquanto que, na ortografia, o maior percentual envolveu o vozeamento. **Conclusão:** Embora se mostrem relacionados, os desempenhos perceptual-auditivo e ortográfico não apresentam correspondência termo a termo. Portanto, na prática clínica, a atenção deve-se voltar não apenas para os aspectos que aproximam esses dois desempenhos, mas, também, para os aspectos que os diferenciam.

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INTRODUCTION

In the last years, investigations on children's writing under different theoretical and methodological approaches have been carried out. In these investigations it is possible to notice: studies that highlight the role of phonological skills at writing acquisition[1,2]; studies that relate writing characteristics to cognitive skills[3,4]; studies that emphasize the relationships between writing acquisition and auditory processing[5-7]; studies that prioritize the social function of writing [8,9]; and studies that propose linguistic reflections associated with Lacanian psychoanalysis regarding reading and writing[10,11].

Specifically concerning the orthography domain, two main trends can be observed in those investigations: on one hand, studies that turn to orthographic productions which are deviant from the conventional writing system, and so are dealt with as a manifestation of writing pathologies[12,13]; on the other hand, there are studies that defend social factors as determining facts for the conditions of writing domain, based upon the idea that spelling mistakes reflect strategies that the child uses for appropriating the language [9,11,14].

The nature and the incidence of spelling mistakes have been shown in Speech-Language Pathology literature. These investigations seek for typifying those mistakes[15,16], or verifying possible changes in their nature along the schooling process[17].

In this scenario, it should be highlighted the fact that those are investigations that point to possible relationships between writing acquisition and auditory characteristics[5-7]. However, when dealing with these relationships, even though the studies mention the importance of the auditory processing in learning issues, the authors are not concerned about searching for more specific information on the relationships between auditory skills and orthographic aspects.

Nevertheless, researchers from the Group for Research on Language Studies (GPEL/CNPq), located at the School of Philosophy and Sciences of the Universidade Estadual Paulista (FFC/UNESP), have called attention to the importance of perceptual-auditory aspects which are possibly involved in orthographic fluctuations in children's writing[18-20]. Besides the works developed by those researchers, another study has also been calling attention to the relationship between auditory perception and orthography[21].

That is, though, an investigation approach which is just beginning. Therefore, the purpose of the present work – investigating the relationships between the auditory perception and orthography in children's writing – is justified specially by the scarcity of studies focusing, concomitantly, on children's perceptual acquisition of Brazilian Portuguese phonological contrasts and on orthography acquisition. It can also be justified by the contribution that it may bring to the knowledge of that relationship.

Thus, aiming at contributing for the understanding of this relationship, the present investigation was guided by the following objectives: (1) verifying the perceptual-auditory and the orthographic performances of 20 children attending the first and the second grade of elementary education in a public school, concerning the identification of contrasts among the fricatives of Brazilian Portuguese; and (2) investigating to which extend those two performances are related.

With the results we could obtain, it is hoped that we can provide contributions for a better understanding of the links between orthography and language phonetic and phonological characteristics (in our specific case, the ones of perceptual--auditory nature), as well as provide tools for Speech-Language Pathology and pedagogical practices with writing acquisition.

METHODS

The study was carried out after being approved by the Research Ethics Comitee of the School of Philosophy and Sciences of Universidade Estadual Paulista "Júlio de Mesquita Filho" – UNESP – Marília Campus, under the number 0303/2011.

Sample

A number of 20 students of both genres, aged between 6 and 7 years old, regularly attending the first and the second grades of elementary education at a public school in the city of Mallet (PR), Brazil, took part of this study. As inclusion criteria, the following were considered: students whose teachers had no complaints regarding their learning and their behavior; and presentation of a Free and Informed Consent, signed by the students' parents or guardians. The exclusion criterion adopted was not participating in some of the steps of the research.

Materials

For data collection, earphones, connected to a laptop computer containing software Perceval, version 3.0.5[22] were used. For the perception experiment, an assessment tool for speech – PERCEFAL[23] was used; we also made use of a black ballpoint pen and A4 blank paper for collecting written production samples.

PERCEFAL was developed so as to assess the perceptual--auditory performance of children (aged 4 years or older), based on an identification task (also called forced choice task), involving phonological contrasts of Brazilian Portuguese (hereinafter BP) in syllabic onset (attack). This tool carries preferably dissyllabic paroxitone words, possibly familiar to the children, involving all the 19 consonantal phonemes of BP in the stressed position.

