

Reinforcement and Homework Control for Children with ASD using a Mobile Application for Apple Watch

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Abstract: The article shows the design and development of a pair of mobile applications for Apple Watch and iPhone devices to reinforce and control tasks for children with autism disorders. This work takes advantage of the possibilities of smartwatches, such as internet connectivity, access to biometric sensors and ease of communication with users, to improve their autonomy in carrying out everyday routines. The application has been designed taking into account the needs and characteristics of this group, collaborating with two non-profit organisations in the area of A Coruña dedicated to the care of children with autism. The obtained final product is functional and has an impact on the quality of life of these children. This development contemplates the possibility of incorporating artificial intelligence to break down a task into smaller sub-tasks, in order to facilitate its understanding and the completion of the activity. Its use could also be extended to adults, if symbols are incorporated instead of pictograms.

1 Introduction

Wearable devices are electronic devices that can be worn as accessories or clothing. These devices are designed to be portable, often incorporating sensors, communication technology and data processing capabilities. Wearable devices include smartwatches, fitness wristbands or headsets and smart glasses, among others (see McCann and Bryson (2022)). These devices allow wearers to monitor and collect information about their health, physical activity or sports performance, for example, as well as provide notifications and additional functionalities (see Sazonov (2020)). They aim to provide a more personalised and accessible technological experience, integrating into the daily lives of users. In particular, in the field of therapies for children with Autism Spectrum Disorder (ASD) (Landa (2011); Organization (2021); Volkmar and Lord (2012)), wearable devices could provide them with a constant and unobtrusive support tool, helping them to organise their daily activities and develop autonomous task completion skills. The watch's display and notifications can serve as visual and auditory reminders, making it easier to follow instructions and complete tasks. In addition, the watch's touch interaction and sensors offer the potential to provide immediate feedback and visual rewards, which encourages task completion and fosters positive reinforcement. Taking into account the difficulties that children with ASD have in planning and organising their activities, it is necessary to develop tools that facilitate the daily lives of children with ASD and their environment, reducing situations of rejection and anxiety. In this sense, an app for Apple Watch, such as the one shown in this article, could be a perfect solution, as this device provides an accessible and portable interface for monitoring and reinforcing their tasks (see Apple Inc. (2022)).

To date, there are no applications specifically designed for wearable devices aimed at people with ASD. Although there are several apps and technological tools for people with ASD, most of them focus on mobile devices such as phones and tablets, offering a wide range of functions such as Augmentative and Alternative Communication (AAC), visual support, routines, and task tracking. The lack of apps specifically designed for wearable devices and people with ASD can be attributed to several factors. Firstly, the development of wearable apps requires special care of the wearable interface and usability, taking into account the specific needs and characteristics of users. This involves adapting the interface to be intuitive, easy to use and accessible, which makes it very difficult to develop. In addition, the design of such applications for people with ASD also needs to consider the particular nature of their needs and characteristics. For example, they may have difficulties with verbal communication and social understanding, requiring specific approaches to the presentation of information and interaction, therefore, existing applications oriented to function as reminders would not work for these individuals.

This paper presents in Section 2 the objectives for the development of a pair of iPhone and Apple Watch applications with the purposes above described; Section 3 shows material and methods used for project development; Section 4 presents the apps developed for iPhone and Apple Watch; in Section 5 the results obtained and expected from these applications are shown and discussed and, finally, the conclusions are presented in Section 6.

2 Objectives

The aim of this work is to design and develop a pair of mobile applications for Apple Watch and iPhone devices that reinforces and monitors tasks in children with autism spectrum disorders. The application leverages the capabilities of smartwatches, such as internet connectivity, access to biometric sensors, and user-friendly communication, to improve the autonomy of children with autism in performing daily tasks. The application is designed focusing on the specific needs and characteristics of this group, with a user-friendly and accessible interface. Therefore, the primary objective is to promote independence and specific skills in performing daily activities, which can have a significant impact on the quality of life of children with autism. The use of an Apple Watch would allow children with ASD to have a constant and discreet support tool for such purposes.

The project must have two types of users who can interact with the two applications: the administrator and the user. The administrator can be any type of parent or educator of the child with ASD, and the application (app in the following) that is intended for him/her is the resulting iPhone app. On the other hand, the user of the Apple Watch app will be the child with ASD. This user will only have access to this app.

3 Material and Methods

For the development of the project we have chosen to use an agile methodology such as SCRUM (Beck et al. (2001); Schwaber (2004)), due to its ability to deal with the challenges of developing a mobile application, such as changing requirements or efficient management of time and resources.

The choice of development tools such as watchOS (Apple Inc., 2023d), Xcode (Apple Inc., 2023e), Swift (Apple Inc., 2023a), SwiftUI (Apple Inc., 2023b) and WatchKit (Apple Inc., 2023c) over alternatives is closely linked to the choice of the Apple Watch as primary device. These tools were designed and developed specifically for Apple Watch development, making them almost exclusive to this task. However, these tools offer a complete and efficient development environment.

