Interactive Speech Therapy for Children

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ABSTRACT
Sound formation is a process involving both the brain and the phonetic organs. This paper presents a study on the ways in which sound creation develops. The main aim is to create an application to aid speech therapy as part of the rehabilitation process that works on patients' phonation. In this case, children with speech problems play games that may affect the teaching and learning process by participating in the research study.

Categories and Subject Descriptors
H.1.2 [**Information Systems**]: User/Machine Systems – *Human Factors, Human Information Processing*.

H.5.1 [**Information Interfaces and Presentation**]: Multimedia Information Systems – *Audio input/output, Video.*

H.5.2 [**Information Interfaces and Presentation**]: User Interfaces – *Graphical user interfaces (GUI), Interaction styles, Screen design, User-centered design, Voice I/O.*

I.4.9 [**Computing Methodologies**]: Applications.

J.1 [**Computer Applications**]: Administrative Data Processing – *Education.*

J.3 [**Computer Applications**]: Life and Medical Sciences – *Health, Medical information systems.*

General Terms
Human factors

Keywords
Speech Therapist, Phonemes, Phonation, Rehabilitation, Cloud Computing, Aphasia, Dysarthria, Human Computer Interaction.

1. INTRODUCTION
This is the first study in a series of studies on speech therapy. Here, the results show that this rehabilitation speciality exists in primary schools as students with speech problems go to speech therapists for treatment.

According to the Royal Academy of the Spanish Language, speech therapy teaches phonation to those who experience pronunciation difficulties. It includes the diagnosis, rehabilitation, and prevention of problems related to communication skills and their associated functions. Following the Spanish ordination law of health professionals (Ley de Ordenación de las Profesiones Sanitarias L.O.P.S. Ley 44/2003, de 21 de Noviembre, de ordenación de las profesiones sanitarias), speech therapists graduate as health assistants. According to the associated legislation, "Graduated students in speech therapy develop the prevention, evaluation and restoring activities of audition, phonation and language problems by means of therapeutic techniques typical of their discipline."

Speech may be divided into two categories: aphasias and dysarthria. Aphasias is produced as a consequence of a lesion or brain injury that leads to the loss of the capacity to produce or understand language (either in adults or in children) [1]. Dysarthria is a language alteration produced by a brain lesion. It differs from aphasia in that alterations are not presented in the prolongation or in the language sequence but exist in associated difficulties with phonological components. In other words, by making language sounds [2].

2. CLASSIFICATION AND TREATMENT
A study was conducted on the classification of these diseases in relation to language problems as well as the evaluation of their treatment. The details of the study are presented here.

2.1 Classification
Areas in the brain that are responsible for language processing as well as the problem areas in regards to language are [3]:

- Wernicke's area: situated in the posterior region of the left temporal lobe it decodes the language hearing information.
- Broca's area: situated in the posterior and inferior region of the left frontal lobe it is connected to the primary motor cortex of the larynx-pharynx muscles in order to code the patterns of the articular speech nerves. In written language, the information is processed to an occipital level (perception of graphical symbols) and is in relation, or not, to the hearing perception in reference to the left inferior parietal lobe.

The human phonetic system is the group of the different organs that take part in the language articulation [4].

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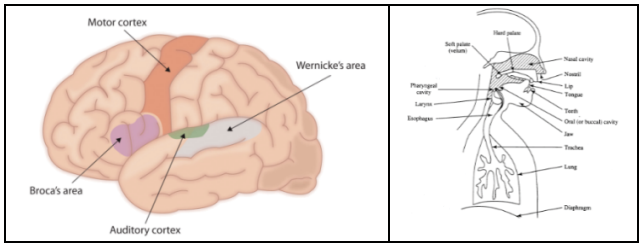

Figure 1. Left: Brain areas. Right: Human Phonetic System.

