ANÁLISE DOS ERROS APRESENTADOS POR ADULTOS ILETRADOS AO LONGO DE UM PROGRAMA INFORMATIZADO DE ENSINO DE LEITURA E ESCRITA

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Resumo

A tipologia de erros apresentados por crianças na aquisição de leitura e escrita tem sido amplamente explorada. A análise de erros permite inferir fontes de controle do comportamento ao longo da aprendizagem, sendo por isso um importante instrumento para o aperfeiçoamento de programas de ensino. No entanto, poucos estudos têm explorado a tipologia de erros apresentados por adultos iletrados. Este é um estudo descritivo que teve como objetivo identificar/analisar os erros cometidos por participantes adultos durante o processo de aprendizagem da leitura e escrita, submetidos a um programa informatizado de ensino, visando verificar a adequação do programa ou a necessidade de procedimentos específicos para esta população. Quinze adultos passaram individualmente pelo programa, constituído por uma sequência de passos de ensino e avaliação (pré e pós-testes e testes intermediários). Os erros foram categorizados e analisados com base nas categorias descritas na literatura e categorias novas, criadas especificamente para este trabalho. Os dados mostraram grande concentração de erros em algumas categorias, principalmente para o primeiro módulo de ensino, com indicação parcial de especificidade de tipologia de erros para a população em foco. Os participantes também mostraram dificuldade na escrita (ditado por construção), indicando a necessidade de aperfeiçoamento do programa quando utilizado na alfabetização de adultos.
Palavras-chave: tipos de erros, leitura, escrita, alfabetização de adultos.

ANALYSIS OF ERRORS PRESENTED BY ILLITERATE ADULTS THROUGHOUT A COMPUTERIZED PROGRAM TO TEACH READING AND WRITING SKILLS

Abstract

The typology of errors presented by children in the acquisition of reading and writing has been widely explored. Error analyses allow inferring sources of behavior control throughout the learning process and are an important tool for improving programs that teach reading and writing. Nevertheless, few studies have explored the types of errors made by illiterate adults. This is a descriptive study aiming to identify and analyze the errors made by adults participating in the process of learning to read and write using a computerized teaching program. The purpose was to evaluate the adequacy of the program and to point out whether there is a need to develop specific procedures for this population. Fifteen adults were individually submitted to the program, which comprises a sequence of teaching steps and assessments (pre and post-tests and intermediate tests). Errors made by the students were categorized and analyzed according to categories described in the literature as well as new ones created specifically for this study. The data show a high concentration of errors in some categories, particularly for the first teaching module, with partial indication of error type specificity for the population in focus. This study also shows the participants' difficulties in writing (construction spelling task), requiring improvement of the computerized program when applied to adult literacy.
Key words: types of errors, reading, writing, adult literacy.

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ANÁLISIS DE ERRORES PRESENTADOS POR ADULTOS ILETRADOS A LO LARGO DE UN PROGRAMA COMPUTARIZADO DE ENSEÑANZA DE LECTURA Y ESCRITURA

Resumen

La tipología de los errores presentados por los niños en la adquisición de la lectura y la escritura ha sido ampliamente examinada. El análisis de errores permite inferir fuentes de control del comportamiento durante el aprendizaje, y se constituye en una importante herramienta para perfeccionar los programas de enseñanza. Sin embargo, pocos estudios han explorado los tipos de errores cometidos por adultos iletrados. Este estudio descriptivo tuvo como objetivo identificar y analizar los errores cometidos por adultos que aprenden a leer y escribir, a partir de un programa de enseñanza informatizado, con el fin de verificar la adecuación del programa o la necesidad de desarrollar procedimientos específicos para esta población. Quince adultos se sometieron individualmente al programa, conformado por una secuencia de pasos de enseñanza y evaluación (pre y pospruebas y exámenes intermedios). Los errores fueron clasificados y analizados con referencia a las categorías descritas en la literatura y algunas nuevas creadas específicamente para este trabajo. Los datos muestran una alta concentración de errores en algunas categorías, especialmente para el primer módulo de enseñanza, con indicación parcial de especificidad de los tipos de errores para la población objeto de estudio. Los participantes también presentaron dificultad con la tarea de dictado por construcción, lo cual indica la necesidad de perfeccionamiento del programa utilizado en la alfabetización de adultos.

Palabras clave: tipos de errores, lectura, escritura, alfabetización de adultos.

INTRODUCTION

Error occurrence may be seen, depending on the theoretical framework, as a positive aspect of the learning process (e.g. Davis & Esposito, 1991; Zorzi & Ciasca, 2009, for a point-of-view compatible with cognitive psychology tradition). On the other hand, it may be seen as a deleterious event that must be avoided, since it generates unfavorable emotional subproducts to motivation and commitment during learning, and contributes to the deterioration of previously learned repertoires (e.g. Stoddard & Sidman, 1967; Stoddard, de Rose & McIlvane, 1986; Terrace, 1963).

According to Stoddard et al. (1986), errors are not at random:

(...) errors are not casual occurrences that decrease gradually and peacefully while learning the correct performance takes its place. On the contrary, a teaching program that allows errors to occur offers an opportunity for a student's behavior to be controlled by irrelevant stimuli. This control may remain in the individual's repertoire, preventing learning, leading to deterioration of previous learning, or contributing to maintaining a permanently flawed performance (our translation, p. 18).

Errors are, therefore, responses of a learner under control of aspects of a task that are different from those planned by the educator to be critically relevant elements. This type of stimulus control displacement (de Rose, 2005) may recur in subsequent learning situations, increasing the probability of occurrence of new errors.

Experimental studies have suggested that apparently irrelevant aspects of a procedure, such as stimuli position, similarity between stimuli or even preference for specific stimuli, which result from the learner's previous history may exert control over the participant's repertoire, resulting in incorrect responding during tasks (McIlvane & Dube, 2003; Ray, 1969; Stoddard et al., 1986). Thus, error occurrence may have important implications for learning in general.

