Evaluation of reading skill in third grade children using acoustic analysis

(Avaliação da habilidade de leitura de crianças da segunda série através da análise acústica)

Mariana Hargreaves Araújo
(Grupo de Estudos de Prosódia da Fala, IEL /Unicamp)
Prof. Dr. Plínio Almeida Barbosa
(Grupo de Estudos de Prosódia da Fala, IEL /Unicamp)

Abstract: *In order to make a detailed observation of some variables in reading performance, two third grade (second series in Brazil) children were selected from a group because their performance differed widely in terms of frequency and type of silent pauses and reading aloud rate. The group was formed by 32 children from 2nd, 3rd, 4th and 5th grades. And, from an acoustic phonetic analysis of data, we were able to measure the reading aloud rate expressed in VV units per second, as well as observing performance and prosody such as: absolute frequency, duration and type of hesitant and non-hesitant silent pauses; stress group average duration; absolute frequency and duration of VV units per stress group; duration of units comprising the first vowel coming before a silent pause and the same. Statistical analysis suggests that the variable silent pause duration does not seem to differ among the children. However, some aspects like number of VV units per stress group, reading aloud rate, frequency and type of hesitant silent pauses vary a lot and may be important as parameters for reading performance.*
Key-words: *reading performance; reading learning; acoustic phonetics; Brazilian Portuguese.*

Resumo: *Para investigar algumas variáveis do desempenho em leitura, duas crianças da segunda-série foram selecionadas de um grupo porque seus desempenhos na leitura foram bem diferentes em termos de frequência e tipo de pausas silenciosas e taxa de leitura. O grupo foi formado por 32 crianças da 1ª, 2ª, 3ª, e 4ª séries (2º, 3º, 4º e 5º anos do ensino fundamental). Através da análise fonético-acústica de um texto lido por elas, conseguimos medir a taxa de leitura expressa em unidades VV por segundo, assim como observar aspectos do desempenho e da prosódia como frequência absoluta, duração e tipo de pausas silenciosas hesitativas e não-hesitativas; duração média do grupo acentual; frequência absoluta e*

duração de unidades VV por grupo acentual; duração de unidades compreendendo a primeira vogal vindo antes da pausa silenciosa e a mesma. A análise estatística sugere que a variável duração de pausa silenciosa não parece diferir entre as crianças. Contudo, alguns aspectos como número de unidades VV por grupo acentual, taxa de leitura, frequência e tipo de pausas silenciosas hesitativas variam bastante e podem ser importantes como parâmetros de desempenho de leitura.
Palavras-chave: *desempenho em leitura; aprendizado de leitura; fonética-acústica; Português Brasileiro.*

1. Introduction

1.1. Reading learning

Subject performance in reading has attracted the attention of many researchers. Issues such as how skilled readers recognize printed words, how the eye movements during reading are controlled, factors limiting reading comprehension, and how to improve reading teaching, are all of central concern in the scientific studies of reading (Snowling; Hulme, 2007). Modern techniques of observation and computational models recently explored reading skills, such as brain imaging, genetics of reading disorders and models of reading process (Snowling; Hulme, 2007).

Reading is a complex skill that has to be learnt and it depends, in principle, on decoding and understanding words in such a way as to be able to understand a text. The decoding and understanding of single words by visually identifying them, and associating them with their pronunciation and meaning, is a process taken as the foundation of reading, called word recognition. If word recognition processes do not work efficiently, reading will be deeply affected. In this experimental study, we shall endeavor to basically restrict our study to word recognition, especially the decoding stage.

Two important theories, presented by Coltheart (1978) and Plaut (1996), help shed light in the study of word recognition processes in reading aloud. Coltheart showed how the pronunciation of a printed word is generated through the dual-route models. Broadly speaking, the first route (lexical or orthographical) involves looking up a word and finding its pronunciation stored in a lexicon, whereas the second route (nonlexical or phonological), involves obtaining phonemes from graphemes and finding the pronunciation of a word from this sequence of phonemes. In a different

vein, Plaut proposed a connectionist model, the so-called triangle model (Plaut; McClelland; Seidenberg; Patterson, 1996; Seidenberg; McClelland, 1989) that abandons the distinction between lexical and nonlexical procedures. Translating visual words into pronunciation is explained by patterns of connections between orthographic inputs and phonological outputs (Snowling; Hulme, 2007).

The central question within the study of word recognition in reading is the role of phonology. According to Van Orden and Kloos (2007), spelling and phonology may be considered as constituting an interactive system in visual and spoken language. There is "interactivity" between the components of word recognition (i.e., orthographic, phonological, and semantic), that is, they mutually activate and inhibit each other during the word's processing. The relation between letters and groups of letters, and phonemes and groups of phonemes changes according to the contexts in which they appear. Children encounter thousands of different words in their reading, most of them are already known when spoken aloud, however this is probably the first time they are seen these words printed. To make the phonological decoding, children must be able to sound out parts of a word, or to "decode" graphemes into phonemes. The phonological decoding can involve different units of recognition, such as the syllable.

A written syllable can, in Portuguese, vary from a single vowel to a larger group of letters (eg. "quinhentos", with the written syllable types CVV: "qui", CCVC: "nhen", and CVC: "tos"). In this specific case, the second syllable, "nhen", signals that the appropriate vowel pronunciation is nasalized, that is, the last consonant has an influence on the pronunciation of the vowel that precedes it. So, it is important for initial readers to decode groups of letters and not only break up syllables at several points or by individual graphemes (Fowler; Treiman; Gross, 1993; Treiman, 1989; Treiman; Fowler; Gross; Berch; Weatherston, 1995). According to Treiman et al (1995), the phonetic segments in a spoken syllable do not form a linear string, that is, each phonetic segment is equally tied to the phonetic segment that precedes it and the phonetic segment that follows it. For example, in a spoken CVC syllable, the vowel has a close bond with the following consonant, these two letters forming the rime of the syllable and the initial consonant forms the onset. In the aforementioned case of "nhen", the last consonant "n" forms a phonological and phonetic unit with the precedent vowel "e", a "nasal" segment. This illustrates that

there are much more possibilities to pronounce a written vowel than those related to prosody and the contrast between the five vowel letters "a" "e' "i" "o" "u" and the twelve vocalic pronunciations {i e ɛ a ɔ o u ĩ ẽ ã õ ũ}. Moreover, as Treiman; Berch; Weatherston (1993) pointed out, stress patterns (related to the sequence of prominent syllables in the word. See Barbosa (2006) stress patterns in Brazilian Portuguese) also play a role in orthographic processing, since young children are less accurate in their spelling on unstressed than stressed syllables.

