

On the use of IT for treating aphasic patients: a 3D web-based solution

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Abstract: This software platform was designed to be a complementary aid in the process of rehabilitating aphasic Portuguese speaking patients. A variety of exercises are provided to the user, in order to train the different components of linguistic skills, such as: reading, speaking and writing. Most of the tasks are conducted in a three dimensional environment, where the user can interact with domestic objects with the aim of promoting a treatment as natural as possible. The platform main particularities lie in the fact that the application is hosted online, does not require an installation of any specific software and allows a remote monitoring by the patient's speech therapist.

Key-Words: 3D virtual environment, web-based application, serious game, stroke rehabilitation software, aphasia.

1 Introduction

1.1 Aphasia

Aphasia is a language and speech disorder resulting from a lesion in an area of the brain responsible for language processing. Depending on the severity, the patient may have a non-coherent speech (phonological errors) and very limited linguistic understanding of speech [1].

1.2 Rehabilitation

The process of rehabilitating aphasia can be time consuming, going through the traditional methods of treatment, in which the speech therapist asks to the patient to perform various types of speech and linguistic exercises according to the patient's condition. Repetition of the tasks is a key point in the rehabilitation process [2][3]. Another approach is to use IT (Information Technology) as a complement to the traditional treatment. Several studies have confirmed the effectiveness of such approach in the treatment of aphasia [3][5]. One of the great advantages of this method is its flexibility, considering the fact that the patient can complete the exercises anywhere, anytime [4]. In this particular project the only requirement is a computer with an

internet connection that provides an access to the web-based application.

2 System's Architecture

The system architecture is organized by interface, game engine, and online server (Fig.1).

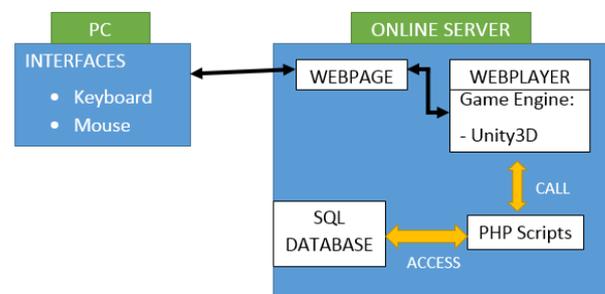


Fig. 1. System's architecture.

2.1 User Interfaces

The interfaces available for the tool use are those most commonly used when discussing the use of a computer, which means keyboard and mouse. In order to reach the largest spectrum of the population, it is important to keep the most usual types of user interface to interact with the system.

2.2 Game Engine

The game engine used to develop this serious game is Unity3D. The freeware version enables us to create several 3D and 2D environments and program them, through the integrated development environment MonoDevelop, in a rather quick and intuitive way [7].

2.3 Online Server

The key point of the tool is based on the fact that it is hosted online (no local installation required) alongside with a server database that stores the performance of each patient. This architecture has the advantage of giving more freedom and autonomy to the user, who can carry out exercises whenever and wherever he/she wants, as long as the computer is connected to the internet. In addition, the centralization/distribution of the information on a server makes possible an almost real-time monitoring of the patient by the speech therapist, who can check the patient's progress and adapt his/her workload accordingly.

The data communication is done as follows: on the user side, a request is sent by JavaScript (read/write) and, on the server side, the request is executed through a PHP script (used for reading and writing, in SQL, into the database).

3 Description of the Application

The software used for developing this application is Unity3D for the game engine and 3DSMax Autodesk for modelling 3D objects. Due to the fact that Unity provides a Plug-in to run the application in an internet browser, it is easy to integrate it in the website, which is built in Joomla.

Tasks are designed by speech and language therapists and divided into four groups, as follows: written expression, listening comprehension, written comprehension and completion of motor tasks (Fig.2). The whole task takes place in a virtual representation of a flat (Fig.3). Each task is composed of a set of specific exercises (Fig.5, Fig.7, Fig.8 and Fig.14).

The entire patient's information, from personal data to performance recording, is stored in a web-based database, which can be consulted by the speech therapist and the patient himself/herself.