However, specifically in learning reading and writing skills, error occurrence may have multiple sources of control. Hence, studies on categorization and specific analyses of reading and writing errors may contribute to teaching such behaviors and, consequently, to academic learning in general.

Under this perspective, it is important to pay attention to factors related to the teaching procedures and to the chosen stimuli (words) in educational and experimental settings. Some of these factors may enable others to avoid the occurrence of errors. During reading acquisition, common errors include substitutions, omissions, and swapping (Cunha & Capellini, 2010; Goodman, 1976, cited by Valle, 1984; Pinheiro, Cunha & Lúcio, 2008), which may indicate characteristics of the reading acquisition progress (Zorzi & Ciasca, 2009).

According to the literature, some factors that influence error production during the reading and writing learning

process include (1) *word familiarity* (Dias & Ávila, 2008; Pinheiro, 2001; Pinheiro, Lúcio & Silva, 2008; Pinheiro & Rothe-Neves, 2001; Salles & Parente, 2002, 2007; Stivanin & Scheuer, 2007), measured by the frequency with which the word occurs in the learner's environment or when he/she is exposed to a specific text, varying from zero (pseudoword) to very frequent words; (2) *word size* (Pinheiro, 2001; Pinheiro, Lúcio & Silva, 2008), measured by quantity of letters, with longer words (regular or non-words) resulting in greater 'processing' time during reading and/or more errors in 5th grade children, which are considered efficient readers. Error incidence has also been negatively correlated to school progression (Capovilla & Dias, 2007; Dias & Ávila, 2008, Nobile & Barrera, 2009).

Overall, these studies have shown that the less familiar the words are to the learner, and the longer the words are (except in Dias & Ávila, 2008),the greater is the occurrence of reading and writing errors (for example, pseudowords). The studies also showed error reduction as children progress in the school system, increasing their reading experience (Nobile & Barrera, 2009).

It has also been reported that errors occur due to control by specific parts of the stimuli used – what has been called partial or restricted control (Alves, Kato, Assis, & Maranhão, 2007; Domeniconi, Costa, de Rose, & de Souza, 2009; Dube & McIlvane, 1997; Hora & Benvenuti, 2007; Stromer, McIlvane, Dube, & Mackay, 1993). This type of occurrence may be exemplified in learning the words "popcorn" and "popsicle". A child may have learned to say "popcorn" when shown the written word "popcorn" by paying attention solely to the first syllable. When coming across a new word that starts with "pop", for instance "popsicle", that child may read "popcorn". This type of error shows us that the response "popcorn" is under control exclusively of the first syllable, "pop".

A good educator should be able to identify which aspects of the environment control the learner's behavior. Error occurrence may guide educators in (re)planning their procedures, strategies, and didactic materials instead of being considered commonplace and inherent to the learning process. Error analysis constitutes a powerful tool in unraveling a learners' trodden path as well as the strategies they use.

A wide variety of error types in the process of learning reading skills may be mapped in numerous studies that had children as participants (Dias & Ávila, 2008; Pinheiro, 2001; Cagliari, 1989, and Carraher, 1990, cited by Zorzi 1997; Zorzi & Ciasca, 2008; Zuanetti, Corrêa-Schnek, & Manfredi, 2008).

Pinheiro (2001), for example, identified the following types: phonetic regularization (grapheme with irregular phoneme used as a regular phoneme: *boxe* vs. *boche*), tonal accent (accenting the wrong syllable: *café* vs *cáfe*), change in vowel qualities (student reads an "open" vowel as "closed" and vice-versa: *vovô* vs *vovó*), translation flaws ["confusion between vocalized – sound – and non-vocalized – deaf – consonants, and between consonants with similar forms, vowel swapping and addition or subtraction of syllables, nasals and post-vocal consonants – r, s, l or n" (our translation, p. 543), and contextualization (i.e. flaws using contextual rules, such as ignoring that, in Portuguese, the letter "s" sounds like a "z" when placed between vowels].

Another study (Zuanetti et al., 2008) found that the most common errors in learning to write were: irregularities; changing, adding, and omitting letters; nasalizing; syllable omission; hypercorrection (i.e. the student learns that not everything is written as it is spoken and starts to "correct" words that were already correct); oral support and accentuation (i.e. writing words as they are spoken).

In a spelling task, Zorzi and Ciasca (2008) reported that the most common errors were: multiple representations (graphemes with more than one phoneme option), letter omissions, and oral support/speech transcription.

Data presented by the above mentioned studies lead to suppose a diversity of aspects in teaching procedures that may originate responses considered to be incorrect in reading and writing tasks. A program for teaching reading and writing must be prepared to identify the types of errors committed by participants. Once such errors are identified, it is possible to develop corrective procedures or even, most desirably, improve the program so as to prevent them.

Considering the critical importance of efficient procedures for adult literacy, it is surprising that only a few studies have explored error typology in reading and writing by youth and adults. The aforementioned studies were conducted with school children. The only exception was Zorzi and Ciasca (2008), who included middle school children and high school adolescents, but did not compare errors between age groups. This gap is especially critical because, as previously pointed out, different types of errors suggest different adaptations of corrective procedures and even specific improvements in standardized programs.

Error patterns presented by adults who are learning to read and write may be different from those found in children, especially considering their extensive life history and exposure to relevant stimuli (written and spoken words). Knowledge on error typology in learning writing and reading by illiterate adults may subsidize future decisions

regarding the possible need for creating specific literacy programs for this population.

With this concern in mind, the present study had the objective of identifying/categorizing errors (types and quantities) committed by illiterate adults during a process of learning to read and write, using a computer software called "Learning to read and write in small steps" (*Aprendendo a ler e a escrever em pequenos passos* – ALEPP; Rosa Filho, de Souza, de Rose, Fonseca & Hanna, 1998). This computerized version was developed after successful tests with conventional materials (de Rose, de Souza & Hanna, 1996; de Rose, de Souza, Rossito & de Rose, 1989).