Accurate identification is also influenced by the linguistic context: to find the appropriate phoneme's pronunciation during the reading acquisition process, the initial reader has not only to recognize letters, but also to develop a metalinguistic ability, the so-called phonemic awareness. This awareness is identifiable to a usable knowlegde of the phonemic organization of speech in an alphabetic script (Byrne, 1998; Hulme et al., 2002; Ludenberg; Frost; Petersen, 1988; Share, 1995). This ability will make possible to split words and syllables into smaller units and blend them by means of the words' phonology. For instance, this knowledge can be operationalized by determining if a child can reliably say that words such as *sun* and *sail* begin identically, that *sun* and *fish* do not, that *pot* and *hat* end identically (Byrne; Fielding-Barnsley, 1989, 1990, 1991) and so on. According to Ehri (1998, 1999, 2002), one important period of knowledge occurs when the child passes on a transition between two phases of learning to read, that are, respectively, the *partial alphabetic phase* and the *full alphabetic phase.* At the end of *the full alphabetic phase,* the reader acquires decoding skill and graphophonemic knowledge that is used to bond spellings fully to their pronunciations in memory. S/he is able to process all the letters in words and read them, to decode new words, and one or a few reading experiences is sufficient to convert unfamiliar words to familiar sight words (Ehri; Wilce, 1979). Some capabilities are important during this transition and can be observed (Juel; Griffith; Gough, 1986) through tasks in areas such as phonemic awareness (segmentation, blending and substitution), exposition to print (level of texts being read in classrooms), cipher knowledge (nonword decoding), and sight word knowledge (recognition of misspellings).

A large demand into memory is required as reading acquisition process progresses. When a child looks at words and reads them immediately, right after seeing them, we can say that the child is able to read words from

memory by sight, the word's pronunciaton, meaning and syntatic role are all activated in memory, that is, mental connections bond written words to their other identities in memory, such as a mental dictionary recorded with its phonology and meaning. According to Ehri (1998, 1999, 2002), a later phase (*consolidated alphabetic phase)* signals the point in which syllabic units and morphemic units are analyzed. Word recognition skills begin to become automatized and the reader reaches what she calls "the sight word reading", the fluent recognition of printed words. Automaticity is important because the child can recognize the pronunciations and the meanings of written words immediately upon seeing them without expending any attention or effort decoding the words. Ehri (2007) pointed out that reading words within one second of seeing them is taken to indicate "sight word reading".

Many factors interfere with the act of learning to read. Judith Bowey (2007) signals two main skills which can co-determine early reading development (in reciprocal relationship with each other): letter knowledge and phoneme sensitivity. According to Ehri (2007) two types of causes producing the development of word reading skill can be distinguished, internal and external. Examples of internal causes can include the facilitation produced by acquiring letter knowledge and general capabilities that serve purposes other than reading such as mechanisms involving vision, language and memory (Rack; Hulme; Snowling, 1993). Examples of external causes can be informal teaching, formal instructional programs, and reading practice. Ellis (1995) also pointed out some factors that can influence, determine or affect the facility or difficulty in which words are recognized: familiarity; frequency; age-of-acquisition; repetition; meaning and context; the regularity of correspondence between orthography and sound or grafeme and phoneme; and interactions between those factors. According to Plaut (1996), based on studies of Jared, Mc Rae and Seidenberg (1990), word recognition may also vary depending on the characteristics of the "quasiregularity" of the orthography and the "neighborhood" of word (where *friends* are words with a similar spelling pattern and similar pronunciation and *enemies* are words with a similar spelling pattern but a discrepant pronunciation) and the type of the word to be read. Thus, words may be classified, using high and low-frequency words at four levels of consistency: *regular consistent words* – words whose pronunciations are easier to adhere to standard spelling-sound correspondences; *regular inconsistent words* – words which pronunciations are not so easy to make the standard

spelling-sound correspondences (for example, an regular inconsistent word such as MINT has a number of friends (e.g., LINT, TINT, PRINT) and just a single enemy, PINT. Against the strengh of friends, the single enemy cannot exert a marked influence (especially when, as is the case of PINT, the enemy is of relatively low frequency); *ambiguos words* – words more difficult to be named (an average of a great number of friends and enemies); *exception words* – words very difficult to be named (an average of few friends and great number of enemies).

Stephen J. Lupker (2007) shows that any complete model of word recognition ultimately will have many phenomena explained from a huge body of experiments.These include the fact that people perceive letters more efficientlly when they are embedded in words, that high-frequency (i.e, more familiar) words are recognized easier than less famliar ones, and that recognition of words is influenced by previously presented ones (seeing a prior word that is related in form or meaning help us to recognize a word that follows it).

1.2. Reading performance

To achieve reading rates in order to support comprehension close to that achieved by listening to the words, children require many encounters with print in order to fix in memory the patterns that correspond to linguistic structures of phoneme, syllable, morpheme, and word (Carver, 1997; Ehri, 2002). When word recognition begins to be automatic, short-term memory is liberated to tasks which require awareness and attention, like comprehension and text analysis (Perfetti,1985; Berninger, Richards, 2002). According to Baddeley (1996), the earlier concept of short-term memory, a limited-capacity temporary memory stored, typified by the model proposed by Atkinson and Shiffrin (1968), was modifyed and extended to the concept of working memory, a system that not only has the capacity of temporarily storing information, but also, the capacity of processing and manipulating information. Baddeley and Hitch (1974) proposed that the working memory is composed of a tripartite system, which involves an attentional controller, the central executive, aided by two subsidiary slave systems, the visuo-spatial sketchpad, which holds and manipulates visual images, and the phonological or articulatory loop, which performs a similar function for speech-based information. Baddeley (1996) explained that the phonological loop has, in general, a limited time of two seconds, and

a simple way of summarizing this relationship is to observe that subjects can remember about as many words as they can say in about two seconds, that is, the acoustic or speech-based information can be held in the form of memory traces and then be spontaneously fade away within the limit-capacity unless refreshed by rehearsal. In 2000, Baddeley extended the model, by adding another component, the episodic buffer, which holds representations that integrate the slave systems (phonological, visual and spacial) and other possible information (e.g., semantic and musical).

Some of the factors mentioned above may interfere in the childs performance during reading acquisition.The inaccuracy in reading aloud can be evaluated through the proportion of hesitations and the nature of these hesitations. A high frequency of hesitant silent pauses, as well as a reduction in rate of reading, has been noted in some children in Brazilian classrooms while learning to read aloud. This seems to be a sign of struggling to process information. To better understand this aspect, it is important to observe the criteria for distinguishing non-hesitant silent pauses from hesitant silent pauses. In this study, we chose to use non-hesitant silent pause instead of fluent silent pause, since the criteria of "fluency" is still subjective and hard to define in children learning to read.

Studies with young adults speech, without reading problems, conducted by Merlo (2006), showed that there are two types of silent pauses in this population: non-hesitant(fluent) and hesitant. To determine if one pause is hesitant or not, syntactic and prosodic cues were used. Non-hesitant silent pauses are common in strong syntactic boundaries, for instance between sentences or between the subject and predicate. In general, the stronger the boundary, the longer the pause (Cruttenden, 1994; Winkworth; Davis; Adams; Ellis, 1995). By contrast, hesitant silent pauses are placed, in general, at weak syntactic boundaries (Cruttenden, 1994). In the following example, Merlo (2006) shows this difference – the first pause is hesitant and is placed at a weak syntactic boundary; the second pause is non-hesitant (fluent) and is between the two sentences (strong syntactic boundary):

hesitant silent pause ↓ ↓ non-hesitant silent pause
"then the father asks for a glass of.....water.....the son answered he is going to get it"

Most non-hesitant silent pauses and, mainly, hesitant silent pauses are frequently observed when children are reading texts aloud in the early stages of learning to read. Non-hesitant silent pauses have been observed

in children during the early stages of learning to read and do not normally precede syllable repetition, and/or word rereading. Hesitant silent pauses, on the other hand, are generally followed by a slow production of each syllable of the word, and/or repetition of isolated syllables or parts of a word, and/or a correct rereading of the word as a whole, making the child pay greater attention to phonological decoding for comprehension.