Depending whether we talk about a neuropsychological alteration or bad functioning of the phonetic organs, the classification is [5]:

- • Aphasia affects the spoken language (Broca's area) while receptive aphasia affects interpretation and language memory (Wernicke's area).
  - Flowing: they are the aphasias that produce a lot of vocabulary without so much articulatory effort but they present many errors, little informative content, a poor vocabulary and, definitely, a non understandable expression due to the presence of deform problems in the words.
  - Not flowing: children make a big articulatory effort, although the content is more understandable than "flowing". In this case, language problems are reductive with difficulties in accessing the lexicon, automatic repetitions of words or phrases, etc.
- In dysarthria, the articulatory alterations are manifested by omission, substitution, addition, or distortion of one or more phonemes, which affect the meaning of speech. In addition, children who suffer from dysarthria have difficulties in moving their phonetic-articulatory organs for any activity. The following areas can be affected: articulation, speed, volume, prosody (intonation), and phonetic respiratory coordination. Dysarthria is the result of a lesion in the central or peripheral nervous system. The common causes include ictus, cranial accidents, neurodegenerative diseases (Parkinson, Multiple Sclerosis, etc.).

2.2 Treatment

Treatment associated to these anomalies is related to each of the organs taking part in the phonemes' creation [6][7]:

- The respiratory system: articulating the phonemes is necessary so that several organs can work together. Oral language alterations are consequences of the unusual functionalities of these specific organs. In these cases, it is necessary that the correct process to breathe is demonstrated through respiratory exercises.
- The main phonation organ is the larynx; along with the tongue, phonation is created. Treatment is usually related to respiratory, tongue, lips, and vocal exercises.
- The resonator system: formed by the inferior area of the supraglottal resonator system, the lips function as the articulator system. To deal with labial weakness, a child performs labial exercises in order to move the lips naturally.

3. RESEARCH OBJECTIVE

The aim of this research is to bring these techniques closer to the TICS rehabilitation so that they can be utilized by speech therapists to prepare appropriate exercises to help children perform their exercises from home. Nowadays, speech therapy is a forgotten area within TICS rehabilitation. Speech therapists are not located in educational centres; hence, this study offers an easy way for teachers to use these techniques with the assistance of a speech therapist.

4. STUDY CASE

In this study, the speech therapist provides a set of exercises in an educational centre for young students, preparing them for when their voice changes (for when they leave aside their infantile voice). This is a very common physical problem for children as their respiratory cavities are adapting and the deficiencies appear following a purely functional cause. These exercises can be classified as respiratory, labial, vocalization, and resonance.

- **Respiratory exercises:** Figure 2 shows the ways the children can improve their respiratory exercises and learn to breathe and increase their lung capacity through games. They are required to blow out the candle while breathing, in other words, providing a constant flow of air from the lungs to the iPad's sensors. A microphone detects the intensity and the airflow through the generated sound. The application offers different types of games for this treatment as seen on the right.

Figure 2. Blowing the candle application.

- **Labial exercises**: Using an iPad pressure sensor, designed and improved in later versions, the game consists of an activity of holding a ball in the air and requires more strength after each attempt. In this way, the child improves their labial strength. It is also aimed at increasing his/her capacity for pronunciation and phonation. As such, the child must blow through a mouthpiece connected to a rubber to guarantee that the lips are positioned correctly over the iPad pressure sensor. As in Figure 3, the application shows a set of exercises including intensity and time factors.
- **Vocalization exercises**: In this case, the kids must vocalize, following a set of steps indicated by the application

Figure 3. Blowing the ball.

As seen in Figure 4, the child can perform the exercises by following the pronunciations shown in the application, for example, a karaoke. Thus, he/she makes the interruptions and the phonemes' prolongations. Pre-visualization of the exercise content is available. In addition, exercise repetitions and examples exist to show the student how to do the pronunciations.

These exercises can be performed at school or at home with the parents' or teachers' help and support. The exercises are very simple to perform and do not require specific therapeutic knowledge. However, time is required for the child in order to rehabilitate the voice's timbre.

