An Educational Digital Game for the Development of Phonological Awareness

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Abstract. Phonological awareness is the ability to perceive the sounds contained in words. This capacity begins to be developed before the literacy period. Some children work their phonological awareness in speech therapy sessions, in which educational games can be used. This work presents the Educational Quiz - Phonological Awareness, a game developed and tested with nine professionals in the Speech Therapy field and with eight children in speech therapy sessions. The game was well rated by experts, who fully agreed that it can be used in speech therapy sessions with children (aged between 4 and incomplete 6 years) with the disorder. The results of these tests are presented in this paper.

Keywords: Phonological awareness · Serious game · Educational digital game · Language acquisition

1 Introduction

Phonological awareness is the ability to manipulate the sounds of our language (Adams 2018). It is, for example, the ability to perceive that a word can start or end with the same sound or when we know that there are also short words and long words; and that there are phrases (and a segmentation in those sentences).

From 3 or 4 years old, the child can already have this awareness. However, it is significant to understand that the evolution of phonological awareness has steps that must be understood to begin the person's learning, namely: the ability to understand the language fractionation levels and the understanding that the same syllables can be seen in different words, however with divergent sound (Antony and Francis 2005). There are some factors that the subject must have to establish and develop language, and they are interdependent. For example, perceiving and reflecting sounds is necessary to understand, organize responses, and then articulate correctly (Adams 2018; Scherer 2007).

Phonological awareness that impairs speech affects more than 6% of children worldwide and is also considered a functional developmental disorder. Generally, these problems are accompanied by disabilities such as hearing, phonological disorder, apraxia,

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among others. In these cases, it is necessary to constantly practice exercises that stimulate speech (Inacio and Nunes 2019).

Thus, it is necessary to seek help in the treatment of these children, which is usually done through follow-up with speech therapists and professionals specialized in the child's development. It is necessary for the patient to practice exercises necessary for their progress in learning to speak. One of the alternatives for this is the use of technologies as learning tools, including digital games (Inacio and Nunes 2019).

On the other hand, the educational game allows you to work with categories of toys, colors, human body, among others, stimulating the learning of children, young people and typical adults or with some disability; thus, they can be used for phonological awareness. Furthermore, digital games have been used as an additional resource to the learning process, as they can reinforce individual interpretation and build a meaningful experience. They simply present the gameplay rules and allow the user to engage himself freely (Noemi and Maximo 2014).

Taking this into account, the project aimed to implement a computational instrument with gameplay that can involve individuals who need to learn phonological awareness so that the instrument can be used as an aid object in speech therapy sessions.

After its implementation, the digital game went through tests with speech therapists and children in speech therapy sessions. The results of these tests are presented in this article.

This paper is structured in the following sections: The "Phonological awareness" section concerns phonological awareness concepts and the use of minimal pairs. The "Related works" section presents studies and games that seek to help develop phonological awareness and includes works with themes in the field that is closer to the instrument developed in this project. On the other hand, the "Methodology" section contains how the project was developed. The "Development" section contains a brief description, the functional and non-functional requirements, the design stage, persona samples and the game elaboration stage. In the "Results and discussions" section, the results of the application of questionnaires answered both by speech therapists, who evaluated the game and by the children who participated in the project are presented. Finally, the "Conclusions" section presents the main points of interest for this project.

2 Phonological Awareness

Phonological awareness is a skill divided into linguistic levels that comprise the segmentation of the language spoken in sentences, sentences in words, words in syllables and syllables in phonemes (Scherer 2007).

Studies focused on phonological awareness argue that children who have difficulties in phonological awareness tasks may be delayed in their acquisition of writing and reading. Therefore, stimulating children's learning through activities that stimulate their phonological awareness is essential, as the mechanism of learning to read and write depends on the subject's understanding of the alphabetical writing system, that is, the letter and phoneme relationship (Ferreiro and Teberosky 1991).

One of the objects of study in this work was to develop, within phonological awareness, the minimal pair's concept. To ascertain the distinct value of a segment, switching is used, representing the comparison between minimum pairs, that is, two words of the language that differ in their concepts only by one segment (Donicht Miranda and Miranda 2019).

According to (Kahl et al. 2007), it can be concluded that there is a minimum pair at the moment when two phonic sequences differ by a single phoneme, such as the Portuguese words "tom" (tone) and "dom" (gift), here there is a minimum divergence defined by the sonority when whereas / t / is cataloged as an occlusive, alveolar, voiceless consonant segment; the / d / segment is classified as occlusive, alveolar, voiced […]. The difference is seen in an identical space since it is found in the course of a single sound, in the same place, in the two sound sequences.

