Brain Rhythm: A Language Rehabilitation and Educational Computer Application for Children with Aphasias

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I. Problem statement & Research question

According to the United Nations, one of every 100,000 neonatal in the world is born with some type of aphasia, while more than a million of North Americans suffer from aphasia [1]. There are different types of aphasias, but they do not present themselves in isolations, they usually are mixed with other types of aphasia.

II. Background

Aphasia: Prevalence of aphasia is approximately 1 million people, or 1 in 250 in the United States, and this refers to number of people living with aphasia in the period tested [5]. Based in the book *Current Diagnosis & Treatment Pediatrics,* Aphasia is defined as "*difficulty in understanding and producing written and spoken language, is categorized as fluent, non-fluent, or global*" [2]. There are methods to treat aphasias that can be used for children and adults, because the semiology is similar in both ages including the initial phases for fluid aphasias and for non-fluid ones, but there is evidence that the treatment of aphasia is more effective in children [3]. Based in Ardila et al, the main objectives of the therapy for aphasias are the following: maintain the child verbally active, re-learn language, provide improvements strategies, provide educational support to the family of child with aphasia and give psychological support [2].

Therapy Techniques: The type of therapy is distinguished by its onset of activity and its length of treatment. They can be categorized as: a) Acute care, which may include medical or surgical procedures and pharmacologic measures to decrease the brain damage and prevent the damage from getting worse. b) Sub-acute care, which may include early intervention and intensive participation promoting functional recovery (participation of physical therapist, occupational therapist, speech-language specialists and neuropsychologists). These patients with injuries can continue with treatment in home [5].

There are different therapies for Sub-acute care as: a) Technique of facilitation of stimuli, this emphasizes in the need to stimulate language for language improvement. Adequate control of stimulation, control of the speed (presentation of language), its complexity and even its volume. Use topics of patient's interest for the best response and for making possible the increasing of difficulty. Thus the three main factors are stimulation (organized presentation of stimuli), facilitation (repeated practice) and motivation (adequate environment). b) Scheduled Learning, therapy with a specific response until reaching critical level, then the therapy is changed to another type of stimuli. c) Unlocking technique, based in the use of the language areas less affected to compensate others. It can use words to unlock channels. d) Reorganization of the functional system, depends on the damage of the patient, in some cases may be necessary to re-learn the language, so is recommendable not present isolated words, but in context. This avoid agrammatism, Broca's biggest residual issue. Patients with dynamic aphasia cannot organize sequences, thus is recommended to give them support. e) Intonation melodic therapy, patient must listen a rhythmic sentence, then try to repeat it. f) Alternative communication systems, every single communication type different from the spoken one [2]. When

testing, visual, auditory and manual may be evaluated [3]. g) Use of Computers in Aphasic Patient Rehabilitation, use of computers programs with the aim of improve understanding, naming, reading, and others channels. h) Sign language, difficult to implement, cause patients usually have apraxia [2].

Long-Term Care: Is the follow-up of the therapy, which may include multidisciplinary evaluation (with neuropsychological testing). Medication may be required. It is also necessary to identify the environment to keep the patient comfortable and motivate their progress [5].

Since 1970, therapies with computer as auxiliary have been implemented [2], where manual, motor and visual aspects have been evaluated [3]. Thus, the proposal for this project is to incorporate a multi- stimuli therapy that must include visual, auditory and manual stimuli with the aim of reaching better results in therapies.

III. Description of Final approach and Design

It is intended to control the game by a wireless cube (Figure 1.D) that performs the functions of a mouse, where when rotated, 4 positions will be detected to choose one of the buttons showed on the screen and the face of the center will work as a neutral position while making a decision. To achieve this a 3-axis digital accelerometer MPU6050 was used, placed on the central face of the cube to be calibrated there as the center. The signal was processed in the Arduino IDE (Integrated Development Environment), using the following steps (Figure 1.C): 1) Calibration of the sensor to detect the center, through a cycle of 2 seconds in which 10 measurements are averaged every 10 milliseconds. 2) Once the zero is taken, conditionals are set according to the pattern that show the coordinates for each face or direction. It was only worked on the "x" and "y" axis since the game does not require any movements on the "z" axis. 3) Once the accelerometer status is read in real time (also by a cycle but this time averaging 20 samples for 1 s to achieve greater accuracy in the reading) and goes through the conditionals, it decides the position of the accelerometer and sends a Character (1,2,3,4,5: center, up, down, right, left) via serial to the game.