The selection of the words was carried out according to the following criteria: contrasting BP phonemes so as to make words minimal pairs; being possible to be represented by pictures; belonging to children's usual vocabulary; belonging to a group of words listed in a previous study[24].

PERCEFAL is composed by a subset of four experiments: PERCVog (which assesses the identification of phonic contrast between stressed vowels); PERCOcl (which assesses the identification of phonic contrast between plosive consonants); PERCFric (which assesses the identification of phonic contrast between fricatives); and PERCSon (which assesses the identification of phonic contrast between sonorants).

Due to the aims of the present study, only PERCFric was used. In PERCFric, the following are analyzed by combinatorial analysis: seven fricatives x six possibilities of combination = 42 combinations, distributed into 21 pairs of fricatives in contrasts. These contrastive pairs are presented in Chart 1.

Chart 1. Minimal pairs of words involving the fricatives of the perception experiment

Contrast between fricatives	Minimal pairs
f x v	*faca* x *vaca*
f x s	*fanta* x *santa*
f x z	*forro* x *zorro*
f x ʃ	*fora* x *chora*
f x ʒ	*faca* x *jaca*
f x ɤ	*fala* x *rala*
v x s	*vela* x *sela*
v x z	*cavar* x *casar*
v x ʃ	*veia* x *cheia*
v x ʒ	*vaca* x *jaca*
v x ɤ	*vaso* x *raso*
s x z	*caçar* x *casar*
s x ʃ	*sapa* x *chapa*
s x ʒ	*selo* x *gelo*
s x ɤ	*sala* x *rala*
z x ʃ	*rocha* x *rosa*
z x ʒ	*zangada* x *jangada*
z x ɤ	*vaso* x *varro*
ʃ x ʒ	*xis* x *giz*
ʃ x ɤ	*baixo* x *barro*
ɤ x ʒ	*rema* x *gema*

Once the words that would compose PERFric were defined, the author of this tool had a typical BP adult speaker record the words selected, using high-fidelity equipment in an acoustic enclosure. The speaker was asked to produce the target words within a vehicle sentence ("Say *target word* to him"), so as to avoid the upsweep characteristic of the production of words isolated repetition. When the recordings were finished, by means of the software PRAAT[25], the minimal pairs were extracted from the vehicle sentence, constituting the auditory inputs of the experiment.

Parallel to the edition of the audio files, pictures selected from the public domain website http://images.google.com.br/, corresponding to each word, were selected. With the software Paint the images were cut and edited so as to standardize them; they resulted in visual inputs of PERCFric.

After the auditory and the visual inputs were established, a script* for the identification experiment to be executed by software PERCEVAL was made.

In relation to the auditory inputs, it should be highlighted the fact that new recordings were carried out by the author of the present study, keeping the same recording procedure, aiming at adapting the fricative production according to the linguistic variety of the subjects involved in this research.

Experimental procedures

The perception experimental procedure proposed by PERCEFAL consists of an identification test, also called forced choice task. This instrument is composed of three different stages: recognizing the words of the experiment; training stage and test stage.

The recognition stage involves the presentation of the visual and auditory inputs to the children, in order to check whether they knew or not the words used at the experiment. After the children were familiar with the experiment inputs, it is verified if the children do know the words. A criterion of 80% of correct words is adopted, so the children can be taken to the training stage, and then, to the perceptual test itself.

The training stage is automatically performed by the software Perceval, in order to warrantee the task understanding by the subjects. This stage is based on the perceptual identification task itself, but the results obtained are not reckoned by the software. The experiment stimuli are randomized and ten presentations are selected. Only then the real test stage is initialized.

For the identification task, the children stayed at school, in a quiet room; they were comfortably arranged facing a computer screen (the computer contained the software Perceval), wearing earphones. Individually, the children listened (with binaural presentation, at an intensity of approximately 50 dB SPL) to one of the words of the contrastive pair and, then, they indicated, by selecting one of the images presented on the computer screen, which picture corresponded to the word presented auditorily. For example, after the word "*vela*" (candle) was presented auditorily, the computer screen showed images corresponding to the words "*vela*" (candle) and "*sela*" (saddle), so the participant would decide and indicate, by typing two computer keys previously agreed upon, which picture corresponded to the auditory stimulus presented.

Both auditory and visual stimuli presentation time and the response time were controlled and measured automatically by the software Perceval. The experiment total duration was of approximately of 10 minutes per child.