Certain pairs of phonemes demonstrate as an attribute the fact that they are distinguished by their loudness, that is, some of them are deaf and others are sonorous. The phonemes / p /, / t /, / k /, / f /, / s /, are considered deaf since they do not present vibration of the vocal folds when produced. In turn, the phonemes / b /, / d /, / v /, / z /, are performed with vocal fold vibration, being considered, therefore, as sonorous phonemes. The tone of sound leads to an important differentiation between the pairs of these sets of phonemes: / p / x / b /; / t / x / d /; / f / x / v /; / s / x / z / (Zorzi 2019).

Minimum pairs were carefully analyzed, and a quantity was selected for the assembly of the game, and they were observed throughout the game.

3 Related Works

The use of digital games is widely referred to in the study of literacy, as in a way, it involves the person in a comfortable environment, ensuring their attention more efficiently compared to other methods.

As mentioned in (Kahl et al. 2007), the world of games enables students to interpret and dictate rules, thus carrying out a social and human activity. Therefore, for the tool to be placed in an educational and study space, it is essential to authenticate the computational tool by professionals in the same field to guarantee the maximum use of it.

Amorin et al. (2020) examines the effectiveness of Escribo Play, a game-enhanced educational program, on preschool students' phonological awareness, word reading, and writing skills in 17 schools with 749 students.

Guindeira y Gil (2017), using the Microsoft PowerPoint programme, aimed at the development of phonological awareness in pre-school children with special educational needs. The study was qualitative and exploratory, constituting a multiple case study.

Studies have been discovered with a similar objective: phonological awareness development, such as Domlexia - Dom e Letras – Afabetização game. It is available for Android and IOS platforms, has a map of Letters AZ, and each map has words and voices corresponding to the chosen Letter, so the child validates whether it is true or false.

The game known as “Kera Puzzle”, available for desktop platforms, was developed to treat phonological disorders. This game is a puzzle that in one of the game modes, every time a piece fits into the other voices is reproduced referring to the minimum pairs, and the user has to interact and validate the voices (Figueiredo et al. 2021).

Another identified study that aims to make users understand how to express proper words is “Tellfunny” (Inacio and Nunes 2019). This game was made available for Android and IOS platforms and divided the gameplay into two parts. Firstly, focusing on word speech and the second with speech exercises based on the understood phonemes.

The main difference of this work in relation to almost all related works is in its use within speech therapy sessions, as an auxiliary instrument for specialists and not a use within schools, in the literacy period.

4 Methodology

Regarding the methodology used in this work, the project initially had a literature review on related topics. The purpose of the review was to understand the phonological awareness concept and information about the necessary components for the game’s development and investigate how methodologies based on educational games are used.

The methodology of this project had a collection of information obtained through the speech therapist specialist, for the elaboration of the educational game that works, in a playful way, the phonological awareness, more specifically, the minimal pair’s concept. Participatory methodology was not used because we are in a period of the Covid-19 pandemic when the game was developed and the children were in social isolation.

The theoretical foundation of the research was obtained through scientific research, websites, articles, publications, descriptive documentation, and theses. The reading and analysis of theoretical material focus on understanding phonological awareness, the treatment techniques used by speech therapists and the creation process as an object capable of assisting in learning.

Soon after the completion of the development stage, a stage of exhibition and execution of the game developed was carried out and then verified by the specialist to validate the game. Therefore, it was sought if the developed game could reach the expected levels to make it viable for users who need to learn phonological awareness in speech therapy sessions.

To achieve the objectives presented in this project, the following steps were performed: a. Study of the content involved (phonological awareness, minimum pairs, educational games, Unity; b. Meetings with a professional in the field of Speech Therapy; c. Research on phonological awareness for individuals who need to develop it; d. Submission and approval of the project to the Research Ethics Committee, number CAAE 38448720.5.0000.0084; e. Implementation of the computational tool through Unity; f. Availability of the game to professionals in the speech therapy field for validation and feedback. Analysis of results/feedback; g. Availability of the game to be tested by children in Speech Therapy sessions; h. Evaluation of results.

5 Development of the Digital Game

This section aims to present the requirements analysis, the project phase and the tool implementation.

5.1 Requirements Analysis

The following sections have the purpose of displaying tool description, personas description, functional and non-functional requirements.