Another performance aspect that motivated this study is that hesitant silent pauses mostly precede or occur word-internally in possible unfamiliar words. That being the case, we set out to verify the following hypothesis: if word familiarity is a factor that interferes in a child´s learning to read, the more familiar any given word is to a child, the smaller the probability of hesitation and the faster her/his local reading rate.

An acoustic phonetic analysis followed by statistical analysis can help assess reading performance. Few studies have been carried out aimed at observing reading performance in children by means of the following parameters: average syllable-sized (VV) duration, average duration, absolute frequency and type of hesitant and non-hesitant silent pauses; average stress group duration; and the reading aloud rate expressed in syllable-sized units per second[1].

2. Methodology

2.1. Participants

32 children took part in the research from 2nd, 3rd, 4th and 5th grades (1st, 2nd, 3rd, 4th. series in Brazil) of a public school known as one of the ten best in the city of Rio the Janeiro. The readings were made in 2007 in April, the beggining of the school year in Brazil. The children were chosen by their own teachers following a subjective criterion of selecting children with

1. It is worth mentioning tendencies in measuring the reading rate in "words per minute", a choice that ends up biasing the results analysis when comparing the results across distinct languages. The lexical item size varies within the same language as well as across different languages. Since in English there is a high frequency of monosyllabic words, this can bias the comparison with Portuguese since in Portuguese there is a higher proportion of bisyllabic words. Therefore, the "syllables per second" counting may more precisely reflect the reading aloud rate.

different skills in text reading. Two eight year old girls from the beginning of the third grade were selected for analysis because they presented very distinct levels in reading performance, according to their teachers, reaching two "extreme behaviors" in reading the same text . These children are referred here as child A ("fluent") and child B ("non fluent").

2.2. Procedure

The research took place in an isolated and relatively noise-reduced room within the school. The children uterances were recorded using a unidirecional Omega 662330 model microphone, and the HP Pavillon dv 2120BR notebook cd recorder and filmed by an JVC GY- DV300 MiniDV DigitalCamcorder professional model camera. Each child was oriented to enter the room alone, sit in front of the computer, and after receiving the instructions, begin to read. The texts were presented in Power Point (Microsoft) and all of the children showed a lot of interest and attention during the reading.

The children's parents authorized the use of the information collected in the research. All the 32 children read two texts in Brazilian Portuguese (hencefoth BP): a specific text compatible with the child's age and academic level and a second text, common for all grades. All the children were evaluated in terms of frequency of silent pauses and reading aloud rate.

The third-grade children read the tale *A rã que queria ser grande como o boi* (The frog that wanted to be as big as an ox) from Jean de La Fontaine, available at http://www.universodasfabulas.hpg.com.br (Appendix 1). The text has 121 words (224 syllables), and was selected by the class teachers as compatible to the children's age and academic level. After that, they read the common text for all grades "O peixinho e o besouro no rosto de Narizinho" (The little fish and the beetle on Narizinho's face), an adaptation with 258 words (502 syllables) from a stretch taken from the book entitled *Narizinho Arrebitado*, a fragment of Monteiro Lobato's *Reinações de Narizinho* (Appendix 2). At the end of each text, all children were submitted to multiple-choice questions intending to evaluate the comprehension of the text. The reason why all children are mentioned here is because a comparison among them and children A and B will be conducted at the end of this study.

For the acoustic analysis of children A and B, the text *A rã que queria ser grande como o boi* was chosen. The acoustic analysis of the data was carried out with the use of the Praat software (Boersma; Weenink, 2008), which allowed quantify the reading aloud rate expressed in phonetic-syllable units per second, as well as observing aspects from the performance of each subject in text reading such as: absolute frequency and duration of hesitant and non-hesitant silent pauses; stress group average duration; absolute frequency and duration of phonetic-syllables per stress group; absolute frequency, duration and type of hesitation (hesitation between syntactic phrases and word-internally hesitation); duration of units comprising the first vowel coming before a silent pause till the end of the consonant after the silent pause, if applicable. The statistical analysis of the acoustic parameters above will be shown in section 3.1.

Stress groups were delimitated by automatically detecting consecutive phrase stress boundaries within and across connected utterances. Since BP is a right-headed language at the stress group domain, a phrase stress at the right end of the corresponding stress group delimits this unit. The sequence of phrase stress positions was then automatically tracked by serially applying two techniques for normalising duration: a z-score transform procedure, and a 5-point moving average filtering procedure. Due to the relevance of delimiting syllable-sized durations with vowel onsets as anchor points instead of syllable onsets, VV units were used as building blocks for stress group delimitation (Cummins; Port, 1998; Barbosa, 2006, chapter 3; Barbosa, 2007). Stress groups were then defined as the phonetic segment between two consectuvie peaks of normalised VV duration. Stress groups finishing in hesitant silent pauses were not taking for the analyses with stress group duration.

The silent pauses related to the slides switch in power point were not considered in the counting because are related to an ability other than reading.

The reading aloud rate, mentioned in this study, represented the total number of syllable-sized (VV) units of the text divided by the total reading duration expressed in seconds (including the hesitant and non-hesitant silent pauses). On the other hand, the absolute frequency of VV units per stress group represented the average number of VV units within the stress group.

3. Results

Diferently to what was observed in adults, some children in this research produced silent pauses that did not fit in Merlo's (2006) definition, since, contrary to adults, non-hesitant silent pauses appeared frequently at weak syntactic boundaries, especially in the group of children considered by their teachers as "non-fluents". The reason for that is most likely related to the stage of reading development. On the other hand, hesitant silent pauses appeared at strong syntactic boundaries. The following examples show this difference.

In the sentence "*a menina nem se mexeu para não o assustar*" (*the girl herself didn´t even move not to frighten the little fish)*, a 7-year old girl from 2nd grade read:

> "a menina...nem...se...mexeu...para...não...o...assustar", making non-hesitant silent pauses at weak syntactic boundaries thoughout the sentence.

In the sentence "*Sentiu cócegas na testa. Virou os olhos para ver melhor" (She felt ticklish in her forehead. She turned her eyes upwards to see it better),* a 7-year old boy from 2nd grade read:

> "Sentiu...cócegas... na testa....V...V...Virou... os olhos... para ver... melhor", making a hesitant silent pause at a strong syntactic boundary, between the two sentences .

Moreover, in the early stages of children learning to read, hesitant silent pauses could appear in two basic different ways, classified in the following types: hesitant silent pauses between syntactic phrases and hesitant silent pauses word-internally. For instance:

In the sentence "*e o médico me receitou ar puro do campo*" (*and the doctor recommended pure air from the fields*), the child (one boy from 4th grade) said:

> "e o médico me receitou...um puro...ar puro do campo", making hesitant silent pauses between syntactic phrases.