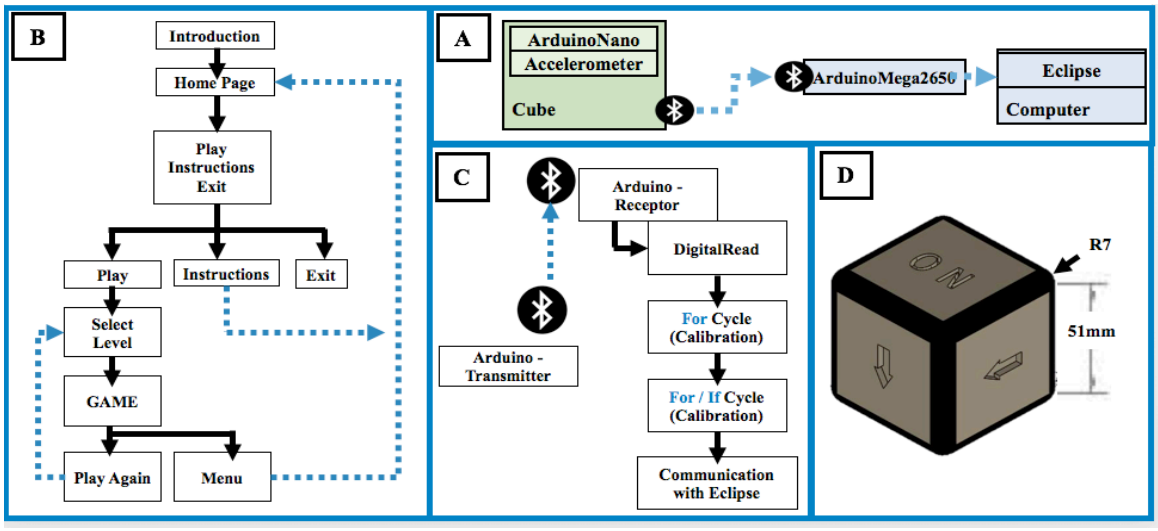

Figure 1. (A) General design of the project, where cube has the accelerometer communicated with Arduino, which is connected to a computer with Eclipse. (B) Flow chart presenting the function of the code made in eclipse for the game. (C) Code for Arduino platform for calibration of accelerometer. (D) Prototype design in SolidWorks.

For communication, an accelerometer, an Arduino Nano (by Arduino) and a Bluetooth transmitter (Guangzhou, China by Guangzhou HC Information Technology Co) were placed in the cube; they were all powered with a 3.7 V 500 mAh LiPo battery. The reception of the sent character was made by the Bluetooth receiver module connected to another Arduino Mega 2560 (by Arduino), which connects directly to the computer to establish the final serial communication with Eclipse (Ottawa, Ontario, Canada by Eclipse Foundation, Inc.), where characters received and assigned to a specific function are detected. Movement of the cursor and selection of words (Figure 1.A). Once communicated with Eclipse, the program is executed to detect the Arduino commands and interpret them to give an answer depending on the movement of the device. The structure of the program in Eclipse includes an introduction that leads to the main menu, to choose the playing modes, instructions or exit the game. Once in the game you can select a level and start playing or return to the menu. At the end of the game you can play again or go to the main menu (Figure 1B).

IV. Outcome

Given the information mentioned above, a logo was created that would represent the intent of the device developed (Figure 2.A). A device that was friendly and dynamic in its use (Figure 2.B) that could contain the necessary elements for the communication of the program (Figure 2.C). The program was developed and executed through Eclipse creating a dynamic game environment (Figure 2.D) and communicated using Arduino Nano and Mega2650 (Figure 2.E).

