Assistive Technologies in Aphasia Rehabilitation: Prototyping for the Task of Object Naming

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Aphasia is a language disorder caused by brain injuries, often as a result of a stroke. This condition significantly impairs communication and profoundly affects the lives of patients. Rehabilitation is critical in improving outcomes and may include tasks such as object naming, where patients identify presented images. This process can be enhanced through the use of assistive technologies. This exploratory study was conducted in three stages: a systematic review, developing and validating a preliminary prototype, and creating the final version. The systematic review revealed that integrating technology into treatment provides immediate and long-term benefits. However, a notable gap was identified: the lack of designed software for this purpose. To address this need, the study proposes developing a prototype application to support aphasia rehabilitation, with a primary focus on object-naming exercises. **Keywords: Aphasia. Rehabilitation. Applications. Naming.**

Aphasia is a language disorder caused by an injury to the brain region responsible for communication skills such as reading, speaking, and writing [1-3]. The injuries can be caused by neurodegenerative diseases, trauma, tumors, and infections, with stroke being the most common [1]. Symptoms vary according to the type and degree of aphasia, but generally, they manifest as a loss of the ability to assimilate, process, and express oral and written language.

An aphasic person may have their professional and personal life affected, directly impacting their well-being and quality of life, because communication difficulties contribute to a feeling of non-belonging. One way to encourage social inclusion is through language. Language is fundamental in this process because it represents a group that shares a culture and communication rules. The use of language, besides generating a sense of belonging, is also an important means of self-expression, ensuring autonomy and freedom for the speaker.

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Legislation that makes the inclusion of different languages aimed at accessibility, such as LIBRAS and braille, mandatory in shows, theater, and schools is an example of the importance of language in the inclusion process. According to Silvia Lane, language acts within groups to generalize and transmit practices for survival, which is essential for transmitting knowledge acquired over time through socialization [4].

Thus, aphasic people are vulnerable in terms of participation in social groups. Besides being made invisible because of their disorder, they cannot communicate clearly through language.

Rehabilitation is crucial for recovering the patient's language skills and contributing to their reintegration into society.

Aphasia rehabilitation can be performed through various tasks. This study focuses on object naming, which involves presenting a physical object or a picture of the object to the aphasic person, who needs to identify it. A speech therapist or a family member can assist with this task by providing hints to help with naming.

Different methods can be used to perform the naming task. One example is "Look, Listen, Repeat," in which a series of photos of objects are presented to the patient, followed by the graphic and phonetic presentation of the object's name, which the patient needs to repeat aloud [4]. This method can be efficient in recovery, as naming difficulty arises from the blockage of lexical-

semantic association, contributing to problems with attention, fixation, and memory caused by brain damage [2].

Constant repetition and reinforcement of rehabilitation tasks contribute to improving the difficulties presented [2]. As part of the treatment, the family member accompanying the aphasic patient needs to reproduce the activities practiced in the clinic at home. This is an important part of recovery because it complements the work done with the speech therapist and facilitates the repetition of training in the comfort of home.

The increasingly widespread use of gamified technological resources in treating different medical conditions has proven effective [5]. The association of games with treatment offers a more engaging and motivating environment for the patient, who participates more actively in recovery. Additionally, using technology in conjunction with treatment offers a broader range of possibilities, such as including games in this process [1,5,6].

In the context of aphasia rehabilitation, technology can act as an ally in systems that help facilitate patient communication. The studies found address applications that assist aphasic individuals in forming sentences, such as the Jellow App, an Augmentative and Alternative Communication application developed by Alam and colleagues designed to compensate for impaired language skills [5]. While they support stimulus therapy, these programs are not designed with a focus on treatment but rather on immediate communication.

During the systematic review conducted for this study, only one project with this proposal was found, the Thai naming application for clients with aphasia [5]. The study selected 5 pairs of caregivers and aphasic patients who underwent treatment together with the application for 12 weeks, showing improvement and stability in word naming. Patients also reported improved quality of life and self-esteem after using the application, showing that assistive technologies can be an effective and accessible tool in the recovery of aphasia patients [7].