In this work we will include pictograms from Portal Aragonés de Comunicación Aumentativa y Alternativa (ARASAAC) (see Palao (2020)), a trademark backed by the Government of Aragon that offers a wide collection of pictograms, named as ARASAAC pictograms.

ARASAAC focuses on providing graphic resources for people with autism, intellectual disabilities, language difficulties or elderly people, among others. The inclusion of this collection of pictograms for communication in our apps is due to their recognition as the most widely used set of pictograms by both associations working with people who have this disorder and their families.

Generative Pre-trained Transformer (GPT)-3 is a language model developed by OpenAI (OpenAI, 2023). This model is based on the neural network architecture known as Transformer and is trained using large volumes of text data from the web. GPT-3 has gained recognition in the field of natural language processing due to its good ability to generate coherent and contextually relevant text in a variety of applications, including language translation, creative textual content creation, question answering and many other tasks. GPT-3.5 Turbo represents an evolution in the GPT-3 series of models, developed by OpenAI in 2022. This version is characterised by significant improvements in text generation. The use of GPT-3.5 Turbo in this project internally provides the possibility of creative textual content creation to allow the decomposition of complex tasks into more manageable sub-tasks, with the purpose of assisting the user in their execution. For example, when the task "Swimming pool" is given, it could provide a simplification into smaller tasks, such as "Hat", "Goggles", "Swimming suit" and "Swimming", which allows to automatically obtain the sub-tasks of a task without the need to set them beforehand.

4 Project Development

We will briefly present in the following two sections the apps developed for iPhone and Apple Watch.

4.1 iPhone App

This app allows users to identify themselves in order to have access to the data they manage under the application. In this way, tasks and data are stored and can be accessed from different devices, such as many models of iPhones and even iPads. The information is kept in the user's account, which ensures availability and continuity of tasks at any time and place. The administrator user can access the child's sensitive data collected from the use of the Apple Watch app. This ensures an adequate level of protection of information, as authorisation is required to access such sensitive data each time it is to be consulted.

The iPhone app also offers a number of account management options for users, so it includes the following: changing the password, logging out, recovering a forgotten password by sending a recovery email and creating a new account. This gives the user control to manage their account in a convenient and tailored way.

This iPhone app also gives users the ability to manage their tasks easily and efficiently, creating, deleting and listing them in an orderly fashion as new tasks are added (see Figure 1). The tasks focus on the ARASAAC pictograms, also allowing customisation to suit the needs of each child, and establishing different parameters to be defined by the user. In addition to the functions related to the tasks, the app also offers a pictogram search engine (see Figure 2). This is particularly useful for users, as they will be able to access a wide variety of pictograms through the ARASAAC database. By using this search engine further facilitates the process of finding and selecting the appropriate pictograms for each specific task or situation. This ensures a personalised experience adapted to the needs of each child.

Some of the sensitive information, to which the iPhone app user will have access, relates to the data collected by the child's Apple Watch app. These collected data are mainly focused on providing relevant information to improve the efficiency and effectiveness of assigned tasks. These include success and failure rates of tasks, time for task completion, time when a task is cancelled, or biometric data provided by the own Apple Watch. Emphasis is placed on the importance of guaranteeing the protection of this sensitive data and ensuring that it can only be

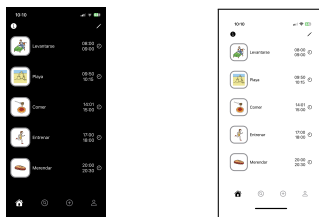


Figure 1: Home page for iPhone app.

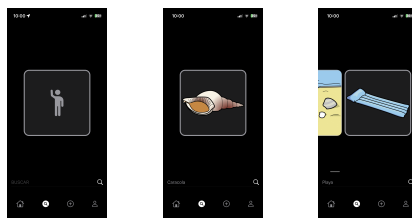


Figure 2: Pictogram search engine.

accessed by the administrator or authorised user. Authentication through password or biometric methods (via facial recognition or fingerprint reader) is an additional security measure that is implemented to maintain the confidentiality and security of the information.

4.2 Apple Watch App

The Apple Watch app provides a complete and up-to-date overview of all the tasks assigned to the child throughout the day. In addition to task displaying, it also provides relevant information on the nature of each one. The current homework is prominently highlighted, allowing the user to interact to successfully complete it, request help or cancel it as needed. This feature gives the user full control over tasks in real time. The app also allows the user to view all tasks, including past and future tasks that are still pending (see Figure 3). This is very useful to have an overview of all scheduled and completed tasks. In this way, the user can progress and make sure that all tasks are completed properly.



Figure 3: Past, current and future tasks.

At any time, a short press on the current task will trigger the display of a spinning coin animation (see Figure 4). This animation will be available for all tasks, whether current, past or future. Through this animation, the task information, including its name, can be accessed in capital letters for clearer understanding, as well as start and end time, represented only with symbols and numbers, which facilitates its use for children with ASD.

Moreover, this app is able to autonomously decompose tasks into sub-tasks using Artificial Intelligence (AI), adapting at all times to a non-verbal language so that the target audience is able to understand it (see Figure 5).