In relation to the hesitant silent pauses world-internally, an example appeared in the word "*mámore*" (*marble*), in the common text for all grades. In

the sentence "*Acho que esse morro é de mármore*"(*I think this hill is made out of marble*), the majority of the kids considered by their teachers as "non-fluents", had hesitations in this word, probably for not being familiar for many children.

As far as quantitative and qualitative evaluations are concerned, child A is faster in reading performance (reading aloud rate of 3,3 VV units per second), showing confidence and holding a still position during the reading of the specific text for 3rd grade. Child B, on the other hand, showed slowliness during the task (reading aloud rate of 1,2 VV units per second), with head moviments associated with the eye moviments, leaning back and forth while seated in front of the computer. Child B also showed more hesitant silent pauses, making some rereadings of specific sounds. Child A was more accurate than child B answering the questions related to the text. Table 1 shows the complete picture.

Table 1: Descriptive parameters of reading performance (significance of the Mann-Whitney U test, if applicable)

	Child A	Child B	Significance
Absolute frequency of hesitant silent pauses	9	43	_
Absolute frequency of non-hesitant silent pauses	24	77	_
Average duration of hesitant silent pauses	582ms	671ms	ns
Average duration of non-hesitant silent pauses	688ms	583ms	ns
Average duration of stress group	1684ms	1584ms	ns
Absolute frequency of VV units per stress group	5,9	2,4	$p < 0.0002$ z - -3,78
Average duration of VV units within a stress group	370ms	732ms	$p < 10^{-6}$ $z = 6.03$
Absolute frequency of hesitant silent pauses between syntactic phrases	7	13	_
Absolute frequency of hesitant silent pauses word-internally	2	30	_

As can be seen in Table 1, a different number of hesitant silent pauses word-internally was observed between the children A and B (child A presented 2 word-internally hesitations and child B showed 30 word-internally hesitations) , which seems to demonstrate different levels in the reading acquisition. Child B, for instance, has shown more word-internally hesitations in words such as *"impressionou-se" (got impressed), "porte" (posture), "minúsculo" (tiny), "pretendeu" (intended), "igualar" (equalize), "admiração"*

(admiration), "envaidecida" (proud of itself), "companheiras" (companions), "vejam" (watch), "foi inflando-se" (inflated itself), "escravo" (slave), "nobre" (nobel), words that the child was probably not very familiarized with, very likely because these words are not commomly used in conversations with her friends although it is common in books for that age level.

It is important to add that child B also had difficulty in finding the correct pronunciation for some graphemes, for example, in the case of "*resistindo*" (*resisting*) she read the first "s" pronouncing the sound [s], although the correct Brazilian pronunciation is [z] ; in the case of the pronoum "*que*" (*which*) and the verbs "*queria*" (*wanted*) and *quer* (*wants*), that are very similar orthographicaly, she was confused about the correct pronunciation since *que* and *queria* are both pronounced with the closed vowel [e], whereas *quer* is pronounced with the open vowel [ɛ].

However, it is interesting to say that child B improved the reading of these words, getting, from that point on, the correct pronunciation throughout the text when such word appeared repeatly (e.g. "*que*") or on a similarly spelled way (e.g., "*igualar*" X "*igualei*"), which demonstrate the child's capacity of rapidly memorize the correct pronunciation of a new word and deduce the correct pronunciation of a new word resulted from this word already memorized, reading it without hesitating.

Child A non-hesitant silent pauses were observed mostly between sentences, at strong syntactic boundaries, whereas in child B, non-hesitant silent pauses were observed at weak syntactic boundaries, mostly preceding one word or groups of two or three words. This aspect may also be related to the different stage of child B's word recognition, which is necessary for her to pause without hesitating before reading the majority of written words, in order to identity them.

3.1. Statistical Analysis of the acoustic parameters

Comparing the hesitant silent pauses (HES) durations between the two children (Subject: Ju – child B; Subject: Is – child A), the non-parametric Mann – Whitney U test revealed no significant statistical difference in the mean duration. Figure 1 shows the histograms of the hesitant silent pauses duration for each child.

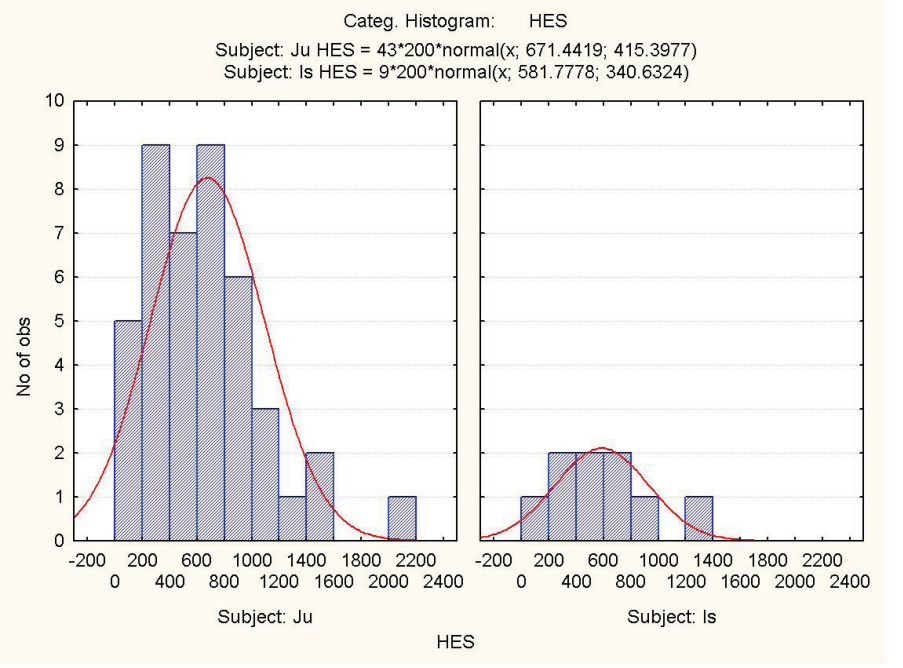

Figura 1: Histograms of the hesitant silent pause durations for the two children (Ju is subject B, Is is subject A).

The Mann –Whitney U Test also revealed that there was no significant statistical difference in the mean duration when the non-hesitant silent pauses (NHES) durations between the children were compared (Figure 2).