However, the application is only available in Thai, limiting its use to speakers of the language. From this, a potential lack of assistive software for aphasia rehabilitation that uses the naming task and can be used by patients with professional guidance was identified.

Other possibilities not identified include software aimed at medium and long-term maintenance of acquired skills, the chance to transfer the battery of tasks performed by the speech professional to the digital environment, recording patient progress, adapting treatment to patient individualities, and a program in Portuguese that meets these requirements.

In this context, this study aims to develop a prototype application to support aphasia rehabilitation, focusing on object naming in a way that can complement the actions of health professionals. Hopefully, the developed system can encourage aphasic recovery and autonomy, positively impacting their rehabilitation process.

Materials and Methods

This exploratory study, conducted between November 2023 and May 2024, comprised four key stages: a systematic review, prototyping of a preliminary version, validation of the preliminary prototype, and development of the final prototype.

Systematic Review

The systematic review explored the state-of-the-art application of assistive technologies in object-naming tasks for aphasia rehabilitation. Conducted using the Scopus platform and CAPES Journals, the review identified 21 articles, of which seven were deemed relevant to the project based on their focus and methodologies.

Preliminary Prototype Development

The preliminary prototype was created using Figma, a free vector graphic editing and prototyping tool. Figma's features enable

the creation of interactive user screens and diverse user flows, making it an ideal platform for developing distinct application interfaces. The prototype adopted the "Look, Listen, Repeat" method [4], presenting an object alongside its written name for the patient to recognize and repeat while omitting the auditory component visually.

Key features included:

Reward System: Users earned a coin for each correct naming attempt. Incorrect answers were not penalized to avoid discouragement.

Hint Options: Two hint mechanisms were incorporated to assist users:

- The first displayed the word spelling incrementally, letter by letter, allowing users to identify the word progressively.
- The second provided the image and complete spelling of a related object to aid associative recognition.

Validation of the Preliminary Prototype

The prototype was presented to a speech therapist specializing in aphasia rehabilitation in Bahia. The therapist evaluated the prototype based on clinical knowledge and practical experience, suggesting adjustments to enhance its relevance and functionality. These insights informed the next stage of prototype refinement.

Final Prototype Development

Feedback from the validation stage was implemented in the final development phase. Additional refinements focused on enhancing the application's usability and patient engagement.

Results and Discussion

Systematic Review Insights

The systematic review highlighted the relevance of object-naming tasks across different aphasia contexts, demonstrating their efficacy in facilitating word retrieval. Combining traditional speech therapy with technological tools enhanced patients' naming and communication abilities.

The research uncovered a gap in domestic contributions to this field, with only one article originating from Brazil. This underscores the need to promote the development of aphasia-specific technologies tailored to the Portuguese language and Brazilian accessibility requirements.

Furthermore, only 3.2% of the reviewed articles were linked to engineering or computer science, revealing a significant opportunity for interdisciplinary exploration in assistive technology applications for aphasia treatment.

Key Findings

Seven of the 21 articles analyzed were selected for their detailed focus on object-naming tasks and the application of assistive technologies. Table 1 summarized the findings, which outlines the main points of each study, emphasizing approaches to object naming and their outcomes.

Implications for Development

The analysis confirmed that object-naming tasks effectively contribute to aphasia rehabilitation when integrated with assistive technologies. However, the limited presence of Brazilian research and engineering contributions suggests untapped innovation potential. This study addresses this gap by proposing a technology-driven solution tailored to local needs and contexts.

This work demonstrates that leveraging assistive technologies can complement clinical efforts, improving the recovery experience for aphasia patients while fostering inclusivity and autonomy.

Summary of Findings

The reviewed studies demonstrated positive outcomes in recovering naming abilities and

Table 1. Sistematic review results.