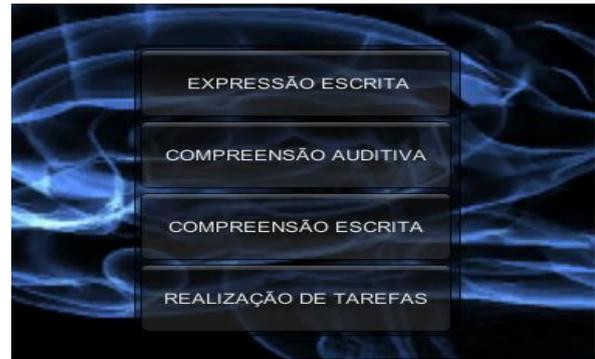


Fig. 2. Four groups of tasks: written expression, listening comprehension, written comprehension and completion of motor tasks.

3.1 Home's Plan

After choosing an exercise, the home's plan is presented to the user, who has to select a room where the exercise will take place (Fig.3).



Fig. 3. House plan, where the user can choose a specific room to complete a exercise. The available rooms are: living-room, kitchen, bedroom, office and bathroom.

3.2 Help Items

Some helps are available to the patients in order to facilitate the execution of an exercise, when they face difficulties to complete it. Depending on the type of exercise these aids, which are represented in form of icons (Table 1), can be voiced, written or visual (photographs of objects and emissions of particles that attract the attention of the user to the desired object). Each time a patient uses an aid, it is recorded in the database.

Table 1. Help icons and their functions.

| | |
|---|---|
|  | Audio Info: repeats the exercise audio instruction. |
|  | Hear Name: provides the audio name of the object. |
|  | Signalize Object / Check Answer: identifies the desired object in the scene / gives a written correct answer. |
|  | Object's Photo: provides a photo of the desired object. |
|  | Sentence Help: a written sentence is provided to aid the user (appears in the written comprehension exercises). |
|  | Written Word: provides the written answer to the exercise (appears in the listening comprehension exercises). |
|  | Home's Plan: provides a map that allows the user to move automatically to a room (after completing the exercise). |
|  | Audio Sentence: provides an audio sentence corresponding to the written instruction presented on the screen. |
|  | Mouse Sensitivity: allows the user to regulate the sensitivity of the mouse to suit the division in which it lies. |

3.3 Word Processing

One of the main features of this therapeutic tool relates to text treatment, in which the user enters a character and the programmed algorithm checks if, in fact, it corresponds to the correct character. Flowchart, in figure 4, exemplifies the whole process of character checking.

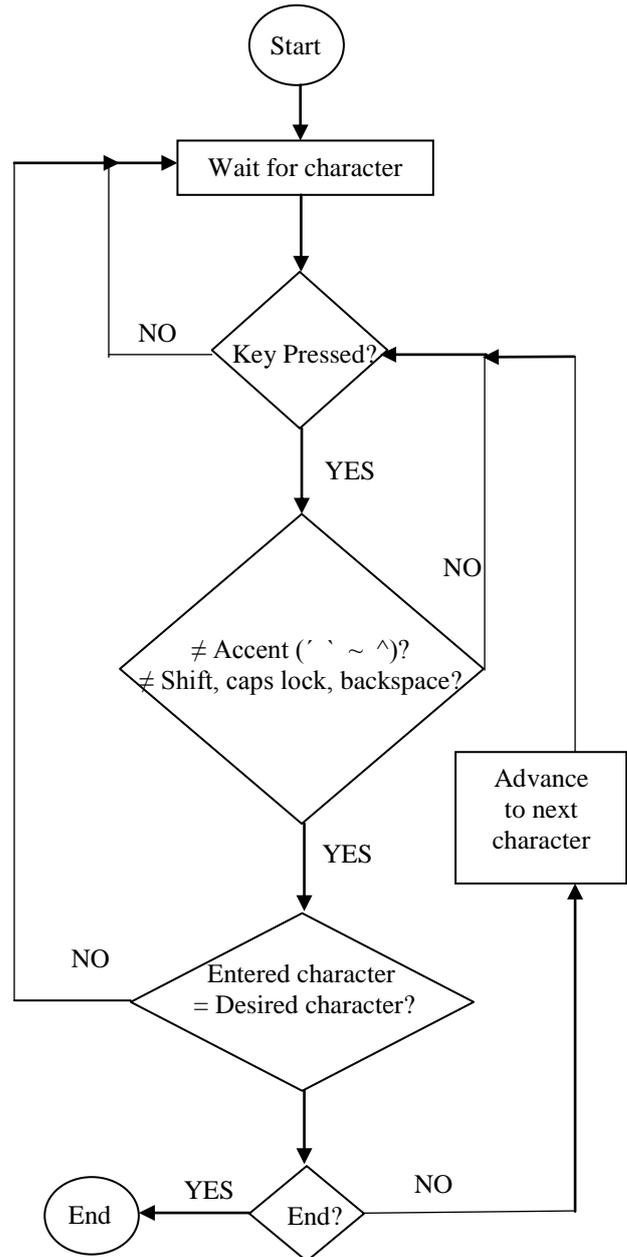


Fig. 4. Process of character verification.