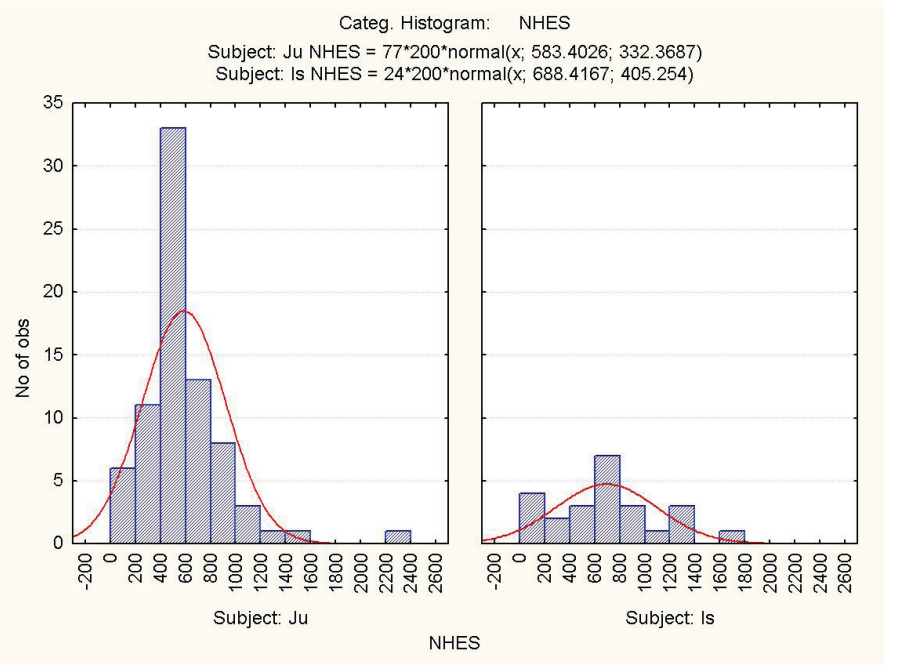

Figure 2: Histograms of the non-hesitant silent pause durations for the two children. (Ju is subject B, Is is subject A).

We notice that there is a right assimetry in the figures above. Child B (Ju) has a tendency of having more extreme values of silent pause duration than child A (Is). The skewness for the hesitant pauses of both children are: child B – 1.2 ; child A – 1.0 and for the non-hesitant pauses are: child B – 2.2 ; child A – 0.5.

When comparing the two subjects for the durations including the voiced segment to the left of the silence till the first lexically stressed vowel leftwards, there was also no significant difference.

However, observe in Table 1 a difference in the absolute frequencies of hesitant silent pauses (mainly word-internal hesitant silent pauses) and non-hesitant silent pauses, between the two children.

The Mann-Whitney U Test revelead that there was also no significant statistical difference in the stress group duration between the children. By contrast, there was significant differences between the average duration of VV units per stress group and the absolute frequency of VV units per stress group. The histograms are shown in Figs. 3 and 4.

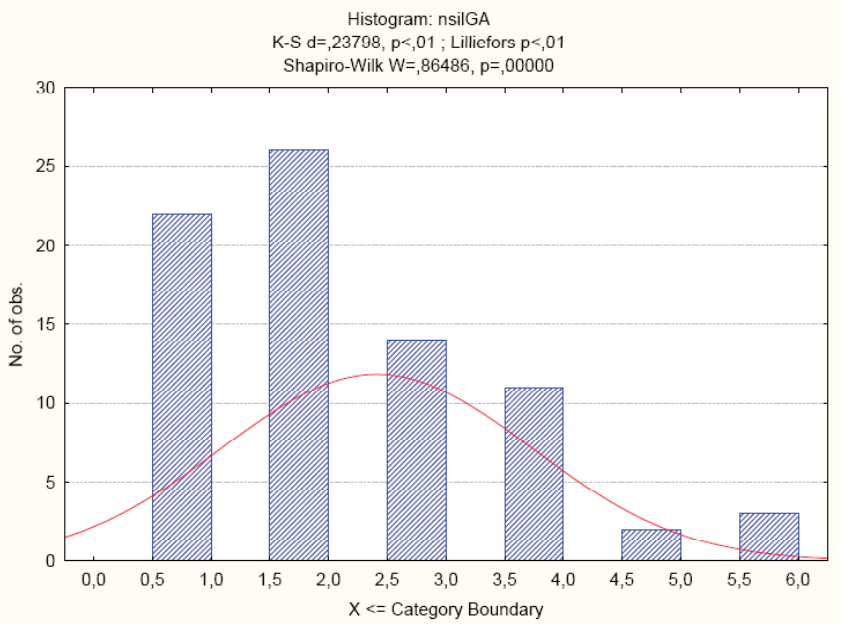

Figure 3: Distribution of the number of syllables in the stress group in child B.

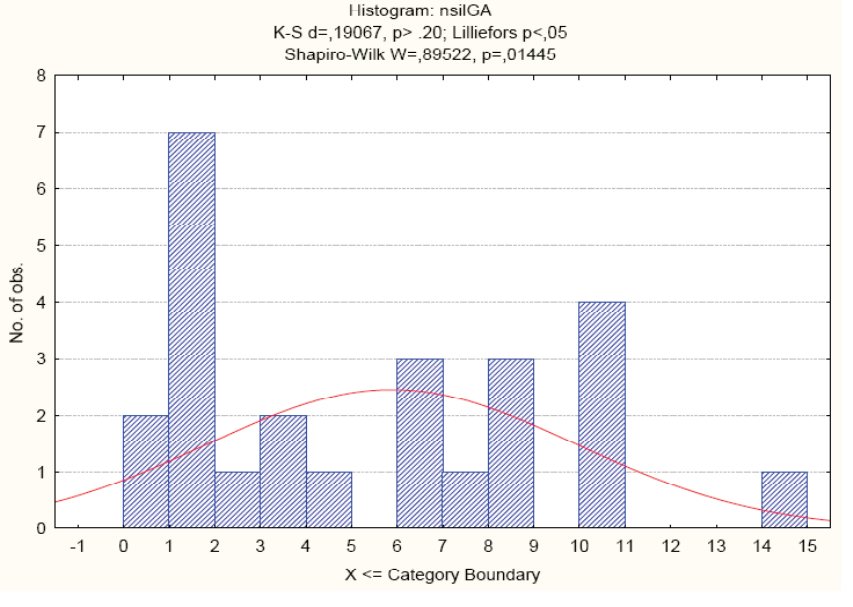

Figure 4: Distribution of the number of syllables in the stress group in child A.

4. Discussion

A few aspects of children reading performance were examined. The interest in analysing two children allegedly in the two "extremes" of the informal fluency scale, is that within those extremes, a few performance parameters reveal variables that may better discriminate between the reading performances.

Some performance parameters such as the average duration of hesitant and non-hesitant silent pauses do not seem to differ betwen the two children. However, some aspects like the absolute frequency of VV units per stress group, the reading aloud rate and the frequency of hesitant silent pauses word-internally can vary a lot and may be important parameters for distinguishing performance in this year group.

Although the two children had passed through the *full alphabetic phase* and seem to display characteristics of the *consolidated alphabetic phase,* child A is more automatizated during reading than child B, perhaps because child B doesn´t have so many spelled familiar words fully secured in her memory like child A. Child B's non-hesitant silent pauses happens before possible familiar words, indicating that she is still probably in a moment of development that requires a few milliseconds to pause in order to mentally "confirm" the subsequent familiar word or the group of familiar words in her memory to be able to read them by sight.

Comparing one child to the other, the picture that emerges is that they differed in performance because, even though the children presented statistically the same stress group duration, of approximately 1.6 seconds, and also statistically the same hesitant and non-hesitant silent pause duration, they presented a hesitation frequency and reading aloud rate quite different from each other. In other words, the two children last the same stress group while reading and, when they stop, they spend the same time in the pause. It´s worth mentioning that this fact may be related to the working memory, since in the 1.6 s pause, within the 2 s order of magnitude, the children may be ellaborating the message, according to the work by Baddeley and Hitch (1974) explored in the Introduction.