Reference	Relevant Topics
Menke R et al, 2009 [8]	Patients received computer-assisted naming training over the course of two weeks. The training involved associative language learning to strengthen the semantic associations between object images and auditory and graphic cues. The training was structured into five levels of difficulty, where the cues provided to the patients were progressively reduced, culminating in the free naming of the object without phonological or graphic cues. The training was supervised by an experienced speech and language therapist, who evaluated the patients' responses and provided feedback after each training block.
Savage SA et al, 2023 [9]	The naming task was applied using photographs of target objects presented in random order through a computer program. The method used was "Look, Listen, Repeat."Slides were created for each item on the training lists, including an image of the target object, followed by the same image with the written label and an audio presentation of the corresponding word. Naming performance improved after each intervention block, with maintenance over time and generalization to naming objects in natural environments.
Alam N et al, 2021 [1]	The study group showed greater improvement in spontaneous speech, naming, and communication. The use of the Jellow app facilitated the effective expression of patients' skills, indicating that the application is a useful complement to stimulation therapy. These findings suggest that integrating technology with traditional therapy can enhance treatment outcomes, providing patients with additional tools to aid their rehabilitation journey.
Barca L et al, 2009 [10]	Visual naming is thought to occur through the interaction of vision, semantics, and language, with visual and functional attributes of objects stored in separate locations, requiring successive access to these locations for effective naming. The studied patient exhibited a more pronounced visual naming deficit when objects were presented visually compared to other sensory modalities. This suggests that the visual processing pathway may be particularly affected, impacting the ability to access the semantic and linguistic information needed for naming. The patient did not show selective difficulties with specific categories of objects, indicating that the naming deficit encompassed a variety of object categories. This broad impact suggests a general impairment in the pathways or processes involved in accessing and integrating visual, semantic, and linguistic information. The patient demonstrated complex performance in object naming tests, with errors that included visually and semantically related errors, unrelated responses, and non-responses. These errors reflect the challenges in accessing or processing the necessary information for accurate naming and suggest a need for targeted therapeutic strategies to address these specific types of errors.
Middleton CQE, Mirman D, 2019 [2]	Identifying omission errors as a failure to attempt naming the object contrasts with commission errors, which involve producing incorrect or non-existent words. Understanding the neurocognitive basis of omission errors is crucial for personalizing treatment and evaluating outcomes. Research into the relationship between the location of brain lesions and the occurrence of omission errors in figure naming can provide insights into which areas of the brain are critical for the different stages of the naming process. This information can help clinicians tailor interventions based on the specific areas of impairment. The use of a computational model of figure naming can be valuable in assessing whether the degradation of lexical-semantic or lexical-phonological connections contributes to omission error rates. By simulating these connections, researchers can explore how disruptions in these pathways might lead to difficulties in accessing the necessary information for naming. Such models can help predict which types of errors are likely based on the nature and location of the brain lesion, allowing for more targeted therapeutic approaches that address the specific deficits contributing to the omission errors.

(continuing)

Trevittaya T, Piyawat K, Chinchal S, 2023 [11]	The categorization of twelve verbs and 58 nouns into two groups involved associating each word with an image, pronunciation, and six different types of cues to aid naming. These cues included semantic hints, the first letter, written words, sentence completion, phonological cues, and spoken words. The content validity of each item, such as words, images, and cues used in the application, was evaluated by three qualified speech therapists using the Item Objective Congruence (IOC) index. This ensured that the items adequately covered the proposed content. A naming rehabilitation app was developed and tested, then reviewed by experts to ensure its validity. The app was subsequently used in a study with five caregivers and five clients with aphasia. The use of the naming app in Thai was positive for the treatment of clients with aphasia. The results demonstrated that the protocol facilitated improvements in naming skills and enhanced the quality of non-verbal communication. The app proved effective in improving the ability of clients with word-finding difficulties to retrieve words and enhance their capacity for spontaneous naming. This indicates that such tools can be valuable in supporting language rehabilitation efforts, offering structured and diverse approaches to word retrieval practice.
Alam N, Kumar R, 2014 [12]	The evaluation of a 50-year-old patient diagnosed with Broca's aphasia was conducted using the first part of the Western Aphasia Battery (WAB). The assessment revealed severe impairments in spontaneous speech, repetition, and naming, although the patient showed better auditory comprehension. The patient was able to name 3 items without any cues and 9 items with tactile and phonemic cues. This suggests that while there is a significant naming impairment, certain strategies or prompts can aid in word retrieval. In the word fluency task, the patient was unable to name three animals within a given minute. This further highlights the challenges in verbal fluency and the ability to generate words spontaneously. For the sentence completion and responsive speech tasks, the patient completed 3 out of 5 items. This indicates some ability to engage in structured language tasks, but with notable limitations. The total score obtained for naming was 29, which indicates significant difficulties in object naming and verbal fluency. These results emphasize the need for targeted therapeutic interventions to address these specific areas of impairment, potentially incorporating strategies that leverage the patient's relatively better auditory comprehension to support language production.