Interaction with the app is constantly guided through intuitive actions, such as swiping the



Figure 4: 3D coin spinning animation.



Figure 5: Example of the use of AI in help: results for two applications.

screen and manipulating the digital crown to navigate between the different tasks predefined by administrators. The inclusion of pictograms and geometric shapes, such as circles and progress bars, is a special consideration to the condition of these children. Careful attention is paid to the presentation colours, which are automatically displayed in a tone that harmonises with the pictogram currently in focus (see Figure 3), and which also play a representative role in the buttons: red colour indicates unsuccessful completion and, otherwise, green is used (see Figure 5). This creates a coherent visual association to facilitate navigation and understanding.

During the use of this app, the user's heart rate per minute is monitored in the background. If it is detected that the heart rate is too high, the user is warned that it is advisable to relax. This situation usually occurs when one of the tasks is causing stress. To provide support, an additional option is offered to terminate the current task, which helps to reduce that level of stress. A request for help is also provided if needed. It is important to note that all user activity within the app is recorded in real time. This includes the time for completing tasks and the total time for application or help use. These logs provide valuable information for detailed tracking and analysis of the user's performance. In addition, this allows to check the effectiveness of both apps and to make improvements based on usage patterns and user needs.

5 Discussion and Results

The data collected through these applications will allow professionals and families of children with ASD to monitor the daily tasks they perform and reinforce behaviours that will enable them to make progress. The statistical data collected will help achieve the improvement in their autonomy and self-esteem that is essential for the quality of life of these people. The project ensures that all this information is recorded, as can be seen in Figure 6, with the administrator being able to consult the data collected by means of interactive graphics. In this figure, as an example, it can be observed that the time spent for the completion of the task is the 99% of the maximum time, the task is successfully completed 9 of 10 times it has been done and the evolution of the number of times the child has consulted the help during the last 10 days.

On the other hand, although from validation and testing with two entities they indicated that the final product was perfectly adapted to their needs, they pointed as improvement the selection of those tasks to control the child's keystrokes and the possibility of replacing pictograms with real pictures for some children. On the other hand, one of the entities highlights the advantage of using a wearable device such as a smartwatch, as the user can carry with him/her the programming of the tasks he/she has to carry out, knowing it in advance in a standardised way, and not worrying about forgetting the device somewhere. In this way, we reduce the situations of anxiety and stress that this type of planning tends to cause in children with these

disorders.

Nowadays, AI is a technology in constant evolution and increasingly present in our daily lives. In the case of this project, even though it was not in the initial objectives and requirements, it was decided to integrate AI to improve task prediction and decomposition. This is due to the fact that children with autism often present situations of stress and anxiety when faced with complex tasks, and they need clear commands and direct instructions to help them perform the different activities of daily life. Thus, they can have automatically generated support thanks to AI that is perfectly adapted to their individual needs.

As for the viability of this developments, it can be affirmed that it is completely viable and this is evident thanks to the factors that will be explained below.

Firstly, it should be noted that the market for mobile applications aimed at children with ASD is constantly growing. This market is characterised by the scarcity of products available and an increasing demand for technological solutions that can improve the quality of life of these children. In addition, the growing popularity of mobile devices and wearable technology, such as the Apple Watch used in this work, offers a significant market potential for the pair of applications here developed. In fact, to date, there is no other application available for the Apple Watch that focuses on this specific audience, which represents a unique opportunity. Also, the resulting Apple Watch app is the first in the world of existing apps for children with ASD to incorporate AI in this specific audience.

From a technical perspective, it is important to note that the developed project is fully viable. This is based on the fact that a fully functional and ready-to-use pair of apps has been created. Moreover, from an economic point of view, the cost of development and maintenance is reasonable.

Finally, it is relevant to mention that the proposed mobile app complies with all applicable laws and regulations, including laws of European Union. Furthermore, any use of external sources is appropriately referenced within the application to ensure compliance with all applicable laws and regulations, including data protection and privacy laws.

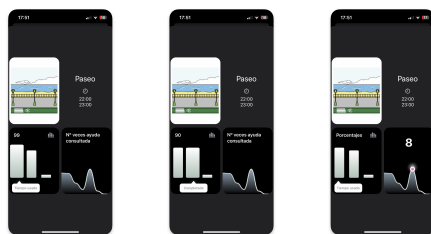


Figure 6: Results with interactive graphics.

6 Conclusions

In the work carried out, it is worth highlighting the achievement of developing two fully functional applications that cover all the objectives proposed at the beginning of the project. The aim of these developments is to meet the real needs of people with diversity, mainly those with ASD, who require comfortable and easy-to-use applications to carry out everyday tasks and thus improve their quality of life. This work responds to these needs, paying meticulous attention to the design of a simple and user-friendly interface, and taking into account the active collaboration of two entities in the area of A Coruña, which participate in the development throughout the whole process. The tests with real users, i.e., children with ASD, will be carried out in the coming months.

The main future direction of this project is its publication in the Apple App Store. Other possible lines are the internationalisation of the app or the use of descriptive icons instead of pictograms, to make them more suitable for adults.

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