For the collection of data of orthographic performance, the same words composing the contrastive pairs used in the auditory perception experiment were used. The students should write down these words, which were dictated, without any kind of instruction on the way that they should spell them, even if they asked about it. The students first did the orthographic performance test and after that, the perceptual-auditory experiment was carried out.

* Those who wish to obtain the identification experiment script can please request it to the author of PERCEFAL through the e-mail address: berti.larissa@gmail.com.

Table 1. Comparison between perceptual-auditory and orthographic accuracy

Accuracy	Auditory perception n (%)	Orthography n (%)	t-value	p-value
Hits	733 (87.3)	645 (79.6)	-4.89	0.00*
Errors	95 (11.3)	81 (19.6)	0.93	0.35
Non-responses	12 (1.4)	6 (0.8)	0.44	0.67
Total	840 (100)	720 (100)	-	-

* Significant values (p≤0.05) – Test T for independent sample

Analysis criteria

In order to analyze the results, regarding the perceptual--auditory performance, the following criteria were adopted: perceptual-auditory accuracy (percentage of mistakes, hits and non-responses); response time of mistakes and hits; ability to identify the contrast between fricatives, i.e., the children's ability to identify the contrasts with more facility or more difficulty[23].

Specifically at the analysis of the identification ability to contrast fricatives, we used the proposal of a confusion matrix to catalogue quantitatively and qualitatively the perceptive mistakes made by the children. This kind of analysis provides information regarding the contrasts more or less difficult, as well as the most recurrent error patterns[26].

In relation to the orthographic performance, the analysis was based upon the spelling accuracy (percentage of mistakes, hits and non-responses) and upon the ability to identify the orthographic contrast between the fricatives, i.e., children's ability to identify the contrasts with more facility or more difficulty, from an orthographic confusion matrix, proposed for realizing the present study.

To analyze the relationship between the perceptual-auditory and the orthographic performances within the sample, it was observed to which extent the changing trends presented by the children at the perceptual-auditory experiment also appeared at the orthographic performance within the same class.

Data was statistically treated, by means of the *s*oftware Statistica (version 7.0), from parametric tests, Test T for independent sample (when comparing perceptual-auditory and orthographic accuracy) and Test T for independent sample (when comparing response time of errors and hits). In addition, Wilcoxon non-parametric test was carried out (when comparing the pattern of perceptual-auditory and orthographic errors). A significance level of $\alpha<0,05$ and a confidence interval of 95% were established.

RESULTS

In Table 1 there are data referring to the accuracy at the perceptual-auditory and orthographic skills.

When comparing the perceptual-auditory and the orthographic accuracy, it was possible to notice that, out of 840 stimuli presented in the auditory perception experiment, a number of 733 (87.3%) were hits, 95 (11.3%) were errors, and 12 (1.4%) were non-responses. At the orthography test, out of 720 productions (100%), there were 645 (79.6%) hits, 81 (19.6%) errors and 6 (0.8%) non-responses (Table 1).

In Table 2, data relative to the time average of the perceptual-auditory skill response (given in milliseconds) for the hits and for the errors are presented.

Table 2. Comparison between response time of hits and errors

Response time	Average in ms (SD)	t value	p-value
Hits	1778.99 (± 395.92)	-0.33	0.74
Errors	1826.68 (± 772.56)		

Test T for dependent sample (p≤0.05)
Note: SD = standard deviation

By comparing the reaction times of errors and hits in milliseconds, it was possible to verify less time for the hits than for the errors (Table 2).

Finally, in Tables 3 and 4, results concerning the identification of contrasts between fricatives, at the perceptual-auditory and the spelling skills, respectively, are shown.

Table 3 presents the results of a confusion matrix, in which the fricative consonants arranged in the first column correspond to the auditory inputs presented, while the cells arranged in the first line (fricative consonants and non-responses) correspond to the possibilities of response of the contrasts investigated. It was also verified, numerically, the quantities of hits (in bold), of errors (in italics) and of non-responses (NR) for each of those contrasts.