maintaining skills over short- and long-term periods. However, none of the software solutions identified offered gamified, customizable treatment tailored for patients to practice and sustain these skills independently. Additionally, there was no software available in Portuguese to serve this purpose. While existing solutions addressed some individual requirements, none encompassed them simultaneously. This gap highlights the potential for developing software with enhanced functionality, broader applicability, and features that address these unmet needs.

In summary, the studies showed good results in patients' recovery of names and in maintaining skills in the short and long term. However, no gamified and customizable treatment software was identified that is available for patients to train and maintain the skills acquired, based on professional guidance, and available in Portuguese. The studies found meet some of the requirements, but not simultaneously, leaving room for the development of software with more possibilities that expand the applicability of this resource and address the identified gaps.

Prototype

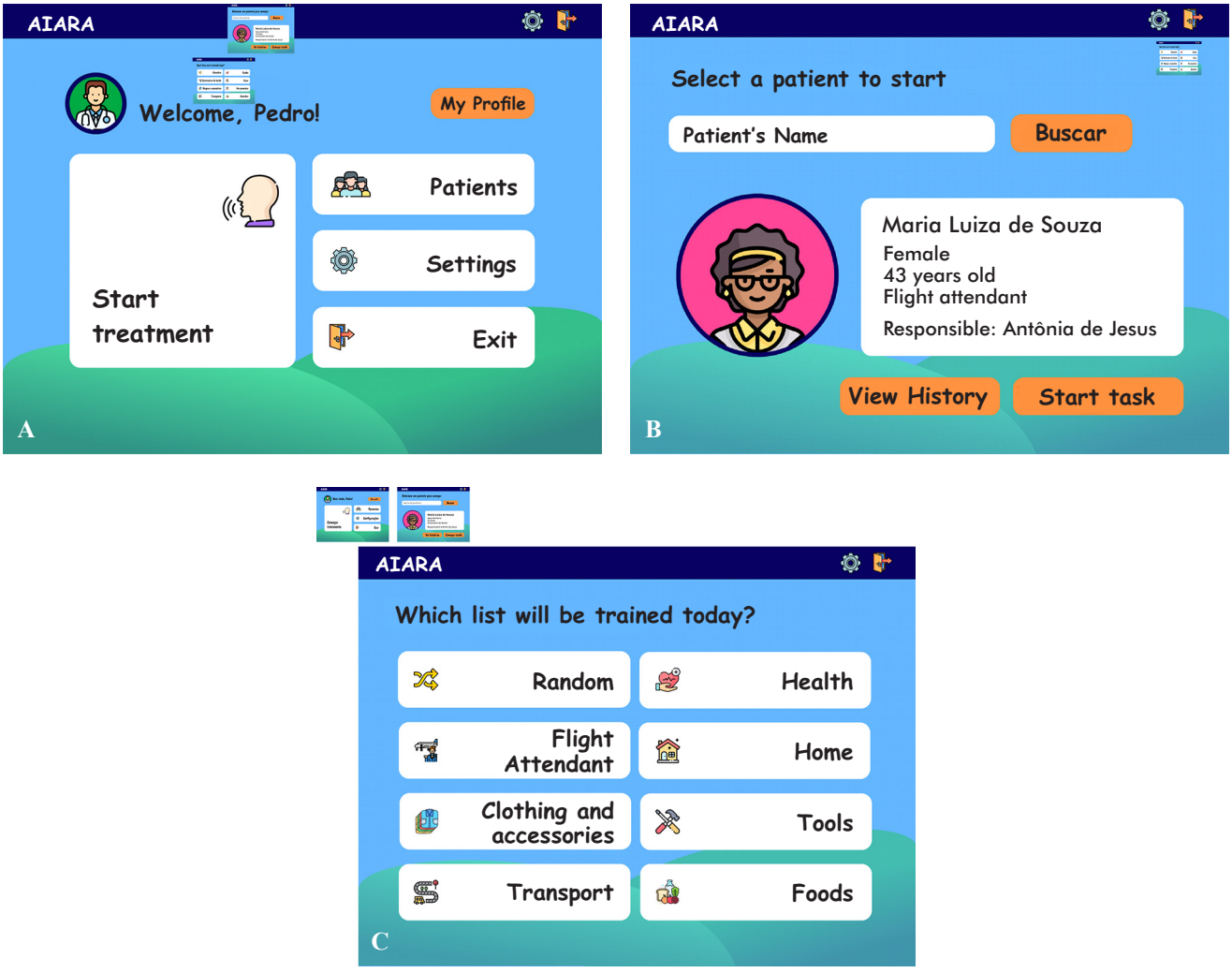
The first version of the functional prototype for the object naming task was developed based on the insights gained from reading the articles. The first step was to catalog the positive aspects identified in the methodology of the articles reviewed. Next, the perceived gaps and implementation possibilities to address these resource deficiencies were cataloged.