3.4 Written Expression

The exercises (Fig.5) available in this task allow the user to practice different kind of writing skills. For example, in figure 6, it is asked to the patient to fill in a sentence, which is related to the 3D immersive environment in which the exercise takes place.



Fig. 5. Set of written expression exercises.



Fig. 6. Example of a written exercise. Here, the patient, who is located in the kitchen, has to insert a noun in a sentence. The question is always related to the room where the exercise takes place.

3.5 Listening Comprehension

In this task the stimuli are audio. There are three types of exercises: objects identification, yes/no sentences and simple order sentence (Fig.7).

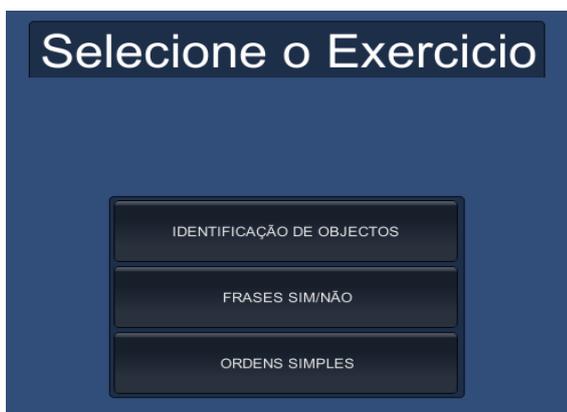


Fig. 7. Set of listening comprehension exercises.

3.5.1 Objects Identification

In this exercise, an audio order with the name of an object is given to user, who has to find the three-dimensional model of the object located somewhere in the room. The patients validate their answer by clicking on an object in the room. They receive an immediate feedback on their response (correct vs. incorrect).

3.5.2 Yes/No Sentences

After listening to the audio stimulus, which is a declaration regarding an object present in the room, the user must choose between “Yes”, if the statement is true, and “No”, if it is false.

3.5.3 Simple Order Sentence

A simple audio sentence, composed only of a subject, verb and complement, is heard and the user has to associate it with an object in the room. An example of one of these sentences is: “It is used to brush your hair” and the patient must point out to the hairbrush.

3.6 Written Comprehension

This task is designed to train different aspects of the written comprehension of aphasic patients (Fig.8). The exercises are divided into five groups, which are: partnering noun (Fig.9), partnering sentence (Fig.10), responsive naming (Fig.11), word intruder (Fig.12), yes/no sentences (Fig.13).



Fig. 8. Set of written comprehension exercises.

3.6.1 Partnering Noun

The name of an object is written on the screen and the user has to walk around the room in order to find the object and submit his/her answer by clicking on the object’s 3D model.



Fig. 9. Example of a written comprehension exercise based on partening noun. The reading skills of the patients are trained by a test in which they have to identify a physical (e.g., perfume bottle) object from its name.

3.6.2 Partnering Sentence

This exercise is similar to partnering noun, except the fact that the stimulus is a definition of the object. The way of answering is exactly the same.



Fig. 10. Example of a written comprehension exercise based on partening sentence. The reading skills of the patients are trained by a test in which they have to locate a physical object from a sentence that defines it. (e.g., find the “painting” from the stimulus sentence: “a decorating that expresses art”).

3.6.3 Responsive Naming

In this exercise an incomplete sentence is displayed and four alternatives are given to the user in order to fill in correctly the phrase.



Fig. 11. Example of a written comprehension exercise based on responsive naming. The patients have to understand the meaning of the sentence in order to complete it with the right word (e.g., “pick up the... *phone*”).

3.6.4 Word Intruder

Five object’s names related to a specific room are presented on the screen. The user’s task is to select the word that does not belong, in terms of properties, to the rest of the set.