In the version used here, the teaching activities were managed by a software platform that displays the activities and records all students' responses (correct and incorrect) on an online database, guaranteeing precision in control and recording of the literacy process. The ALEPP program has been applied in large scale with school children and has been efficient in teaching sets of words as well as showing effects on generalized reading and writing (Alves, Assis, Kato, & Brino, 2011; Benitez & Domeniconi, 2012; de Souza, de Rose, Faleiros, Bortoloti, Hanna, & McIlvane, 2009; Felippe, Rocca, Postalli, & Domeniconi, 2011; Lima, de Souza, Martinez, & Rocca, 2010; Reis, de Souza, & de Rose, 2009; Souza Junior, Monteiro, Pereira, Barros, & Marques, 2012).

ALEPP has also been used with illiterate adults (Bandini, Bandini, Sella & de Souza, 2014) and general results (percentage of correctness in pre and posttests) have replicated those for children. However, the authors did not analyze the types of errors presented by the students throughout the teaching procedure, which would have been useful for a better understanding of this population learning process, as intended by the present study.

METHOD

The present study is descriptive, as it identified and categorized errors committed by adults while learning to read and write using a computerized teaching program.

Participants

Fifteen illiterate adults (eleven men and four women), aged between 17 years and 6 months and 62 years and 2 months, participated in this study. Thirteen participants were enrolled in two Youth and Adult Education (YAE) classes in a municipal school in the state of São Paulo, Brazil; two did not go to school. All of them had at least one interruption in their school career, either because they had difficulty in reconciling work and study, or because they lived far away from schools (farms around urban areas).

Two participants only started attending school as adults. None had any diagnosis of cognitive or developmental disorders, nor any indication or evaluation that would lead to considering them as possessing any degree of cognitive deficit. Teachers' reports (for those that attended school) and an evaluation conducted by one of the researchers indicated, for all participants, low or null scores for reading isolated words. Before effectively starting the program, participants signed the Informed Consent Form, which was read and explained by the teacher and/or some participant's relative.

Instruments, materials, and experimental setting

Three notebooks, note-taking material, recording sheets for the participants' daily activities and the computerized teaching modules were used in this study.

The program was conducted at the school attended by the participants at night (YAE classes) for 13 participants. Two participants that did not attend school participated at home during afternoons. During data collection, only the researcher and participants were in the room. Each participant worked individually at a computer, which presented the teaching material in discrete trials, involving visual and auditory stimuli. To avoid interference among students, computers were set so that students would not see each others' screens; moreover, each participant used headphones.

Two initial modules of the "Learning to read and write in small steps" program were used.

In Module 1, 60 regular Portuguese words were taught, composed of two or three consonant-vowel syllables, for example: *bolo* (cake), *loja,* (store) *luva* (glove), *mala* (suitcase), *pato* (duck), *pipa* (kite), *rede* (hammock), *suco* (juice), *tatu* (armadillo), *vaca* (cow), *cavalo* (horse), *gaveta* (drawer), *janela* (window), *menino* (boy), *salada* (salad), *tomate* (tomato). These were distributed in 20 teaching steps (three words per step). Details regarding content, sequence, and procedures in each step may be found in previous publications (de Rose et al., 1996; de Souza et al., 2009; Reis et al., 2009).

Module 2 comprises a teaching program of 320 irregular words, called "linguistic difficulties" because they result in learning difficulties. Activities are distributed into 80 teaching steps (four words per step), which are organized in 20 units. Each unit is to teach one set of 16 words (four steps) with the same difficulty (or "learning problem"), so that each module may be taught altogether or by unit. The configurations of the text units that represent the target "difficulty" for each unit (one example of each) were: **ç** (*moça*); **c** that sounds like **s** (ce-ci: *cebola*, *vacina*); **lh** (*milho*); **nh** (*dedinho*); **ch** (*chave*); **g** that sounds like **j** (ge-gi: *gema*, *magia*); soft **r** (*farofa*); **s** that sounds like **z** (s between vowels: *vaso*); **que-qui** (*queijo*; *quina*); **x** that

sounds like **ch**(*lixo*); **ã-ão**(*rã*; *pavão*); **gue-gui** (*gueto*, *guia*); and the consonant clusters **rr** (*carro*), **ss** (*massa*), vowel-r-consonant (**VrC**: *farda*), vowel-s-consonant (**VsC:** *pista*), vowel-n-consonant (**VnC**: *canto*), vowel-l-consonant (**VlC**: *palco*), consonant-r-vowel (**CrV**: *fruta*), consonant-l-vowel (**ClV**: *globo*).

In both modules, discrete trials involved matching dictated and printed words, copying with word construction (constructing a word that is equal to the sample-word displayed at the upper-center area of the screen, by choosing each letter from a set displayed at the bottom area of the screen), spelling with word construction (constructing a word by letter selection, with a dictated word as sample), handwritten spelling. Module 1 also displayed matching trials between dictated words and figures, printed words and figures (and vice-versa), and dictated and printed syllables.

Procedure

1. Applying the teaching program

All participants went through an initial computerized evaluation of reading/writing simple/regular words (i.e. no difficulties), called Module 1 Pre-.evaluation. Each adult was assigned a percentage of performance precision in this assessment as their starting point in the teaching and evaluation sequence. Participants could be assigned to Module 1 (precision below 70%), to Module 2 Pre-evaluation (precision greater or equal to 70%), or to Module 2 (precision below 70% in the Module 2 Pre-evaluation).

Teaching sessions were conducted daily from Monday to Friday (but students' assiduousness defined how many sessions were conducted weekly). Students could complete up to three steps (of teaching, or teaching and evaluation) in one session, depending upon their disposition. They could also interrupt the sessions at any moment (as stated in the Informed Consent Form).

Generally, two or three computers were used simultaneously. Each participant would sit in front of a computer, with their headphones on, for the session to begin. Teaching and test trials occurred in succession and the participant had to actively respond to complete a trial and proceed to the next one. Response requirements depended on the type of task:

Reading tasks

Receptive reading or word or syllable recognition; reading with comprehension; oral reading (or textual behavior).