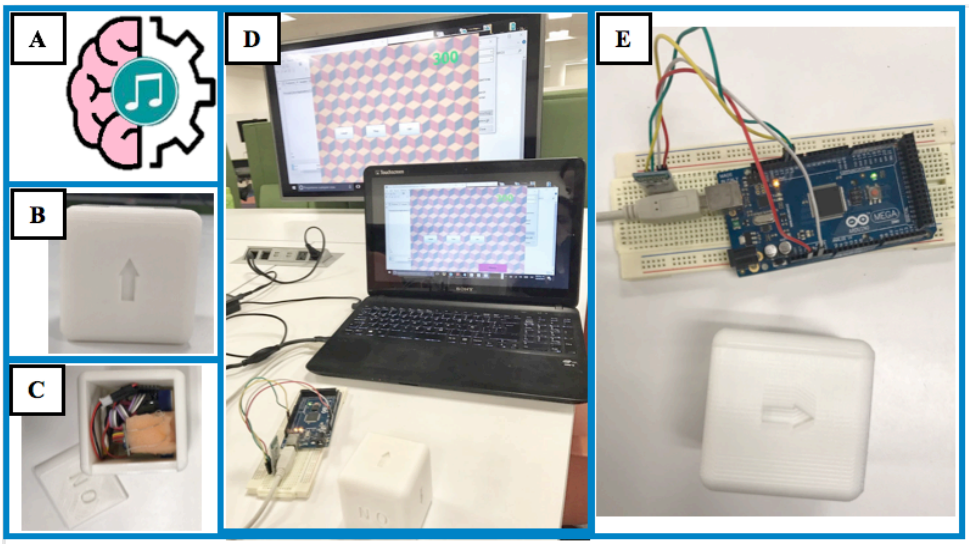

Figure 2. (A) Logo for Brain Rhythm, represents the functional stimulation with use of rhythmic words. (B) Cube Prototype. (C) Cube open, to see where the components are placed. (D) Actual view of an area prepared to play with Brain Rhythm. (E) Cube and Arduino connected to a breadboard that is communicated with the computer.

The flow of the game begins on the home screen that has the buttons for: Instructions to understand how to play (Figure 3.B), Exit to end the game and Start to go to the selection screen of difficulty level (Figure 3.A). Once in the difficulty selection menu, you can choose the level and start playing or you can return to the menu (Figure 3.C). While playing, the words will be positioned and at the end of each session (Figure 3.D and 3.E), a sentence will feed back the child's punctuation (Figure 3.F).