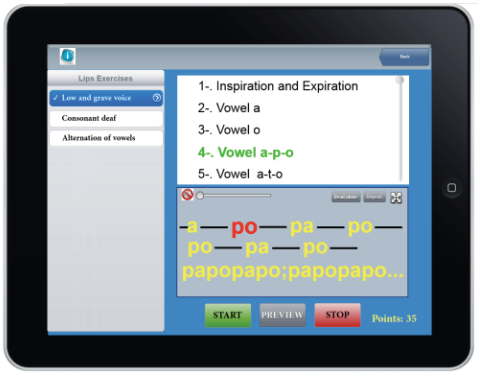

Figure 4. Vocalization exercises.

Nowadays, there are books related to speech therapy that offer treatment guidelines. However, no specific platforms and applications exist to bring speech therapy closer to the educational centres and to the parents.

5. SYSTEM ARCHITECTURE

An English language teacher checked the uses that the application could have in foreign language learning. She said that this type of rehabilitation is typical for each language. However, the option of using phonetic sounds was suggested as a part of the application because the phonetic is the same for every language.

In the suggested cloud-based system architecture, the web services are the input and output for communication with the application. In other words, data is sent and processed in the system located in the cloud. The case study presented games as the rehabilitation exercises, so that the children could stimulate their organs, and used vocalization and phonetic exercises as the research focus of this paper.

The phoneme generation area is in the brain, so the same idea is used for the cloud system, based on the phonetic generation as with the language translation. The system sends the phoneme to the application, which processes it. A complex system takes part within a neuronal network oriented to phonetics, where the sounds' pronunciation follows the phonetic symbols. These phonetic languages and their combination in the brain area produce the vocalization.

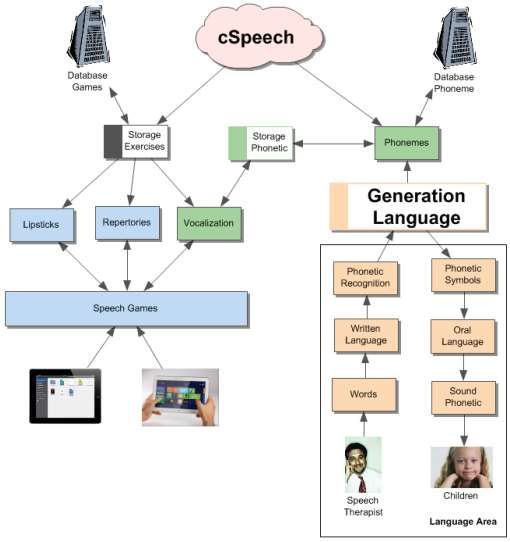

Figure 5. Conceptual architecture.

Two different parts are presented in Figure 5; on one hand (in blue), the game platform is classified in labial, respiratory, and phonetic types. Both the specialists and the teachers create these games. On the other hand (in green), the vocalization games exist where the phonetic exercises are needed for the language generation.

The language treatment is emphasized in a light brown colour, where the speech therapist, using the introduced words into the platform, generates exercises similar to the case study. Therefore, the therapist generates vocalization exercises and the platform generates the sounds depending on the child's language. Thus, a layer in the cloud is included for the phonetic function and the sound's translation, in order to improve the vocalization for any language.

6. CONCLUSIONS AND FUTURE WORK

It is important that voice problems can be treated early in infancy and adolescence. Though this can cause a delay in the teaching/learning process, with suggested and performed exercises, a child with speech difficulties usually exhibits rehabilitation of the phonation system organs. Furthermore, this training also affects the brain where the sound is produced because the child associates those sounds with images, causing training and rehabilitation to occur.

This is the first research study on the speech therapy field as a non-traumatic rehabilitation process produced and suggested by

speech therapists. This paper depicts the ways sound is formed in the brain and how the organs taking part in the formation process work while targeting deep understanding voice rehabilitation and providing life quality improvement for children with such problems.

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