Selection responses: The trial began with a sample, or conditional, stimulus (a dictated word or syllable, a printed word, or a figure). Next, comparison, or choice, stimuli were presented (printed words or syllables, or figures). The student's task was to choose (by mouse click) the word, syllable, or figure that corresponded to the sample, among those displayed on the screen simultaneously. In receptive reading, or recognition, the sample was dictated and the comparison stimuli were printed words or syllables; reading with comprehension was measured by matching between figures and printed words and vice-versa.

Naming response (oral production): One printed word, syllable or letter was displayed on the upper-center portion of the screen. In this task, the learner was instructed to read out loud what was printed and the experimenter recorded, using the keyboard, whether the response was correct or incorrect. When incorrect, the experimenter also recorded what the participant read/said. A transcription was recorded in a file but was not displayed on the screen.

In Module 1, oral figure naming (one figure per trial, displayed on the upper-center portion of the screen) was also required even though it was not characterized as a reading task.

Spelling task

Participants would write the words or syllables dictated by the computer. This response could be handwritten (using paper, pencil, and eraser) or constructed on the computer. In the latter, many letters were displayed on the bottom of the computer screen, in an area called "choice catalog", and the participants would mouse-click on the letters, which moved to a superior portion of the screen and were displayed in order of selection, forming a word. Responses in the handwritten spelling task were recorded by the experimenter, who typed the "correct" key or, in case or error, typed literally what the student wrote on paper. Construction spelling responses were automatically recorded by the computer.

Copying task

When a word or syllable was presented on the upper portion of the computer screen (sample), the participant would compose the syllable or the word by choosing letters (or syllables) among the options (letters or syllables) exhibited on the list.

In the teaching tasks (reading, spelling, and copying), a selection by the participant or a recording by the experimenter immediately produced an auditory feedback for correct answers (sounds, praises, clapping, among others) and the next trial. Errors produced either an informative message (for example "No, that's not it") or a repetition of the same trial. During test trials there was no feedback for correct or incorrect answers.

2. Categorization and error analysis

For each participant, all incorrect answers in the reading and spelling (written or by construction) tasks were identified and separated according to the task, the study

phase (pre-evaluation and tests during teaching) and by modules (1 and 2).

Initially, each error was evaluated according to its possible pertinence to one of the 14 categories reported in the literature (Barrera & Maluf, 2003; Cagliari, 1989, and Carraher, 1990, both cited by Zorzi, 1997; Nobile & Barrera, 2009; Salles & Parente, 2002, 2007; Zorzi & Ciasca, 2008; Zuanetti, Corrêa-Schnek & Manfredi, 2008). However, a large amount of incorrect answers produced by the participants in this study did not fit in any of these 14 categories. Thus, it was necessary to create nine other categories. A categorical framework including 18 categories was then established (Table 1 – Appendix). Categories found in the literature or created by the experimenters that were not adequate to illustrate the errors analyzed in this study were excluded from the table (Categories 1, 3, 10, 13, and 18). In order to guarantee data reliability the table's original numbering was maintained, without the excluded categories. A total value (N) of the frequency of error occurrence was obtained for each category.

Agreement between assessors

An independent assessor was trained to categorize errors using the categorical framework. Agreement was entirely assessed (100% of the data) for Module 1 and assessed through sampling (10% of the data) for Module 2. For each category, the procedure to assess the agreement index was to divide the smaller N (Assessor 1 or 2) by the larger N and then multiply by 100. Thus, for example, if Assessor 1 assigned N=12 to a certain category and Assessor 2 assigned N=13, the agreement index would be: 12/13 x 100 = 92.30. The agreement rate between independent assessors was 88.5% for Module 1 and 93% for Module 2.

RESULTS

The data obtained were analyzed regarding the identified categories, the quantity of errors (frequency) per category, a comparison between the occurrence of errors in Modules 1 and 2 in their totals and for each task (reading, spelling by construction and handwritten spelling). The frequency of errors per categories considering the pre-testing activities and tests during teaching was also analyzed.

Out of the 15 participants submitted for pre-evaluation, seven initiated the Program with Module 1 and only two of them advanced to Module 2. Eight participants initiated the procedure with Module 2: five because in the pre-evaluation they did not obtain the criterion of 70% of correct answers in writing, although they had shown precision above 70% in reading; and three because they obtained scores lower than 70% in both reading and writing. None of the participants completed Module 2.

In the set of teaching and evaluation steps executed by the participants, 433 errors were identified in the execution of Module 1 and 1668 during Module 2. This difference is understandable considering Module 2 involved teaching words with linguistic difficulties.

Table 1 (See Appendix A) presents the categories used to classify the errors made by participants (categories described in the literature and categories created for the study).

Classifiable errors for six of the 14 pre-existent categories were not identified during Module 1 (resulting in 42.9% of categories with N=0) and were not found for four of the 14 categories for Module 2 (21.4% of categories with N=0); 61% of the errors identified in Module 1 and 13% in Module 2 were classified according to one of the new categories. Errors in the new categories were mostly concentrated in category 17 for Module 1 and Categories 17, 11 and 21 for Module 2.

Regarding the frequency of errors per category, the data show that the prominent categories with the highest incidence in Module 1 were 17 (saying *I don't know* or writing a disorderly set of letters, with 55% of the errors) and 6 (switching, adding or omitting letters with 25.5% of the errors). Together, the errors in these two categories accounted for 80.5% of the errors in Module 1. Among the categories with moderate incidence of errors were 16 (phoneme discrimination between two graphemes, with 5%), 11 (graphic similarity between letters, with 2.3%) and 7 (swapping, adding, or omitting syllables, with 4%).