After presenting the preliminary version to a specialized professional, they implemented the suggested adaptations. The prototype development was carried out by integrating these aspects. Two primary interfaces were created, one accessed by the speech therapist and the other by the patient. The goal is to create a unified environment that can be used in the clinic and at the aphasic individual's home. This way, the patient will be more familiar with repeating exercises at home, providing a more efficient way to transfer the word list.

Two distinct flows were created to allow and restrict the speech therapist's ability to customize the aphasic person's treatment. Viewing the patient list and editing the boards or word lists is only permitted for the speech therapist. With these functions, the professional can tailor the treatment for each patient according to their specific needs. The word lists are thematic and associated with patients as needed.

Upon accessing the app, the screen illustrated in Figure 1A is presented. The "Patient" button displays the list of registered patients, allowing users to view their medical information and history. The "Settings" button leads to a screen for customizing text size, buttons, and contrast and allows the word list to be edited. Pressing the "Logout" button logs the user out of their profile. This functionality can also be executed by the button in the upper right corner and the settings, and it works the same for the aphasic individual. When accessing the "Start Treatment" button, the

Figure 1A. A. Speech therapist interface. B. Patients search interface. C. List selection interface



speech therapist needs to select the patient they are attending to through the database search (Figure 1B). Upon selecting the patient, the word list options are presented for the therapist to select which one needs to be trained during the session (Figure 1C). The speech therapist could use the platform for treatment and indicate to the patient which lists should be practiced at home. However, the patient interface functions are limited and operate differently from the speech therapist's interface.

The patient is not permitted to create, alter, or delete lists. Furthermore, the training will be limited to the list indicated by the speech therapist responsible for their treatment, and they cannot choose autonomously.

Upon logging into the application, the user is presented with the screen illustrated in Figure 2A. The "Logout" and "Settings" buttons function like the speech therapist's interface. Clicking the button to start training presents the theme selected by the speech therapist (Figure 2B) for that particular training, which begins by pressing the "Start Task" button. Both interfaces allow for app customization to ensure accessibility. Users can adjust contrast, font size, and sound volume. The buttons are designed in sizes that allow the patient to handle the app independently, which is important as many patients have impaired motor skills due to their injuries. The interfaces contain only the necessary information to avoid user confusion and errors. The texts are designed to be large enough for comfortable reading, avoiding excessive text on the screens. Care was taken to select colors that facilitate visibility and differentiation between buttons, text, and other elements. The treatment execution has the same interface regardless of the user type. After completing the necessary steps and starting the training, a screen is displayed with the image of the object (Figure 3). The screen also includes four buttons at the bottom: two for navigating between words, indicated by the letter A (previous and next); one to count correct answers (B); and another for the patient to try again (C). The list being trained is indicated at the top.