- **Tool description**. The game's purpose is to be applied as an instrument to help professionals in the speech therapy field in the treatment of people who are in the process of literacy and who need stimuli for the development of phonological awareness, ensuring the focus and interaction of children throughout the tasks.
- **Personas description.** Two personas were created and described below to understand the children profiles sought to achieve with the educational game.

  Roberto is 3 years and 7 months old. During the last two months, he attends the speech therapist once a week, preferring to stay at home rather than appearing because he finds it repetitive and not very encouraging. One way for Roberto to continue in the treatment process while having fun will be using the tool, as it will be effective for learning and fun.

  Gabriele is 4 years and 2 months old and has been attending the speech therapist for three months. However, her parents notice that she still finds it exceedingly difficult to perform activities that need to describe the initial Letter of the images.
- **Functional requirements**. For the game, the following functional requirements were found through frequent meetings with a specialist in Speech Therapy:

  - Function to decrease and increase the volume of the Music/Effects.
  - Choose the Theme you want to play.
  - By clicking on the Theme, load the game screen and display the respective questions.
  - Game mode 1: show a Picture and by clicking on the sound icon, play the sound.
  - Game mode 2: show an Image and the user click on the initial Letter of it.
  - Game mode 3: show a Letter and the user click on the Picture that starts with that it.
  - Save game progress automatically.
  - Reset game progress functionality (found in Options).
  - Back to the menu functionality, where it will exhibit all available themes.
  - Redo the game mode functionality, after finishing it.
  - Exit functionality by clicking the X button found in the upper right corner, in the respective scenes.

- **Non-functional requirements**. The educational game was developed to be easily installed and used, to be intuitive, fun, educational. For installation, the computer/notebook or device must meet the following requirements:

- Operational system - Windows 7 or higher, or macOS 10.12 or higher (if computer/notebook),
- The device must have audio/sound output.
- If it is a mobile device, it must be Android 4.1 or higher.
- The device should have 27.4 MB of available storage.

5.2 Design Phase

The educational game was developed to be compatible with desktop/notebook devices, Windows and macOS operating systems, Android 4.1 or higher mobile devices.

For the application development, the C# programming language was manipulated, and the element packages provided by Unity Engine were used.

1. Creation of scenarios and figures: Most of the figures were taken from Assets available on the Unity website, and some of them modified as necessary.
2. Audio creation: The "TextAloud" software was used to create the audios responsible for interacting with the user in each game mode.
3. Creation of gameplay: When it comes to gameplay, it was thought about how the user can interact with minimal pairs playfully. Different game modes were created that could fulfill the requirements.

For example, there is a game mode focusing on listening to phonemes and puts the user in a situation that dictates whether he/she can distinguish words with similar phonemes. Another game mode aims to display an image to the user and to validate the initial Letter of the image presented. Finally, a game mode in which a Letter is displayed, and the user needs to decide which figure corresponds to the Letter presented.

5.3 Game Implementation

UnityEngine, known as Unity 3D or simply Unity, was used for the construction of the game. It is a 3D and 2D game engine created by Unity Technologies, which supports the use of several assets found on the Internet on the Unity website itself. In the case of game development, 2D technology was used, as it is a simple game.

Regarding the interaction with the application, the user needs to use the mouse if it is a desktop or the touchscreen if it is an Android device because it was developed to have easy-to-use controls. Next, the game process, along with the images, will be presented.

An important point to mention is that a large part of the game screens has linked audio, explaining the instructions for each screen. These details will be presented below.

When opening the game, the user is presented with the welcome screen (Fig. 1a). Next, an audio is played that portrays the information the image is going through, in this case, "Welcome to the game!!:) Is it your first time playing? If you have any difficulty, ask an adult for help". After a few seconds, Fig. 1b, The Play and Options screen is displayed.

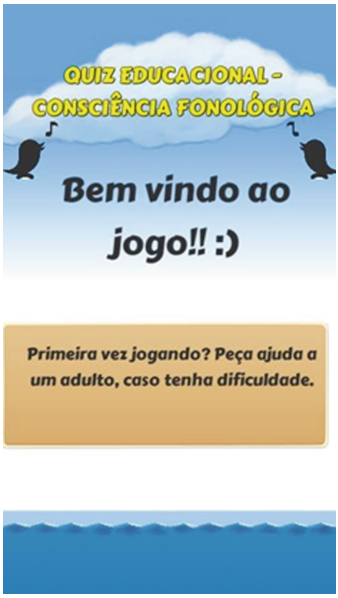

Fig. 1a. Welcome screen

Fig. 1b. Play/Option screen

By clicking on the Options button, a screen is loaded (Fig. 2a) with the player's preferences regarding the Effects/Music volume and the option "Reset Game Progress". By clicking the button with the Play icon (Fig. 1b), the Themes screen (Fig. 2b) is displayed, with the 3 available Themes in the game. In addition, there is an audio on this Themes screen, which says "Select a theme".