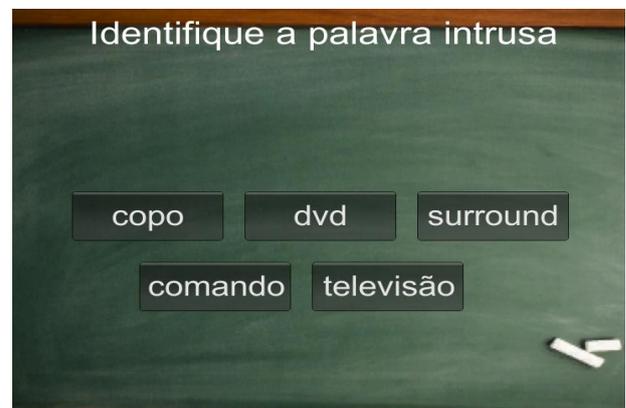


Fig. 12. Example of a written comprehension exercise based on word intruder. The patients have to choose the word that does not belong to the family of the other four. (e.g., “glass” vs “dvd, surround, remote control, TV”).

3.6.5 Yes/No Sentences

It is similar to the exercise yes/no sentences of listening comprehension, except the fact that the stimulus source is not spoken but written.



Fig. 13. Example of a written comprehension exercise based on yes/no sentence. Here, the patient has to discriminate between a true and false statement, which is related to an object in the living-room.

3.7 Motor Tasks

In this last task, the user has to carry out an action in the 3D environment in order to complete an exercise. There are two different types of exercises: simple tasks and compound tasks (Fig.14).

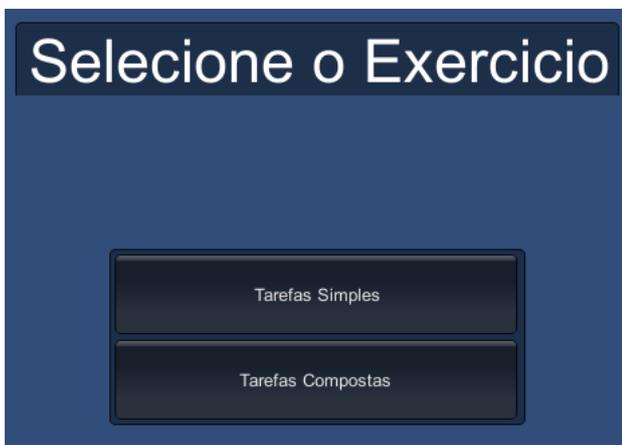


Fig. 14. The two kinds of motor tasks, which involves different levels of motor skill.

3.7.1 Simple Tasks

In this exercise, the user is prompted to interact with the objects exposed in the room, following the order that is given to him/her (Fig.15). To do so, he/she has to click on the designated object, hold down the mouse button to grab it and release the button to drop the object over the final desired location.



Fig. 15. Example of a simple task: “Put the soap in its holder”.

3.7.2 Compound Tasks

This motor task is similar to the previous one. The only difference is based on the fact that the patients have to understand a more complex order, in which they have to execute more than one action to complete the exercise. For instance, the order can be: “Open the door of a closet and put the shoes inside”.

4 Database’s modelling

A web-based database is used to store data on each user and their respective performance. This database is divided into six related tables, which are described below (Fig.16).



Fig. 16. Entity and relationship diagram.

4.1 Table “registro”

This table is dedicated for storing all user personal account information, such as: name, email, username, password...

4.2 Table “sessoes”

It is a simple table that stores the total number of sessions (“Total_Sessoes”) and total time (“Tempo_Sessoes”) spent on it.

4.3 Table “registro_exercicios”

In “registro_exercicios” all the parameters of the patient’s performance are recorded, such as the amount of correct answers (“Resposta_Corretas”), wrong answers (“Respostas_Erradas”), kind (“Id_ajuda”) and number (“Ajudas_Utiliz”) of aids used and the time span taken for each exercise (“Tempo_Exe”).

4.4 Relationship between tables “registro”, “registro_exercicios” and “sessoes”

The relationship between these three tables revolves around the user id, which makes the account unique and enables the relationship between the exercises taken in “registro_exercicios” and time and session parameters in “sessoes” (Fig.15).

4.5 Tables “tarefa”, “exercicios” and “relacao_tarefa_exercicios”

The table “tarefa” refers to the four task groups of the application, which are identified by a specific id (Fig.17). Similarly, an individual id is associated to each exercise in the table “exercicios” (Fig.18). The relationship between these two tables (Fig.19) is made through the table “relacao_tarefa_exercicios”, which defines from which group belongs an exercise (Fig.20).

| id_tarefa | Nome_Tarefa |
|-----------|-----------------------|
| 1 | Expressao Escrita |
| 2 | Compreensao Auditiva |
| 3 | Compreensao Escrita |
| 4 | Realização de Tarefas |

Fig. 17. Structure of the “tarefa” table.