Additionally, the screen includes three more buttons in the designated area. One of the buttons expands the screen (D), allowing the patient to view the object more clearly if necessary (Figure 4). The other two buttons are related to hint options. The button indicated by the letter E activates the semantic hint, where an object associated with the object that needs to be identified is displayed on the screen (Figure 5). The button indicated by the letter F activates the spelling hint, where the word is presented one letter at a time.

A reward system was also added to encourage the patient to participate in treatment. The player earns a coin for each correctly named object in this system. This reward is an incentive, as the patient undergoing treatment aims to name the words correctly to earn more coins or rewards.

Figure 2. A. Patient interface. B. Start task patient interface.

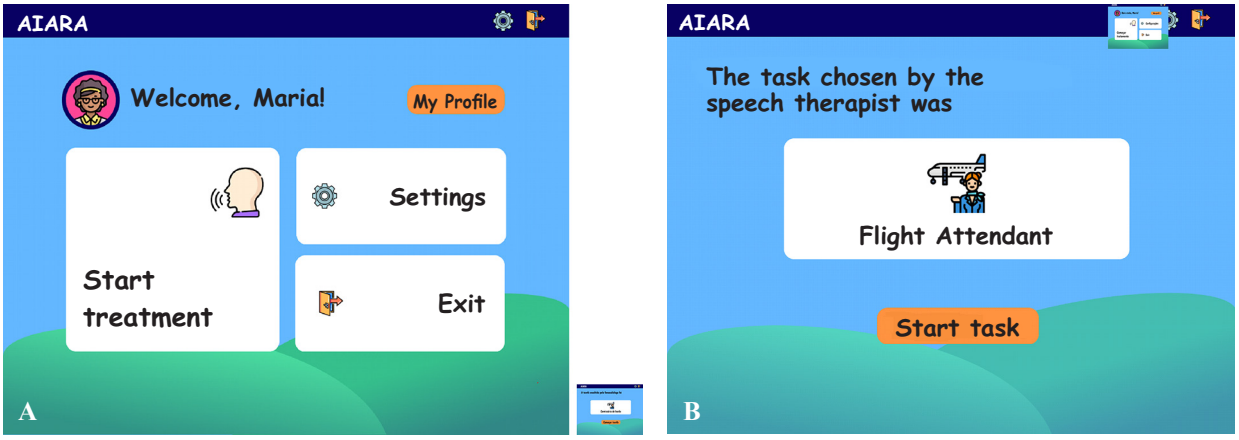


Figure 3. Training page.

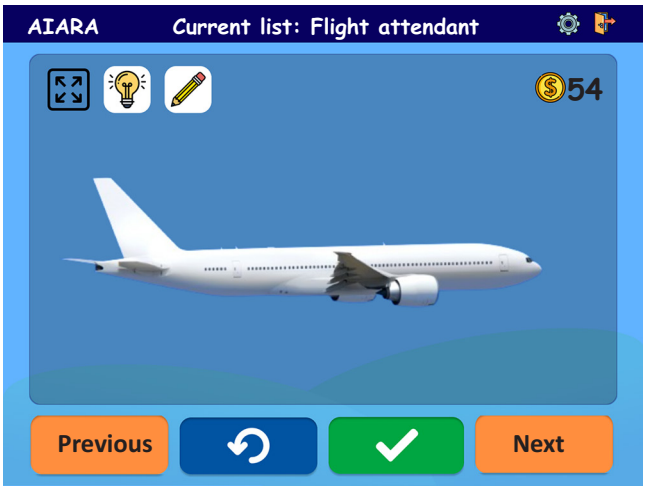


Figure 4. Image with zoom-in.

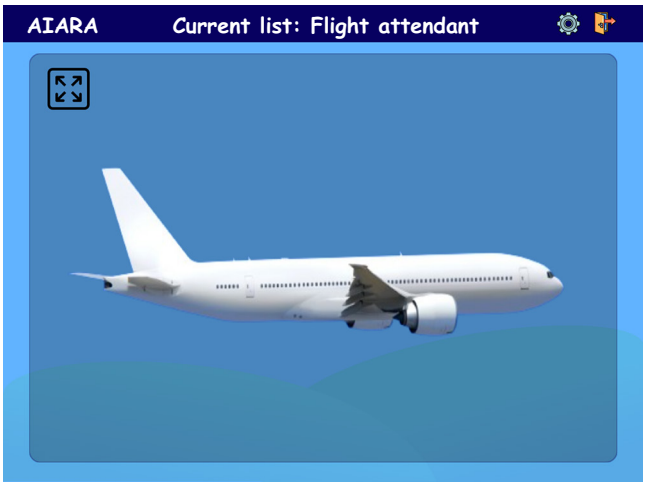


Figure 5. Semantics tip.