Child B basically reads syllables, one, two or at most three words within the stress group while child A, on the other hand, read an average of at least four or five words within the stress group. So, child B reads more slowly

each syllable within the stress group: child B has a VV average duration of 732 milliseconds and an absolute frequency of 2,4 VV units / stress group, whereas child A has a VV average duration of 370 milliseconds and an absolute frequency of 5,9 VV units / stress group. Compare these figures with the 6.5 average number of VV units per stress group in a reading task by male adults in Barbosa (2006, chapter 3).

Child B's slowliness in pronouncing each syllable may be related to the different stage of automaticity compared with child A, since child B probably still needs to process component letters to read words, whereas child A reads the majority of the words as single units.

The reading aloud rate of child B (1,2 VV units per second) is a consequence of the high frequency of silent pauses, hesitations and slowing down. As a matter of fact, child B seems to be trying to process the information and, since she presents a word recognition difficulty, makes more hesitant silent pauses and reads slowly. Child A, which has less difficulty in word recognition and, probably, is more familiarized with the text words, reads more syllables (3,3 VV units per second) during the same time.

As to the comparison with the children in the same grade, even though they were not statistically analysed like children A and B above, all the 32 children were also evaluated in terms of frequency of silent pauses and reading aloud rate with the specific text for each grade as well as the common text for all grades. In general terms, it was observed a decreasing number of silent pauses from 2nd to 5th grades although not in an homogeneous way. For instance, a 2nd grade child considered by the teachers as a "fluent reader" presented less silent pauses than a 3rd grade child considered by the teachers as a "non fluent reader". In the following table, we choose one sentence from one of the texts to better exemplify this progression.

Table 2: Example of the pauses developmental progression

Age	Grade/ Serie	Child considered by the teachers as	Sentence: "Vim tomar o remédio neste lugar que conheço muito bem, mas encontrei esse morro que me parece estranho."	Number of pauses
7	2nd 1st	Non Fluent	Vim...tomar...o..re...mé...dio...neste...lugar...que...co...nheço....muito...bem,... mas....en...con...trei....esse...mo...rro...que...me.....parece...es...tra...nho.	25
7	2nd 1st	Fluent	Vim tomar...o remédio neste lugar...que...conheço muito bem,... mas...encontrei esse morro...que...me parece estranho.	7
8	3rd 2nd	Non Fluent	Vim tomar...o remédio...neste lugar...que...conheço....muito bem, ... mas...en...contrei...esse morro...que...me...parece...estranho.	13
8	3rd 2nd	Fluent	Vim tomar...o remédio neste lugar...que conheço muito bem,... mas encontrei esse morro...que me parece estranho.	4
9	4th 3rd	Non Fluent	Vim tomar...o remédio...neste...lugar...que conheço...muito bem,... mas encontrei...esse morro...que me...parece estranho.	9
9	4th 3rd	Fluent	Vim tomar o remédio neste lugar que conheço muito bem,... mas encontrei esse morro que me parece estranho.	1
10	5th 4th	Non Fluent	Vim tomar...o remédio...neste lugar...que conheço muito bem,... mas encontrei esse morro...que me...parece estranho.	6
10	5th 4th	Fluent	Vim tomar o remédio neste lugar que conheço muito bem,... mas encontrei esse morro que me parece estranho.	1

An average variation in the reading aloud rate was also observed for the 32 children's texts from 1,0 VV units per second to 4,5 VV units per second. Children A and B were within the average range presented by all the other children. In general, the children classified by their teachers as "fluent" readers, presented an average variation in the reading aloud rate from 2,5 to 5,0 VV units per second. Some of them reached over 5,0 VV units per second. Barbosa (2006, chapter 3), studying Brazilian young adults speech during a reading task, observed a variation in the reading aloud rate from 3,5 to 7,0 VV units per second. Therefore, some of the children classified by the teachers as "fluent" readers seem to be reached an adult average reading aloud rate.

5. Conclusion

An acoustic phonetic analysis carried out to evaluate two girls (children A and B) from third grade showed that some reading performance parameters were extremely different. Statistical analyses revealed a great difference between these children in the reading aloud rate, in the absolute frequency of non-hesitant silent pauses, and mainly, in the absolute frequency of hesitant silent pauses word-internally. These findings corroborate with our

hypothesis that some factors, such as the word familiarity, may interfere in the frequency of hesitations and in the variation of the reading aloud rate during reading learning process. But not only the word familiarity may explain Child´s B slowliness in reading syllables, since, in general terms, it also happened even with the text words that she was familiarized with. This situation seems to be related to the different stage of word recognition compared with child A, since child B still needs to decode some component graphemes into phonemes to read words, whereas child A reads the majority of the words as single units.

It's worth mentioning that the objective of this study was not establishing a threshold of good performance in reading in order to exclude certain children of a specific group. The main goal was to point out which variables could be the most relevant ones for evaluating children's reading performance. It is also important to say that the reading performances by the children in this specific school may not be the same found in other public or private schools. Therefore, the comparison between these descriptive parameters in other studies, could better trace or measure a profile of the reading performance variation in each school grade and help children with reading difficulties.

6. Acknowledgments

The second author acknowledges a grant Produtividade em Pesquisa from CNPq (number 300371/2008-0). We gratefully acknowledge the collaboration of Colégio de Aplicação – UFRJ (children, parents, teachers, coordinators, principals, hall-supervisors, staff of informatics and audio-visual, doormen and employees). Also, we thank the volunteer assistance of Afonso Antonio Pragana in informatics and in the power point texts preparation.

Recebido em maio de 2009
Aprovado em outubro de 2009
E-mails: marianaharaujo@gmail.com
pabarbosa.unicampbr@gmail.com

References

Atkinson, R. C.; Shiffrin, R. M. 1968. Human memory: A proposed system and its control processes. In: Spence, K. W.; Spence, J. T. (Ed.). *The psychology of learning and motivation.* New York: Academic Press. v. 2, p. 89-195.

Baddeley, A. D.1996. Exploring the Central Executive. *Quarterly Journal of Experimental Psychology*, v.49, p.5-28.

_____. 2000.The episodic buffer: a new component of working memory? *Trends in Cognitive Sciences*, v.4, p.417-423.

_____; Hitch, G. J. 1974. Working memory. In: Bower, G.A. (Ed.). *Recent Advances in Learning and Motivation*. New York: Academic Press. v. 8, p. 47-89.

Barbosa, P. A. 2006. *Incursões em torno do ritmo da fala*. Campinas: Pontes.

_____. 2007. From syntax to acoustic duration: a dynamical model of speech rhythm production. *Speech Communication*, v.49, p.725-742.

Berninger, V.W.; Abbott, R. D.; Abbott, S. P.; Graham, S.; Richards, T. 2002. Writing and reading: Connections between language by hand and language by eye. *Journal of Learning Disabilities*, v. 35, p.39-56.

Boersma, P.; Weenink, D. 2007. *Praat: doing phonetics by computer.* 2008. (Version 5.0) [Computer program]. Retrieved May 16. from http://www.praat.org/.

Byrne, B. 1998. *The foundation of literacy*. Hove, UK: Psychology Press.

_____; Fielding-Barnsley, R.1989. Phonemic awareness and letter knowledge in the child's acquisition of the alphabetic principle. *Journal of Educational Psychology, v.81*, p.313-321.