Only 8.3% of the errors occurred in the other categories, which indicates a high concentration of errors in only five categories. The larger quantity of errors in category 17 is explained by the fact that it encompasses typical errors of nonreaders (saying *I don't know*, or saying or writing a word totally distinct from the word presented as the sample or even writing a set of meaningless letters). Figure 1 shows such data.
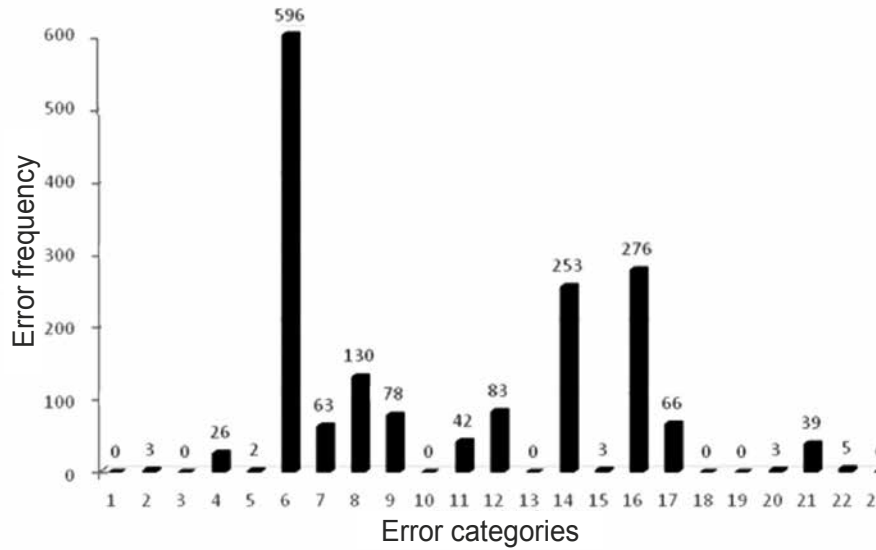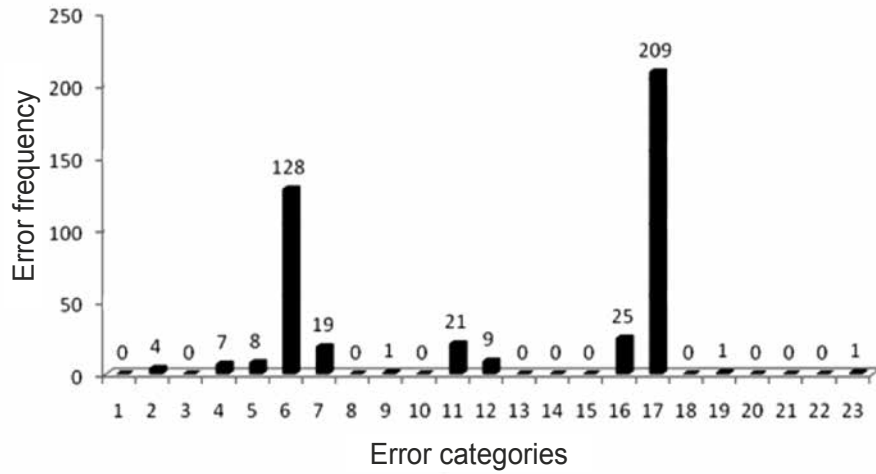
Figure 1. Frequency of error categories (1 to 23 on X axis) during Module 1 (upper panel) and Module 2 (lower panel)

The categories with the highest incidence in Module 2 were 6 (swapping, suppressing and adding letters, with 35.7% of errors), 16 (phoneme discrimination between two graphemes, with 16.5%) and 14 (swapping complex syllables for simples syllables, with 15.2% of errors). Together, the errors in these three categories account for 67.4% of the errors in Module 2. The categories with moderate incidence of errors were 8 (nasalization difficulties, with 7.8%), 12 (direct speech transcription, with 5% of errors), 9 (when a grapheme has two possible phonemes and the incorrect one is chosen, with 4.7%), 17 (with 3.9%) and 7 (swapping, omitting or adding a syllable, totaling 3.8% of errors). Only 7.4% of the errors occurred in the other categories.

Figure 2 shows the distribution of errors, divided by task (reading, handwritten and construction spelling). The figure also considers the separation between pre-evaluation and errors during testing in the teaching phase (even though an evaluation of the efficiency of the teaching program is not the central focus of the present study).
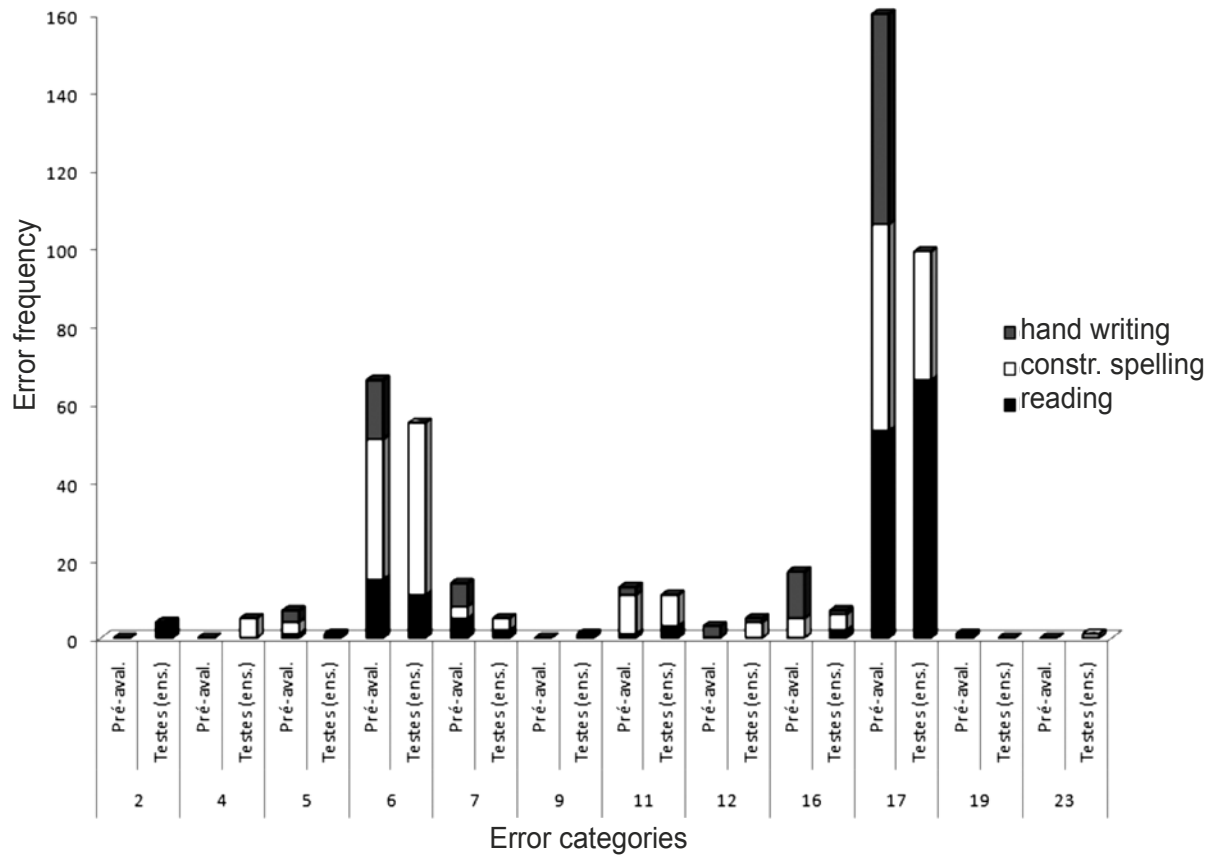
Figure 2a. Frequency of error categories (only for values greater than zero), in the reading, construction, and hand written spelling tasks, during the Pre-evaluation (before starting the teaching program) and tests throughout the teaching program – Module 1.