Table 3. Perceptual-auditory confusion matrix

	f	v	s	z	ʃ	ʒ	ɤ	NR	Total
f	**99**	*2*	*11*	*3*	*2*		*1*	1	120
v	*3*	**108**		*2*	*2*	*1*	*1*	2	120
s	*3*	*1*	**108**	*1*	*2*	*3*	*1*	1	120
z	*2*	*1*	*1*	**105**	*3*	*5*	*2*	1	120
ʃ	*2*	*2*	*1*	*2*	**107**	*1*	*3*	2	120
ʒ	*1*	*1*	*3*	*6*	*2*	**103**	*2*	2	120
ɤ	*3*	*1*	*2*	*1*	*4*	*2*	**103**	3	120
Total	113	116	126	120	122	115	113	12	840

The numbers in bold letters refer to the hits, and those in italic letters, to the errors.
Note: NR = non-response

The data of this matrix regarding the errors of auditory perception are interpreted according to three classification parameters: point of articulation, voicing and point of articulation and voicing. It is possible, thus, to verify that, in a total

Table 4. Orthographic confusion matrix

	f	v	s	ss	c	ç	sc	sç	xc	x	z	sh	ch	j	g	r	rr	OC	NR	Total
f	**71**	*1*																		72
v	*5*	**67**																		72
s			37		17	4				1	12								1	72
ç			11	6		55														72
z		1	13							*1*	**55**		2							72
ch			2							16		*1*	**42**	*5*	*1*			*3*	2	72
x			1							60			9	1	1					72
j			1							1	2			58				*8*	2	72
g			1							1				*3*	**67**					72
r																71		1		72
rr																*9*	**62**		1	72
Total	76	69	66	6	17	59	0	0	0	80	69	1	53	67	69	80	62	12	6	720

The numbers in bold letters refer to the hits, and those in italic letters, to the errors. Underlined numbers refer to orthographic, but not phonological errors.
Note: NR = non-response; OC = substitutions for other class different from the fricatives

of 95 errors: 49 (51.58%) involved the point of articulation, such as confusions between [f] and [s] or between [j] and [z]; 13 (13.68%) involved voicing, such as confusions between [f] and [v]; and 33 (34.74%) involved, at the same time, point of articulation and voicing, such as confusions between [f] and [z].

Table 4 shows the results concerning the fricatives orthographic performances. It is an adaptation (carried out by the authors of this study) of the confusion matrix of the perceptual-auditory skill, which will be called matrix of orthographic confusion (MOC).

In this table, the first column shows the target consonantal graphemes that occurred in the first words of the experiment. The first line shows all the orthographic possibilities of fricative consonants which the target consonant graphemes could be potentially contrasted with; substitutions with graphemes of other class (OC) different from fricatives; and, finally, the non-responses (NR). It was also verified, numerically, the quantities of hits (in bold), of errors (in italics). It should be highlighted that the orthographic errors which do not alter the grapheme phonological value (for example, the word "*casa"* written as "*caza"*), besides being marked in italics, were also underlined.

According to what was previously mentioned, the errors were grouped in two big classes: one for the errors that would alter the grapheme phonological value (a total of 68 occurrences), identified in italics, without being underlined; and one for the errors that do not alter the grapheme phonological value (a total of 73 occurrences), identified in italics and underlined. It should be recalled that, from a total of 68 errors that alter the grapheme phonological value, 12 were substitution alternatives that are not in the fricatives class. This way, the errors that caused phonological alterations between fricatives, i.e., the ones that are analyzed in the present study, were a number of 56 occurrences. These errors, in turn, were classified according to three description parameters, as they involved: only point of articulation (7; 12.5%); only voicing (44; 78.57%); and point of articulation and voicing, simultaneously (5; 8.93%).

Finally, in Table 5, the patters of perceptual-auditory and orthographic errors are compared.

Table 5. Comparison between perceptual-auditory and orthographic error patterns

Error pattern	Auditory perception n (%)	Orthography n (%)	Z value	p-value
Point	49 (51.58)	7 (12.5)	3.23	0.00*
Voicing	13 (13.68)	44 (78.57)	2.73	0.00*
Point + voicing	33 (34.74)	5 (8.93)	1.55	0.11
Total	95 (100)	56 (100)	_	_

* Significant values (p≤0,05) – Non-parametric test Wilcoxon

The main trends of perceptual-auditory and orthographic errors can be visualized, highlighting the hierarchy of these trends, which changes in function of the kind of the performance assessment skill. It means that auditory perception and orthographic errors are not necessarily related (Table 5).