_____; Fielding-Barnsley, R. 1990. Acquiring the alphabetic principle: A case for teaching recognition of phoneme identity. *Journal of Educational Psychology, v.82* , p.805-812.

_____; Fielding-Barnsley, R. 1991. Evaluation of a program to teach phonemic awareness to young children. *Journal of Educational Psychology, v.83*, p.451-455.

Bowey, J.A. 2007. Predicting individual differences in learning to read. In: Snowling, M. J; Hulme, C (Ed.). *The science of reading: A handbook*. Oxford: Blackwell Publishing, p. 155-172.

Carver, R. 1997. Reading for one second, one minute, or one year form the perspective of rauding theory. *Scientific Studies of Reading, v.1*, p.3-43.

COLTHEART, M. 1978. Lexical access in simple reading tasks. In: UNDERWOOD, G.(Ed.). *Strategies of Information Processing*. London: Academic Press.

_____; CURTIS, B.; ATKINS, P. et al. 1993. Models of reading aloud: dual route and parallel-distributed-processing approaches. *Psychological Review*, v.100, p.589-608.

CRUTTENDEN, A. 1994.The forms of intonation. In: *Intonation*. 4th ed. Cambridge: Cambridge University Press. p. 35-74.

CUMMINS, F.; Port, R. 1998. Rhythmic constraints on stress timing in English. *J. Phon*., v.26, p.145–171.

DAVELAAR, E.; COLTHEART, M.; BESNER, D. et al. 1978. Phonological recoding and lexical access. *Memory and Cognition*, v.6, p.391-402.

EHRI, L. C. 2007. Development of sight word reading: phases and findings. In: SNOWLING, M. J; HULME, C (Ed.). *The science of reading: A handbook*. Oxford: Blackwell Publishing. p. 135-154.

_____. 1998. Grapheme-phoneme knowledge is essential for learning to read words in English. In: METSALA, J.; EHRI, L. C. (Ed.). *Word Recognition in Beginning Literacy.* Mahwah, NJ: Erlbaum. p. 3-40.

_____. 1998. Research on learning to read and spell: A personal-historical perspective. *Scientific Study of Reading*, v.2, p.97-114.

_____. 1998. Word reading by sight and by analogy in beginning readers. In: HULME, C.; JOSHI, M. (Ed.). *Reading and Spelling: Development and Disorders.* Mahwah, NJ: Erlbaum, p. 87-112.

_____. 1999. C. Phases of development in learning to read words. In: OAKHILL, J.; BEARD, R. (Ed.). *Reading Development and the Teaching of Reading: A Psychological Perspective.* Oxford, UK: Blackwell Publishers. p. 79-108.

_____. 2002. Phases of acquisition in learning to read words and implications for teaching. *British Journal of Educational Psychology: Monograph Series*, v.1, p.7-28.

_____. 2002. Reading processes, acquisition, and instructional implications. In: REID, G.; WEARMOUTH, J. (Ed.). *Dyslexia and literacy: Theory and practice*. West Sussex, UK: John Wiley. p. 167-185.

_____; WILCE, L. S. 1979. The mnemonic value of orthography among beginning readers. *Journal of Educational Psychology*, v.71, p. 26-40.

ELLIS, A. W. 1995. *Leitura, escrita e dislexia: Uma análise cognitiva*. Porto Alegre, RS: Artes Médicas.

FOWLER, C. A.; TREIMAN, R.; GROSS, J. 1993. The structure of english syllables and polysyllables. *Journal of Memory and Language*, v.32, p.115-140.

Hulme, C.; Hatcher, P. J.; Nation, K.; Brown, A.; Adams, J.; Stuart, G. 2002. Phoneme awareness is a better predictor of early reading skill than onset-rime awareness. *Journal of Experimental Child Psychology,* v.82, p.2–28.

Jared, D.; Mcrae, K.; Seidenberg, M. S. 1990. The basis of consistency effects in word naming. *Journal of Memory and Language,* v.29, p.687-715.

Juel, C.; Griffith, P. L.; Gough, P. B.1986. Acquisition of literacy: Alongitudinal study of children in first and second grade. *Journal of Educational Psychology*, v.78, n.4, p.243-255.

La Fontain, J. *A rã que queria ser grande como o boi* copied from www.universodasfabulas.hpg.com.br.

Lundberg, I.; Frost, J.; Petersen, O. P. 1988. Effects of an extensive program For stimulating phonological awareness in preschool children. *Reading Research Quarterly*, v.23, p.264-284.

Lupker, S. J. 2007. Visual word recognition: theories and findings. In: Snowling, M. J; Hulme, C (Ed.). *The science of reading: A handbook*. Oxford: Blackwell Publishing. p. 39-60.

Merlo, S. *Hesitações na fala semi-espontânea: análise por séries temporais*. 2006. Texto apresentado para qualificação de mestrado no Instituto de Estudos de Linguagem, Unicamp.

Microsoft Corporation. 2000. *Power Point.* Office.

Monteiro Lobato. 1931. Narizinho Arrebitado*. Reinações de Narizinho*.

Perfetti, C. A. 1985. *Reading Ability*. New York: Oxford University Press.

Plaut, D.; Mcclelland, J.; Seidenberg, M.; Patterson, K. 1996. Understanding normal and impaired word reading:Computational principles in quasi-regular domains. *Psychological Review,* v.103, p.56–115.

Rack, J.P.; Hulme, C.; Snowling, M.J. 1993. Learning to read : a theoretical synthesis. In Reese, H.W. *Advances in Child Development and Behavior*. Orlando, Florida : Academic Press, v.24. p.99-132.

Seidenberg, M. S.; Mcclelland, J. L. 1989. A distributed, developmental model of visual word recognition and naming. *Psychological Review,* v.96, p.523–568.

Share, D.L. 1995. Phonological recoding and self-teaching: Sine qua non of reading acquisition. *Cognition*, v.55, p.151-218.

Snowling, M. J; Hulme, C. 2007. *The science of reading: A handbook.* Blackwell Publishing.

Treiman, R. 1989. The internal structure of the syllable. In: Carlson, G.; Tanenhaus, M. (Ed.). *Linguistic structure in language processing*. Dordrecht, The Netherlands: Kluwer, p. 27–52.

_____; Berch, D.; Weatherston, S. 1993. Children's use of phoneme-grapheme correspondences in spelling: Roles of position and stress. *Journal of Educational Psychology* ,v.85, p.466-477.

_____; Muilennix, J.; Bijeljac-Babic, R.; Richmond-Welty, E. D. 1995. The special role of rimes in the description, use, and acquisition of English orthography. *Journal of Experimental Psychology.General,* v.124, p.107-136.

_____; Fowler, C. A.; Gross, J.; Berch, D.; Weathrston, S. 1995. Syllable structure or word structure: Evidence for onset and rime units with disyllabic and trisyllabic stimuli. *Journal of Memory and Language,* v.34, p.132–155.

Van Orden, G.C.; Kloss, H. 2007. The question of phonology and reading. In: Snowling, M. J; Hulme, C (Ed.). *The science of reading: A handbook*. Oxford: Blackwell Publishing. p. 61-78.