Data from Module 1 show great efficiency of the teaching program to reduce errors in the handwritten spelling task, in Category 6 as well as Category 17 (see difference between pre-evaluation and teaching). The program also demonstrated efficiency in reducing errors in Categories 5, 7, 11 (specifically for handwritten spelling) and 16 (reading and handwritten spelling).

Data from Module 2 in Figure 2 systematically demonstrate the efficiency of the teaching program in reducing errors between the pre-evaluation and the evaluations during teaching, in the handwritten spelling (Categories 8, 9, 14, 16, and 21) and reading tasks (Categories 6, 7, 8, 9, 11, 16, 17).

Persistent errors in the pre-evaluation and the tests during teaching allow to infer participants' difficulties in the construction spelling task in various categories for both modules (e.g. Categories 6, 17, but also 11, 16, and 7 from Module 1; Categories 6, 14, and 16, but also 7, 8, 9, 11, 12, and 17 from Module 2).
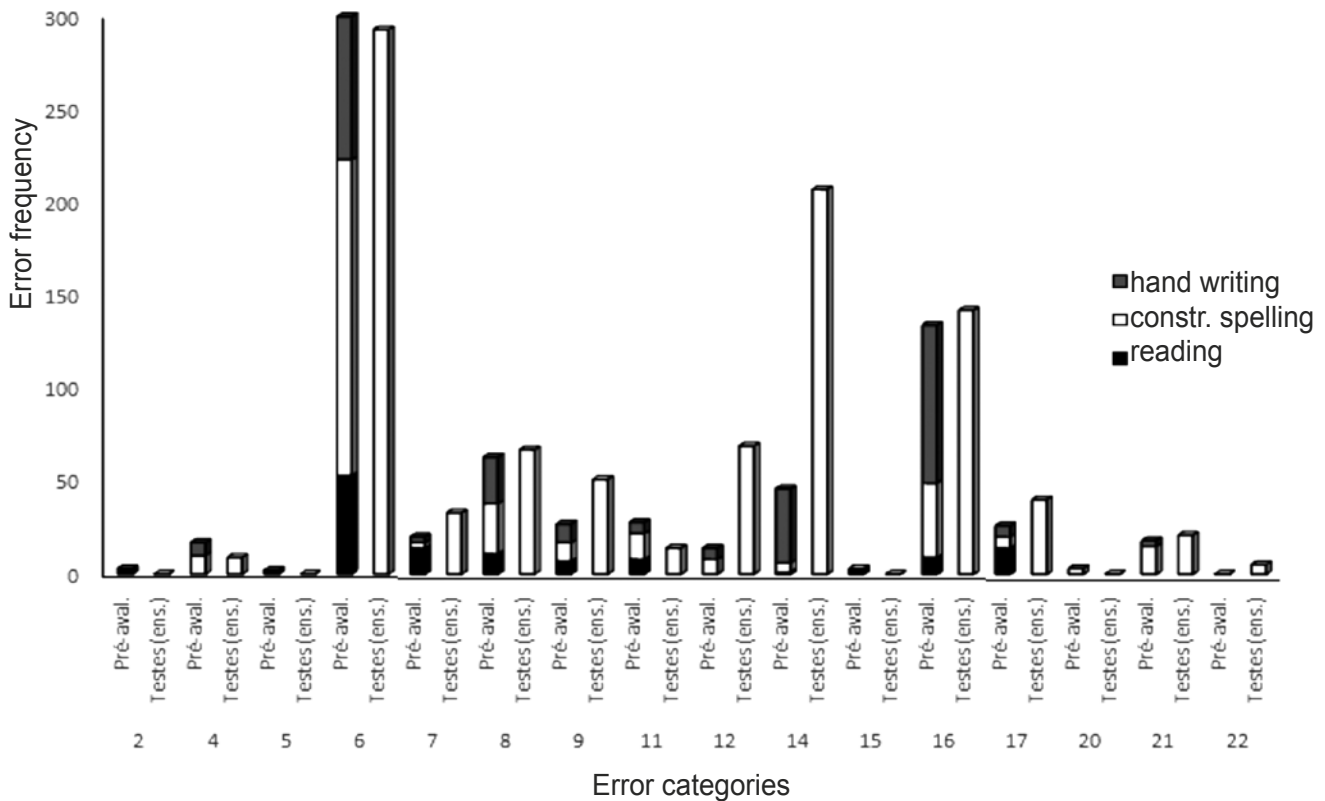
<u>Figure 2b.</u> Frequency of error categories (only those greater than zero), in the reading, construction, and hand written spelling tasks, during the Pre-evaluation (before initiating the teaching program) and tests throughout the teaching program – Module 2.