| id_exe | Nome_Exe |
|--------|----------------------------------|
| 1 | Substantivos |
| 2 | Verbos |
| 3 | Frases - Inserir Nomes |
| 4 | Frases - Inserir Verbos Presente |
| 5 | Frases- Inserir Particulas |
| 6 | Erros Fonologicos |
| 7 | Palavras Desordenadas |
| 8 | Inserir Nomes |
| 9 | Inserir Verbos |
| 10 | Inserir Palavras Função |
| 11 | Inserir Palavras |
| 12 | Emparceirar Nome |
| 13 | Emparceirar Frase |
| 14 | Responding Naming |
| 15 | Palavra Intrusa |
| 16 | Frases Sim/Nao |

Fig. 18. Structure of the “exercicios” table.

| id_tarefa | id_exe |
|-----------|--------|
| 1 | 1 |
| 1 | 2 |
| 1 | 3 |
| 1 | 4 |
| 1 | 5 |
| 1 | 6 |
| 1 | 7 |
| 1 | 8 |
| 1 | 9 |
| 1 | 10 |
| 1 | 11 |
| 3 | 12 |
| 3 | 13 |
| 3 | 14 |
| 3 | 15 |
| 3 | 16 |

Fig. 19. Structure of the “relacao_tarefa_exercicios” table.



Fig. 20. Table “relacao_tarefa_exercicios”.

5 Results

At the moment no tests have been made with aphasic patients, because the tool is still a prototype in development. Nevertheless, some preliminary results based on regular users are already available for consulting on the application data interface.

Analysing the performance data through the “consult records” (“consultar registros” – Fig.21), it is possible to verify how well the user is taking the exercises.



Fig. 21. Global records.

For a deeper analysis, it is also possible to consult each exercise individually. For instance, in figure 22, the user has 75 % of correct answers for the written comprehension exercises and only 37.5% in written expression (Fig.23). From such results, the speech therapist can easily conclude that a high amount of workload should be done to improve the written expression skills of this individual.

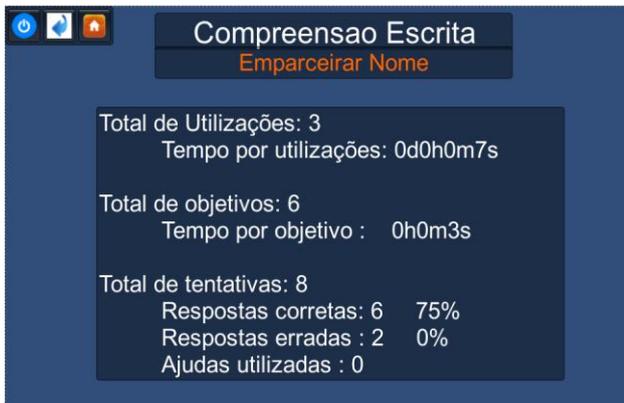


Fig. 22. Written Comprehension records.

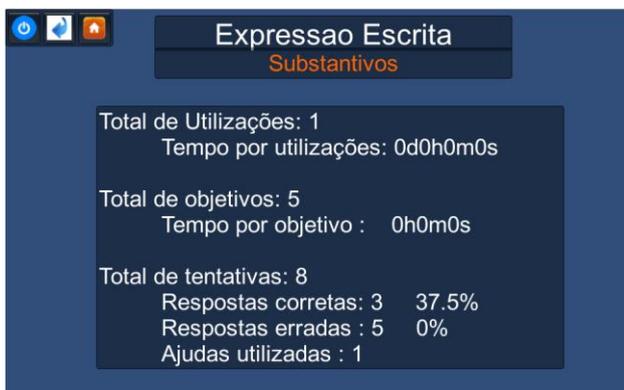


Fig. 23. Written Expression records.

6 Conclusion

According to the previous projects in the field [8][9], this last generation of IT to support linguistic impairments is expected to be a relevant aid in the treatment of Portuguese speaking aphasic patients. The most significant features of this application is to provide the user (i) a wide range of linguistic exercises immersed in a realistic virtual representation of a three dimensional flat and (ii) an easy web-based access to perform exercises and consult data.

To highlight the fact that the tool allows the patients a greater autonomy and freedom,

considering the fact that they can execute tasks with high frequency (they only need a computer with an internet connection). Last but not least, the treatment exposure based on the concept of serious game is another motivational factor for the patients to continually outperform their past results. All these aspects are key points in the recovery process from the disease.

Acknowledgements:

This project is supported in part by the Portuguese Foundation for Science and Technology (FCT).

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