Fig. 2a. Option screen

Fig. 2b. Theme selection screen

If the user selects Theme 1, Fig. 3a is loaded. The user identifies the drawing, clicking on the Soundbox, and validating (true or false) whether the audio matches the displayed image. When loading Game Mode 1, automatic audio is played that says, “Does the picture correspond to the audio? True or false?”. If the user selects Theme 2 (Fig. 2b), Fig. 3b is displayed. Now, the user discovers the initial Letter of the image presented. When the user selects Game Mode 2, automatic audio is played that says, “Discover the initial letter of the figure shown below”. If the user selects Theme 3 (Fig. 2b), Fig. 3c is displayed, presenting a letter on the screen and four alternatives with images. The user must validate which image corresponds to the Letter presented. When loading Game Mode 3, automatic audio is played that says, “Which figure corresponds to the letter shown below?”.

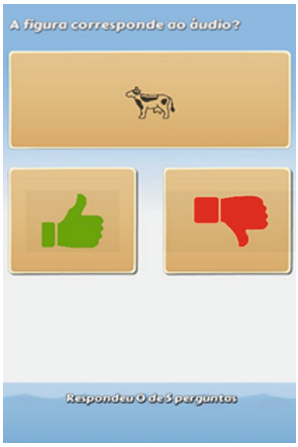

Fig. 3a. Game mode 1

Fig. 3b. Game mode 2

Fig. 3c. Game mode 3

The feedback screen is displayed by the user finishing any of the Themes, whether they are 1, 2 or 3. If the user’s score is negative feedback, the user scored was 4. Figure 4a is displayed. Then the audio says, “Ops! You didn’t do very well this theme”. If the feedback of the user’s score is positive, in the following example, the user scored 10. Figure 4b is displayed. Then, the audio says, “Congratulations!! Wow, you got all the correct questions!”.

Fig. 4a. Negative feedback

Fig. 4b. Positive feedback

6 Results and Discussions

The structure for carrying out the tests comprised two questionnaires developed and applied by the speech therapist.

Speech therapy professionals answered the first questionnaire after evaluating the tool. The second questionnaire was answered by the child audience, under the supervision of their parents. The results of these questionnaires can be checked in the section below.

The executable format of the game was made available so that professionals in speech therapy and children could play and evaluate the game.

The questionnaires mentioned above were made to collect information related to the game and its evaluations for improvements in the game. Recruitment of the 8 children it was for convenience and their age was 4 to 6 years old. All children were already attending speech therapy sessions. The questionnaire made for the child audience was evaluated by the children during the days 17 to 18 of November 2020. Recruitment of the 9 professionals of speech therapy it was for convenience. They had at least 10 years of experience in the field. The questionnaire made for the professionals of speech therapy was evaluated during the days 16 to 18 of November 2020.

6.1 Test with Experts

The experts' questionnaire addressed themes related to motivation, design, audio, being intuitive, suitable for the treatment or diagnosis of children. The results were:

- "The game is motivating for children between the age of 4 and 6 years old": the majority (2/3) of the professionals considered that the game is motivating to be used by children of the stipulated age group. This may mean that, concerning motivation,

the tool was evaluated positively; however, 11.1% disagreed. Therefore, there may be future work to improve this issue.
- "The design is adequate (colors, figures, texts, buttons and messages": the majority (2/3) of the professionals considered that the design of the tool is adequate and pleasant; however, 22.2% remained neutral. So, it is possible to think about a future work to improve the design of the tool.
- "The audio of choice of pictures is adequate for the treatment": 100% of the professionals considered that the audio of the figures is adequate for the treatment. This may mean that in future changes to the tool, the audio will not be affected.
- "The game is intuitive": 100% of the professionals considered that the audio of the figures is adequate for the treatment. This may mean that in future changes to the tool, the audio will not be affected.
- "The game is adequate for aid in the treatment of diagnosis of children children (aged between 4 and incomplete 6 years)": 100% of the professionals considered (strongly agree or agree) that the game could aid in the treatment or diagnosis of children (aged between 4 and incomplete 6 years) with the disorder. This may mean that the game is a potential tool to be used by professionals in their sessions.