DISCUSSION

This study explored the identification and categorization of errors made by illiterate adults during the reading and writing learning processes with a computer based teaching program. As previously pointed out, error analysis is an important source of identification of deficiencies in teaching programs and may indicate a direction for improvement and creation of specific tasks that overcome the source of error control. Furthermore, this may suggest lines of research that explore teaching conditions compatible with the initial repertoires of illiterate youth and adults with the purpose of successful teaching. Thus, the occurrence of a large quantity of errors that negatively interfere with learning would be avoided (McIlvane & Dube, 2003; Stoddard et al., 1986; Stoddard & Sidman, 1967).

Data displayed in Table 1 (Appendix) suggest a certain specificity of the typology of errors observed in teaching adults to read and write in relation to the typology of errors reported in the literature, especially regarding Module 1. This, however, is a speculation that points to the direction of future research, in which the difference in typology of errors should be experimentally analyzed comparing a group of adult participants with a group of children.

Data presented in Figure 1 show that, although a greater variety of categories than those reported in the literature (c.f. Table 1) was mapped, the errors are concentrated mainly in two (17 and 6) categories for Module 1 and three (6, 16, and 14) for Module 2. Therefore, data obtained in the present study do not allow us to consider a larger variety of types of errors with adults solely because it was necessary to create new categories.

The inexistence, in the literature, of data on error analysis with children that used the same computer based program makes it impossible to assert with precision which aspect of the study (specificity of participants [adults] or procedures) was responsible for the occurrence of these new error categories.

Data presented in Figure 2 indicate the importance of carefully planning teaching programs for illiterate youth and adults regarding the construction spelling task. It is possible that construction generated persistent errors due to participants' restricted experience with computer based resources. The data show that participants performed better when the spelling task was handwritten. It is possible that precise performance may also have been obtained with spelling by construction using manageable, three-dimensional wooden letters (such as the sticks employed by Hanna, de

Souza, de Rose, & Fonseca, 2004) or rubber ones (EVA), so that the students would be able to construct the words, even with unsophisticated manual skills. This, however, is an issue to be verified experimentally.

The use of a mouse, keyboard, and monitor differs greatly from the use of pencil, paper, and blackboard. A significant quantity of letter mix-ups was due to the confusion involving graphic similarity between the letters available to be chosen in the construction spelling task (where a limited set of letters is presented on screen and the participant chooses the letters that compose the word in supposedly the correct sequence). Errors tended to occur, for example, in cases where the options were similar in form (t-f, i-l, m-n, h-n, u-n, p-q, d-b, g-p...). This type of error corresponds to one of the new categories (number 11). Other examples that are clearly linked to the specificity of the method applied are categories 22 (lack of understanding of the acoustic model) and 23 (non-textual factors), which group errors due to the use of technology, such as difficulty in discriminating the acoustic word dictated by the computer (female voice recorded and presented using speakers) or clicking outside the correct area on the screen.

However, the advantage of computer-based construction spelling is that the system provides immediate feedback for right or wrong responses with no need for monitoring by an instructor (which allows large scale applications, with no need to have a large number of instructors). Handwritten spelling tasks make it necessary for the student to wait for the instructor's feedback. This is why it is advisable that computer-based programs foresee an initial stage of learning basic computer skills for this population; so as to maintain computer construction tasks without inducing errors. Also, this may have a positive impact in terms of motivating and engaging participants (Stoddard et al., 1986).

Data presented in this study show that the adopted methodology is promising in order to explore an aspect that seems central to this area of study: the search for more complete knowledge on typology and diversity of errors in alphabetization with different populations and its different sources. The present study is an initial step in mapping the types and nature of errors found in the acquisition process of reading and writing by youth and adults, considering the variety of types of errors already reported in the literature. Further investigations on this typology of errors could be conducted with experimental studies that explore variables such as types of procedures (computer based or not) and materials used (two or three-dimensional, manageable or not), as well as the quantity of exposure to relations between printed and written words (by selection or by production of oral and written responses). It would also be important to

isolate aspects of schooling experience of adult participants (would there be differences in performance among those who had some degree of schooling interrupted a long time ago and those that have no academic experience?).

Comparison between groups of children and adults would also benefit from greater data volume and especially from data collected under similar teaching and testing conditions. A limitation of the present study is the fact that the data are based on the application of a computerized system and the categories found in literature are based on studies that in general do not follow this format. Although the application of this very same computer software is being carried out in large scale at municipal schools in the state of São Paulo (de Souza et al., 2009), specific studies on the typology of errors have not been conducted. It is suggested that subsequent studies on the present analysis also conduct error data analysis with children (target audience of the original program) with the purpose of obtaining a mass of data base concerning error typology compatible with what was reported here.

Additionally, specific studies on the efficiency of this computer based program with illiterate adults should be (and are being) developed. Evaluating the learning process of reading and writing implies assessing the conditions in which learning occurs, that is, the training conditions programmed by the educator, rather than evaluating performance *per se*. If such conditions do not result in learning of the programmed content, then they should be revised. Thus, one should consider the adaptation between the learner's initial repertoire and the initial content, the quality and quantity of necessary instructions and those effectively provided for task completion, the organization of content (sequence, unit size, among other aspects) and the quality and quantity of feedback provided.

The analysis conducted in this study does not fully answer the question of the program's efficiency in reducing errors, but indicates a need to investigate the program organization (quantity and sequence of reading and writing activities, word choice, moment of presentation of pseudo words or generalization words [words composed by reorganizing the letters and syllables of words that were taught only during testing, with no feedback]), and consider reformulations that could improve its efficiency and efficacy in the assimilation of both of these abilities.

For example, one could consider planning the learning process of writing from the beginning. In the system's current structure, only in Module 2 writing skills are required as a criterion to proceed to the teaching steps. In Module 1, writing trials are only probes (monitoring the emergence of writing), where incorrect answers do not generate planned

steps to teach the ability. Adding direct teaching of writing in Module 1, with only a few regular words (controlling less complex stimuli), may result in a lower quantity and diversity of errors in the development of writing skills, improving not only learning to write, but also learning to read, since previous studies have indicated that teaching one skill contributes to learning the other (Reis, Postalli, & de Souza, 2013).