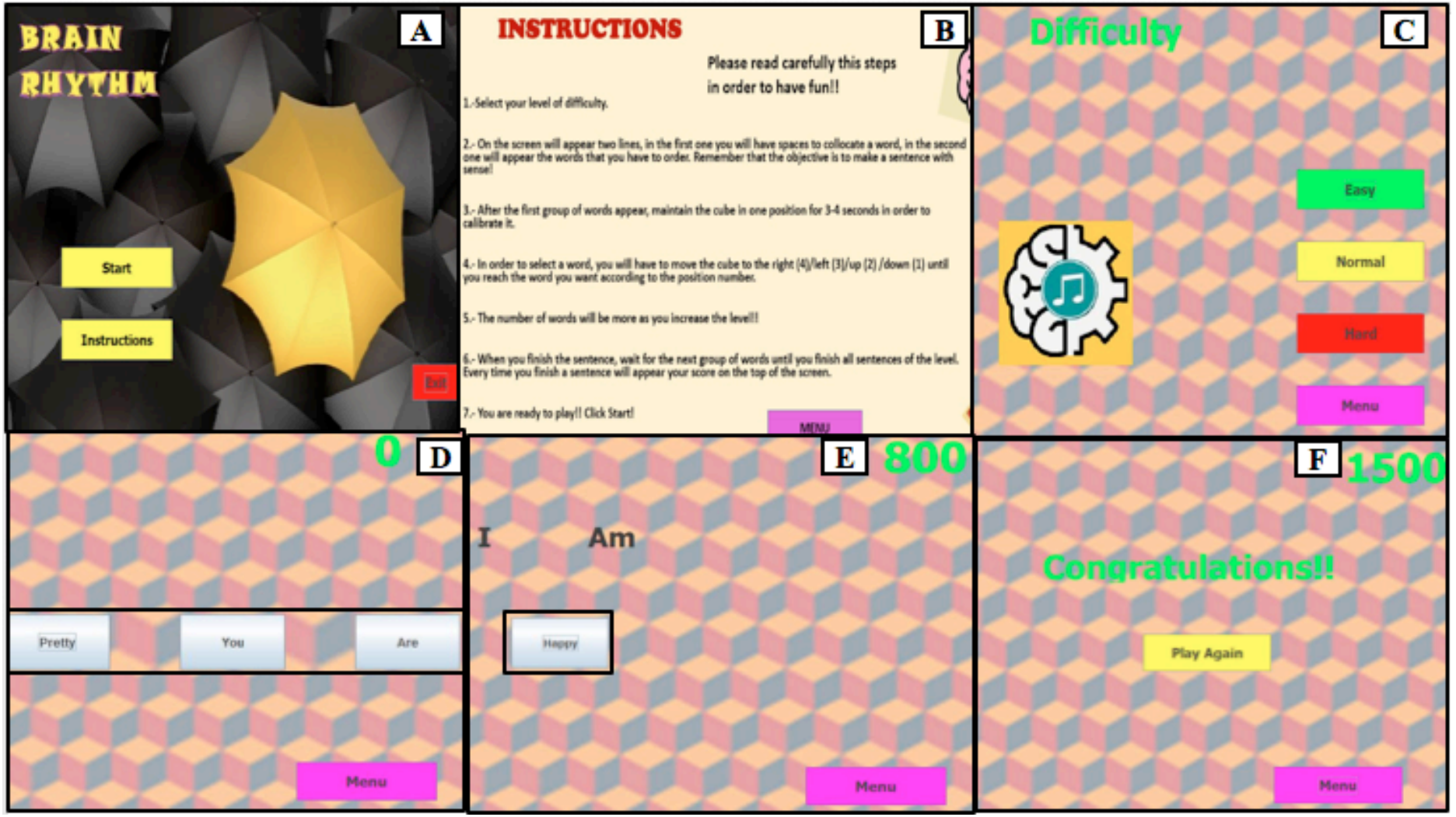

Figure 3. Game Screens. (A) Game menu that shows start and instructions options buttons. (B) Instructions about how to play and a button for menu. (C) Difficulty selector, with easy, normal and hard mode, where user can also return to menu. (D) First playing screen, words are placed in disorder (Pretty, You, Are). (E) When selecting words, the user can score points, and words will be placed. (F) When game finishes, user gets a score, depending on effort user can receive “Congratulations”, “Thanks for playing” or “Try Again”.

When using the device, the speed response is approximately 5 seconds, it is caused by the Bluetooth communication that has a 1.5 seconds timing and Eclipse communicating with Arduino lasts about 3 to 4 seconds.

V. Cost

This section presents the material and software the team required for the development of the gadget, details can be seen in table 1.

Table 1. Costs of material and software used in the developments of Brain Rhythm.

Unit price per unit device		
Material		
Component	**Quantity**	**Unit Price (dollars)**
Arduino Mega 2650	1	37.34
Arduino Nano	1	24.4
Bluetooth HC06	2	10.36
Computer	1	Provided by team members
Accelerometer	1	5.31
Cube	1	36.12
mini protoboard	1	3.95
LiPo 5V 500 mAh	1	Provided by university
Software		
Eclipse neon	1	Free download
SolidWorks 2016	1	Provided by university
Arduino IDE	1	Free download
	Total price	**117.48**

*** These costs do not include cost of consulting of programming, manufacture, rent of lab or professional licenses**

VI. Significance

As previously presented, the objective of this project was to develop a multisensory software and hardware application to help children with aphasia. It is our expectation that by implementing a multisensorial therapy children with aphasia will have a quicker and stimulating recovery. The main users are expected to be children of different ages who know already how to read. The rehabilitation system can also be used by adults with very critical aphasias, although their improvement is not expected to be as promising due to their reduced cerebral plasticity [2].

VII. Acknowledgements

The authors wish to express their gratitude Ricardo Ríos, psychopedagogue specialist in children and adolescents with learning problems for his time and support in the project.

VIII. References

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