6.2 Test with Children

The children's questionnaire addresses themes related to pictures and sounds. The results were:

- "Did you like the figures in the game?': the great majority of the child audience liked the figures in the game; however, 25% remained neutral. This may mean that, in future work, there may be an improvement in the tool's figures.
- "Did you like the sound of congratulations": the great majority of the child audience liked the tool's voices; however, 12.5% remained neutral. This may mean that there may be an improvement in the game's voices in future work, but it will not be the focus.
- "Did you like the sound "try again"": 75% of the child audience liked the sound of try again; however, 12.5% remained neutral, and 12.5% disagreed. This may mean that, in future works, there may be an improvement in the sound of the try again, which is reproduced when the user scores less than 5.

When the children were asked about what they liked the most, they answered: "To listen often", "To try again", "Guessing", "To play alone", "To choose right". When the children were asked about what they liked least, they answered: "From the end", "From the cell phone", "It's very easy", "It's very fast".

7 Conclusions

The project aimed to show the stages of building a computational tool able to help speech therapists in sessions for training phonological awareness.

Investigations were made to understand why an educational game becomes effective in learning, such as what type of design would be ideal for users and how the gameplay would need to be developed aiming to be intuitive and easy to understand.

Through the information collected in the questionnaires, it can be seen that the game can be used in speech therapy sessions to train phonological awareness, also taking into account its playful character.

The game will be standardized in future works since some points need to be modified and corrected as the game design issue. For example, there are black and white figures, and there are also color images. That means that the color pattern is required.

It is also thought to add new themes. Currently, there are only three. The goal is to study and validate which theme can be added to make the game more and more complete. There may be an improvement to make the game more motivating since 11.1% of the professionals disagree that it is motivating.

Another future work, totally considerable, is about the sound effects and audios of the figures. As seen in the graphics of evaluations about the game, one of the points mentioned and needs attention is these. It is reflected in adding more appropriate voices to be heard to make the game more fun and interactive.

All tests were carried out online due to the social isolation period because of the Covid-19 pandemic. The speech therapist who effectively participated in this project was responsible for making the contacts so that the tests could be carried out.

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References

Adams, M.J.: Consciência fonológica em crianças pequenas. Artmed Editora (2018)

Amorim, A.N., Jeon, L., Abel, Y., Felisberto, E.F., Barbosa, L.N., Dias, N.M.: Using escribo play video games to improve phonological awareness, early reading, and writing in preschool. Educ. Res. **49**(3), 188–197 (2020)

Anthony, J.L., Francis, D.J.: Development of phonological awareness. Curr. Dir. Psychol. Sci. **14**(5), 255–259 (2005)

Bimonti, R.P.: A Importância da Consciência Fonológica na Educação Infantil, São Paulo – (2008). http://www.crda.com.br/tccdoc/20.pdf. Acesso em: 08 maio 2020

Donicht, G., Miranda, A.R.M., Cunha, A.P.N.D.: Estudos sobre aquisição da linguagem escrita (2019)

Figueiredo, K.O., Cardenuto, R.R., Amato, C.A., Martins, V.F.: KeRa Puzzle: Jogo Digital Educacional para Apoio à Intervenção Fonoaudiológica. Revista Ibérica de Sistemas e Tecnologias de Informação **E41**, 503–515 (2021)

Guindeira, T., Gil, H.: Digital educational games & phonological awareness. In: 2017 12th Iberian Conference on Information Systems and Technologies (CISTI), pp. 1–5. IEEE, June 2017

Inácio, A., Nunes, S.: Tellfunny: auxiliando crianças na pronúncia e aprendizado das palavras através de um jogo. In: Anais da XIX Escola Regional de Computação Bahia, Alagoas e Sergipe, pp. 89–94. SBC, April 2019

Kahl, K., de Oliveira Lima, M.E., Gomes, I.: Alfabetização: construindo alternativas com jogos pedagógicos. Extensio: Revista Eletrônica de Extensão **4**(5) (2007)

Noemí, P.M., Máximo, S.H.: Educational games for learning. Univ. J. Educ. Res. **2**(3), 230–238 (2014)

Scherer, A.P.R.: Princípio alfabético e consciência fonológica: fatores determinantes no tempo de leitura de crianças em processo de alfabetização. Signo **32**(53), 82–99 (2007)

Unity User Manual: Documentação do Unity (2019). https://docs.unity3d.com/Manual/. Acesso em: 10 maio 2020

Zorzi, J.L.: As trocas surdas sonoras no contexto das alterações ortográficas. Soletras (15) (2008)