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APPENDIX A

Nº	Error Categories	Description	Example(s) in Portuguese
2	**Hipersegmentation**	**The student separates the words incorrectly with an excess of segmentation.**	Writes *EU QUE RO U VA* instead of *EU QUERO UVA*.
		Separates syllables during reading or vocalization of the word when writing during dictation.	*Separately reads the syllables RA-PO-SA, CA-RE-CA.*
			Reads *RAPOSA* with a mild R.
4	**Lack of knowledge of contextual rules**	The student lacks knowledge that certain letters do not precede others, or that the same letter has a different sound when at the beginning of a word or when "in the middle" of a word, *or even, that in oxytone words the tonic syllables (last) ending in (a), (e) and (o) must always be accentuated.*	Writes *COMTO* instead of *CONTO*. *LENBRAR* instead of *LEMBRAR*. Writes *CAFÉ* instead of *CAFÉ, VOVO* instead of *VOVÔ, SOFA* instead of *SOFÁ.*
5	**Neologisms**	**The student does not know the word that is being read and creates a new one, based on the reading lexical route – syllables with sonority already known by them.**	*Reads SANGADO instead of ZANGADO, or SAVALO instead of CAVALO. Writes CACOLA instead of SACOLA.*
6	**Swapping, omission or addition (of letters)**	**Self-explanatory name. The student swaps the correct letter for a different one, does not use the correct letter or uses more letters than necessary.**	Swaps: writes *PREÇO* instead of *PRE-SO.* Omits: writes *MAO* instead of *MATO*. Adds: *writes DTODO* instead of *DEDO.*
7	**Swapping, omission or addition (of syllables)**	**Self-explanatory name. The student swaps the correct syllable for a different one, does not use the correct syllable or uses more syllables than necessary.**	Swaps: Reads *LUGAR* instead of *LUPA*. Omits: Reads or writes *PACA* instead of *PAÇOCA*. Adds: Reads or writes *BATATA* instead of *BATA*.
8	**Nasal problems**	**The student cannot replicate in writing what is spoken in the case of nasal sounds – m, n and n, h are classic examples; thus seeking letters and known combinations with similar sonority or omitting certain nasal sounds.**	Writes or reads *CASADO* instead of *CANSADO*; *ENCOTROU* instead of *ENCONTROU*. *Writes GALINEA instead of GALINHA.*
9	**Multiple representations**	**The student needs to read a grapheme that has more than one possible phoneme (sound) according to its lexical route, and opts for the incorrect option.**	*Reads TOSSO instead of TOCO.*
11	**Graphic similarities between letters**	**Self-explanatory name.** **The student incorrectly selects a letter that has some resemblance to the other (correct) in the construction or handwritten spelling task.**	*Chooses the letter **d** instead of **b** or **b** instead of **d** (digobe [bigode], dico [bico], tagete [tapete]), **n** instead of **u**, **h** instead of **n**.*

Nº	Error Categories	Description	Example(s) in Portuguese
12	**Direct speech transcription**	**The student writes the same way he or she speaks.**	Writes *BULI* instead of *BULE*; *DEDU* instead of *DEDO*; *ROPA* instead of *ROUPA*, *TUMATI* instead of *TOMATE*.
14	**Complex syllables**	**The student cannot decode non-regular syllables, in other words, in a format other than consonant-vowel and makes an error.**	Writes or reads *PARAIA* instead of *PRAIA*; *FEREVO* instead of *FREVO*.
15	**Super correction**	**The student strives not to make mistakes when he or she realizes that writing is not completely the same as speaking and starts correcting words that do not obey this rule.**	*Writes VIO* instead of *VIU*; *ALTORA* instead of *AUTORA*.
16	**Concurrence**	**This happens when there are concurrent letters – two graphemes (letters) with the same phoneme (sound) or very similar sonority – and the student opts for the incorrect letter when writing.**	Writes *GILÓ* instead of *JILÓ*; *ÇAMBA* instead of *SAMBA*; *APELHA* instead of *ABELHA*. *Writes PONECA* instead of *BONECA*.
17	**Complete lack of knowledge of the word**	The student does not know how to read or write a certain word nor its smaller units (syllables and letters). Thus, either he does not read or makes a mistake when he attempts to do it.	Says 'I don't know' before the written words DEDO, or dictated word SUCO; or writes several letters together ("fauvlb") when the command was to write the word "LUVA".
19	**Lacks knowledge of the syllable**	The student does not know the pair or trio of letters that he or she should read or write and chooses another syllable.	Says 'I don't know' before the written syllable BA; Reads GU instead of TA.
20	**Swaps or omits letters in a syllable**	The student switches the letter of a syllable for another, or omits one of the [letters].	Writes O instead of GO; reads CA instead of FA.
21	**Inversion of the position of the syllable or letter in the word**	Self-explanatory.	Writes FAAC for FACA.
22	**Incomprehension of the sonorous model [2]**	The student does not hear the command very well, or hears it and does not comprehend it, and selects or writes a similar word.	Selects 'LUA" with the command "LUPA".
23	**Non textual factors**	The student has demonstrated good reading and writing knowledge in other tasks, but makes mistakes because he or she is distracted, tired, makes technical failures during the task (clicking on the wrong place on screen), among others.	The participant–that already demonstrates reading and writing repertoires, selects the word ROUPA at the command "VIOLINO".

Note: Names and descriptions from categories found in the literature are in bold.

[1] Barrera & Maluf (2003); Cagliari (1989) and Carraher (1990) cited by Zorzi (1997); Nobile & Barrera (2009); Salles & Parente (2002, 2007); Zorzi & Ciasca (2008); Zuanetti, Corrêa-Schnek, & Manfredi (2008).

[2] Some occurrences of these types of errors were accompanied by verbalization of the student who was not sure of having heard correctly.