Winkworth, A.; Davis, P.; Adams, R.; Ellis, E. 1995. Breathing patterns during spontaneous speech. *JSHR*, v.38, p.124-144.

Appendix

APPENDIX 1

A rã que queria ser grande como o boi	**The frog that wanted to be as big as an ox**
Certa rã viu um boi e impressionou-se com seu belo porte. Envergonhada com seu minúsculo tamanho, pretendeu encher-se de ar, até igualar o tamanho do grande animal, objeto de sua admiração.	A certain frog saw an ox and got impressed with its beautiful posture. Being ashamed by its tiny size, intended to fill itself up with air, trying to equalize the big animal's size, object of its admiration.
Envaidecida, disse a suas companheiras:	Proud of itself, the frog asked its companions:
– Vejam, irmãs, estou ficando grande? Já igualei meu tamanho ao do boi?	– Watch, sisters, am I becoming bigger? Have I already equalized to the size of the ox?
– Não! – responderam.	– No! – they answered.
– E agora?	– And now?
– Ainda não.	– Still not.
– Agora, penso que consegui...	– Now I think I´ve got it...
– Ainda está muito longe!	– You're still far behind!
A rã, então, foi inflando-se, cada vez mais, até que sua pele, não mais resistindo, se arrebentou.	The frog, then, inflated itself, more and more, untill its skin, not resisting, blew up.
Moral: O mundo está cheio de gente assim. O escravo quer ser rei, o plebeu quer ser nobre, o pobre quer ser rico, e todos, às vezes, têm o mesmo fim da rã.	*Story´s moral*: The world is full of people like this.The slave wants to be king, the plebeian wants to be nobel, the poor wants to be rich, and all, sometimes, have the same end as the frog.

PERGUNTAS:	**MULTIPLE-CHOICE QUESTIONS:**
1) Essa história é sobre: a) uma rã e um coelho. b) uma aranha e um boi. c) uma girafa e um ratinho. d) uma rã e um boi.	1) What is the story about? a) a frog and a rabbit. b) a spider and an ox. c) a giraffe and a mice. d) a frog and an ox.
2) O que a rã pretendia fazer? a) Ficar pequena como uma barata. b) Nadar como um pato. c) Voar como um passarinho. d) Ficar do tamanho de um boi.	2) What the frog intended to do? a) get small like a cockroach. b) swim like a duck. c) fly like a bird. d) become the same size of the ox.
3) A rã tentou: a) comer um bolo de chocolate bem grande. b) beber bastante suco. c) encher-se de ar para aumentar de tamanho. d) engolir um monte de moscas.	3) The frog tried to: a) eat a big chocolate cake. b) drink plenty of juice. c) fill itself up with air to increase its size. d) swallow a whole bunch of flies.
4) O que aconteceu com a rã? a) Foi inflando-se até que sua pele se arrebentou. b) Ficou muito maior que o boi. c) Pulou muito até que se machucou. d) Mergulhou no lago e foi embora.	4) What happened to the frog? a) It got inflated untill its skin blew up b) Got a lot bigger than the ox. c) Jumped a lot untill it got hurt. d) Took a dip into the lake and left.

APPENDIX 2

O peixinho e o besouro no rosto de Narizinho.	**The little fish and the beetle on Narizinho's face.**
Uma vez, depois de dar comida aos peixinhos à beira do rio, Narizinho sentiu muito sono. Deitou-se na grama com a boneca Emília no braço e ficou olhando as nuvens que passavam pelo céu. E já estava quase dormindo quando sentiu cócegas no rosto. Abriu bem os olhos: um peixinho vestido de gente estava de pé na ponta do seu nariz. Vestido de gente, sim! Usava casaco vermelho, chapéu na cabeça e guarda-chuva na mão – na maior elegância!	Once upon a time, after feeding little fishes on the river´s edge, a girl named Narizinho felt sleepy. She laid on the grass with her doll "Emilia" in her arms, and stared at the clouds that passed by in the sky. She was almost falling asleep when she felt ticklish in her face. She opened her eyes wide open: a little fish dressed like human was stand in the tip of her nose. Dressed like people, indeed! It worn a red jacket, with a hat upon its head and an umbrella at hand – very elegantly!
O peixinho não sabia que estava no nariz de Narizinho.A menina nem se mexeu para não o assustar, e ficou assim até que sentiu cócegas na testa. Virou os olhos para ver melhor: era um besouro que tinha pousado na sua testa. Mas um besouro também vestido de gente, usando casaco preto, óculos e bengala. Narizinho ficou bem quietinha porque estava achando muito interessante aqueles dois bichinhos.	The little fish did not know it was on Narizinho's nose. The girl herself didn´t even move not to frighten the little fish and stood like that until she felt ticklish in her forehead. She turned her eyes around to see it better: it was a beetle that landed in her forehead. But a beetle also dressed like people, wearing a black jacket, glasses and a cane. Narizinho stood quiet because she was thinking it was all very intersting those too little beings.
O besouro, que sabia que o peixinho era um príncipe, falou: – Muito boa tarde, senhor príncipe! – Olá, senhor besouro! – foi a resposta do peixinho. – Que novidade traz Vossa Alteza por aqui? – É que fiquei doente e o médico me receitou ar puro do campo. Vim tomar o remédio neste lugar que conheço muito bem, mas encontrei esse morro que me parece estranho – e o príncipe bateu com a pontinha do guarda-chuva no nariz de Narizinho. – Acho que esse morro é de mármore – disse o príncipe. O besouro abaixou-se, examinou o nariz de Narizinho e disse: – Muito mole para ser mármore. Deve ser requeijão.	The beetle knew that the little fish was a prince, and so spoke: – Very good afternoon, Your Highness! – Hello, Mr Beetle! – was the fishe´s reply. – What good news Your Highness bring to this neck of the woods? – The thing is I was sick and the doctor recommended pure air from the fields. I came to get some medicine in this place that I know so well, but I found this little hill that sounds to me so weird – and the prince hit the tip of the umbrella at Narizinho's nose. – I think this hill is made out of marble – said the prince. The beetle laid down and examined Narizinho´s nose saying: – Too soft to be marble. It must be cream-cheese.

PERGUNTAS:	**MULTIPLE-CHOICE QUESTIONS:**
1) Que bichinhos estavam no rosto de Narizinho? a) Uma borboleta e um besouro. b) Um peixinho e um sapo. c) Um peixinho e um besouro. d) Um sapo e uma borboleta.	1) Wich little things were in Narizinho's nose? a) a butterfly and a beetle. b) a little fish and a frog. c) a little fish and a beetle. d) a frog and a butterfly.
2) Qual a cor do casaco do peixinho? a) amarelo b) azul c) verde d) vermelho	2) Wich color was the little´s fish jacket? a) yellow b) blue c) green d) red
3) O peixinho achou que o nariz de Narizinho era: a) um castelo. b) um morro. c) uma árvore. d) uma casa.	3) What did the little fish think of Narizinho's nose? a) It was a castle. b) It was a hill. c) It was a tree. d) It was a house.
4) O besouro achou que o nariz de Narizinho era feito de: a) chocolate. b) sorvete. c) requeijão. d) chiclete.	4) What did the beetle think Narizinho's nose was made of: a) chocolate. b) ice-cream. c) cream-cheese. d) chewing gum.