DISCUSSION

As for the comparison between perceptual-auditory and orthographic accuracy, the results exposed in Table 1 show that the children presented a better performance at the auditory skill than at the orthography. This better performance was probably due to the fact that, in the experiment, only two elements were contrasted, for example: [f] (in "*faca*") and [v] (in "*vaca*"). In its turn, at writing, there were different correspondence ways between the fricative consonants and the graphemes represented by them. For example, the consonant [s] admitted, in the material, the following orthographic representations: <s> (in "*selo*") and <ç> (in"*caçar*"), while the grapheme <s> occurred in the material having [s] value (in "*sapo*") and [z] (in "*casar*").

A better children's perceptual-auditory performance also suggests that, in spoken language (in relation to the

perceptual-auditory aspect), the acquisition is more advanced than in the written language. It should be highlighted, though, that orthographic errors are a part of the process of language orthographic system appropriation, and that mistakes tend to decrease along the schooling period, up to the moment when the student will be able to spell, more adequately, the irregularities of written language[15].

In relation to the response time of hits and errors at the perceptual-auditory experiment, although the results have not shown a significant statistical difference between the two kinds of responses, two trends should be highlighted. The first of them is about a shorter average time of response in the errors than in the mistakes; the second one is about a lower variability (in terms of standard deviation) of this time in the hits than in the errors.

The combination of these two trends suggests that the auditory perception of different contrasts between fricative consonants do not have the same statute for the children. As we could observe, some contrasts appeared to them as more problematic than others – statute difference already described in the international literature[27]. Therefore, also confirming the international literature[28], the domain of contrasts within the same class seems to occur gradually at the language acquisition.

Finally, as for the error patterns, the results showed a high correspondence between auditory perception and orthography within the fricative class, once there was only 1.4% of non-responses to the contrast identification task and 1.66% of orthographic errors that involved other classes of consonant segments. These results are in agreement with the literature[5-8], that suggests that difficulties in auditory skills may affect the linguistic performance (including orthography). It should be highlighted, though, that in those studies, the auditory skills are the ones involved in auditory processing, not necessarily referring to the identification of the language consonant contrasts.

However, if on one hand, this correspondence is strong when we are dealing exclusively with one phonological class, the fricatives, on the other hand it is weak when more specific characteristics within this class are involved (such as, in the cases analyzed, point of articulation, voicing, and point of articulation + voicing).

Indeed, at the perceptual-auditory identification task, the errors involving point of articulation were predominant – this result reaffirms a classic study[26]. In that study, the authors observed that the lane of voicing is perceptually more robust than the lane of the point of articulation. In other words, the lanes that mark voicing are more noticeable to the auditory perception than the lanes that mark the point of articulation.

Differently, at writing, the orthographic errors that involved presence/absence of voicing prevailed. Among these errors, from a total of 44, 33 (75%) concentrated on the contrasts among the fricatives [s], [z], [ʃ] and [ʒ]. Nevertheless, these contrasts, in the material analyzed, corresponded to 11 different orthographic possibilities, namely: [s] = <s>, <ss>, <c> and <ç>; [z] = <z> and <s>; [ʃ] = <x>, <sh> and <ch>; and [ʒ] = <j> and <g>. It means that there were practically three possibilities of representation for each consonant.

Thus, the results suggest that, preferably, these mistakes happen due to the multiple representation possibilities of the presence/absence of voicing, in agreement with results described in previous studies[16,29], specially when one phoneme could correspond to different graphemes, or, inversely, in situations in which one grapheme could correspond to different phonemes[30]. Therefore, possibly, at the writing task, the students were less worried about the phonological value (in relation to the characteristic ±voice) of each consonant than with the fluctuation that the BP orthography has for the spelling of coronal fricatives

However, due to the limitations of this study, regarding mainly the low number of subjects, the realization of further studies, with more subjects, with subjects at different ages, investigating the relationship between auditory perception and orthography for other BP phonological contrasts in other classes, is suggested.

CONCLUSION

The children of this study presented a better perceptual--auditory performance than orthographic performance. In both performances, the domain of contrasts among fricative consonants was gradual, as, within the same phonological class, certain contrasts were better noticed and registered than others.

Indeed, although the performances have shown some relations regarding the phonological class factor, perceptual-auditory and orthographic performances do not present a term by term correspondence concerning more specific phonological aspects.

Therefore, at the clinical practice, attention should be paid not only to the corresponding aspects of those two performances, but also – and mainly – to the aspects that differentiate them, once the differences will signalize the complexity of the relation between auditory perception and orthography.

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