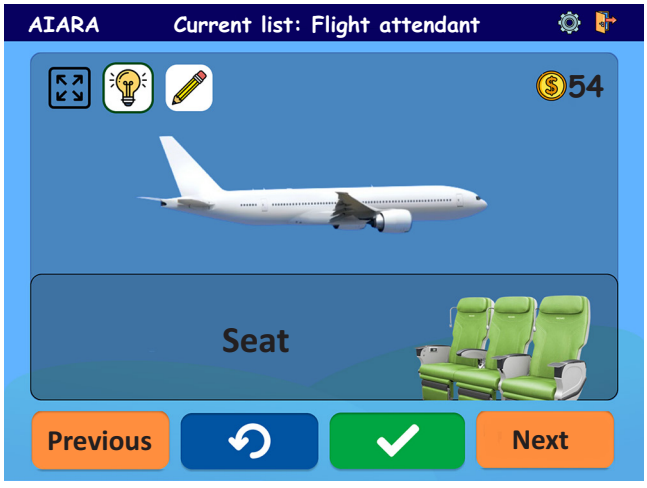
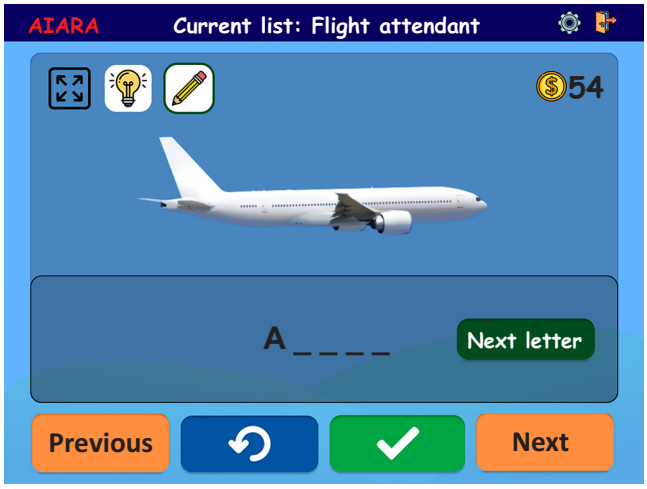


Figure 6. Spelling tip.



There is no deduction of coins for incorrect identifications, as implementing such a rule could have the opposite effect on the reward system's objective. However, errors are recorded with each new attempt, along with correct identifications, for logging in to the patient's profile. These records serve as a way to track progress and allow the speech therapist to analyze more precisely which adaptations are necessary and need to be made throughout the rehabilitation process.

Conclusion

With the development of the functional prototype of an application that can support aphasia rehabilitation through the task of object naming, it was possible to verify that this tool could be an important resource in the treatment. The intention is to model the application based on the developed prototype so that it can be implemented and made accessible to speech therapists and aphasic patients.

Moreover, using additional resources can contribute to word recovery and improve patient communication and quality of life. Tasks such as object naming, especially when assisted by gamified technologies, are practical in various contexts, emphasizing the need for personalized and adaptable treatments.

The prototype can aid in the development of the application and contribute positively to

aphasia treatment, helping recover the patient's communication skills and promoting a better quality of life and autonomy.

The next research phase, which aims to develop and implement the application, is also expected to fill the gaps found in similar services identified during the systematic review by offering an interactive naming system that encourages recovery and autonomy for aphasic individuals.

The prototype can promote the continuation of treatment outside the clinical environment by considering the creation of user-friendly and accessible interfaces for speech therapists and patients. This is essential for consolidating acquired skills through repetition and reinforcement. A reward system and auxiliary hints can enhance patient engagement, making the rehabilitation process more motivating and effective.

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