Design and Implementation of a Selective Attention Computerized Test

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Abstract

The development of the Computerized Test Margaritas arises from the need of the research team in the area of psychology to have an automated tool that supports the diagnosis of selective attention in children between the ages of 6 and 12 years. This document presents the different steps that lead to the achievement of a software product that supports the aforementioned need, designed for mobile devices, specifically for 7-inch tablets. The construction of this product began with the lifting of requirements, definition of the software architecture, database design, interface design prototype, software development and finally, application of pilot tests until obtaining the desired final product. After passing the pilot test stage, a sample is considered at the level of several cities of Ecuador in which the test is applied to measure its reliability obtaining a value of 0.90 according to the Kuder Richardson method and whose result guarantees the validity of the test.

Keywords
Selective Attention, UDA automated test, daisy test, attention software and software.

1. Introduction

Add introduction here including motivation of the research (why this research is important / why this research is needed), and problem statements. (10 font) Attention is the behavioral and cognitive process of focusing on a discrete aspect of information while ignoring other perceivable information (Anderson 2004). Attentional mechanisms play a fundamental role in the functioning of other cognitive processes such as perception, memory, and or language. Several studies suggest that selective attention plays a crucial role in academic success. In the meta-analysis conducted by (Duncan et al. 2007), it was found that the level of attention at the beginning of the school stage is a strong indicator of later reading and writing learning and achievement in mathematics. Selective attention has also been related to regulating behavior and emotions (Rueda et al. 2010), so children who do not have adequate selective attention skills may derive more easily into behavior not conducive to learning due to poorly regulated emotions. On the other hand, the cultural practices of the families, communities, and institutions in which children participate seem to influence the development of their attention patterns.

In evaluating selective attention, several instruments are used to analyze attention processes. For example, the attention d2 test evaluates different aspects of selective attention, including mental concentration, visual perception, visual scanning capacity, and perceptual speed (Baron 2003), (Brickenkamp and Zillmer 1998). The Stroop color-word interference task evaluates selective attention and inhibitory control (Stroop 1935), (Spieler et al. 1996). The differences perception test or Test of Faces (Thurstone and Yela, 2012) is a discrimination test of similarities and differences. During the test, participants determine the element different from a group of three schematic elements. These elements consist of simple line drawings that represent faces, two of the three faces are the same, and one is different. All these tests are paper-based and have been validated for populations and environments culturally different from the Ecuadorian. Paper-based tests have limitations regarding the kind of information that can be collected, such as the time between answers and the time it takes for a subject to answer a section of the test. Collecting this data using paper-based tests can be impractical and costly in terms of time and resources. In psychologists' and pedagogues' practice, it is common to apply psychometric paper-based tests. They usually face the additional difficulty of manually scoring the test and storing the data obtained for future use in research. In this paper, we propose developing a mobile application as an alternative solution to these limitations of paper-based tests.

The current characteristics of mobile devices offer opportunities for the development of increasingly sophisticated applications that take advantage of the multipurpose hardware of modern devices to their fullest extent. The development of applications, as is the case with any other software product, must start from a design with a high level of quality, the products obtained must be safe and robust, and the requirements must be carefully designed, in accordance with the standards of the industry. The relevance of classical software engineering methods in this type of application is still under discussion (Majchrzak and Heitkotter 2016). Mobile technology has also led to the emergence of new challenges such as the need to develop on multiple platforms, context-sensitivity, as well as problems related to mobility-dependent performance and security, and energy conservation (Dehlinger and Dixon 2011), (Joorabchi and Mesbah 2013).

This document describes the design and implementation of the Computerized Margarita's Test, a mobile application to assess selective attention. A subset of UML diagrams that fit the needs of the mobile application domain was carefully identified. This subset includes the use case diagram to document the requirements elicitation, the class diagram to model the structural view of the system, and the state diagram to model the behavior of the mobile application. In Latin America, the penetration of mobile devices based on the Android operating system is around 84%; for this reason, the application was developed for devices based on this operating system. The application was implemented using Java and the Android SDK. The data collected by the application is stored locally in an SQLite database.

2. Literature Review

Five different paradigms are used to assess attention: a) sustained attention (continuous monitoring of different stimuli), b) selective attention, c) stimulus-response compatibility (with the use of double-input conflicting stimuli, Stroop test), d) the orientation of attention, and e) divided attention. Voluntary attention, of cultural, historical construction, refers to selective-focused attention, which allows selecting the available information so that only the

pertinent stimuli for the activity in progress can be retained or treated, inhibiting the response to the other stimuli present.

Several studies have addressed attention assessment with the support of technological devices, focusing on the development of computerized tests for the evaluation of different types of attention, including sustained attention, selective attention, and visual attention.

Martin, Torres, and Lopez-Tolsa(Martin et al. 2017) propose a sustained attention model under a virtual environment, using a Psychomotor Vigilance Test (PVT) technique to measure the Attention performance of a virtual agent under conditions of impairment and enhanced factors (the circadian rhythm of sleep and by sleep deprivation). (Morenza Padilla et al. 2011) present a computerized video game based on Sustained Actuation Tests (PAS) to assess sustained visual attention. The task consisted of pressing a button when the participant perceives a signal that is displayed in the center of a computer screen that simulates a spaceship cabin, obtaining indicators about the speed of reaction, learning, and attention. The Computerized Digit Vigilance Test (C-DVT), designed by (Yang et al. 2015), is a test adapted from the DVT test. It is based on the stimuli and administrative rules of the DVT as references for the design of the C-DVT. The C-DVT was designed to assess sustained attention with a limit of random measurement errors. The results demonstrated that the C-DVT has concurrent validity, ecological validity, and test-retest reliability in stroke patients.

The study by (Craven and Groom 2016) focused on selective attention. It describes several game designs that aim to monitor or improve the attention of children or adults through a mobile application that applies Continuous Performance Test (CPT) through AX-CPT tasks (displays a sequence of letters of the alphabet) and X-CPT tasks (displays a sequence of fruit graphics). A new version uses performance/reaction time tests with Go/No-go and Stop-signal tasks.

The test for joint attention developed by Caruana et al. (2017) used an eye gaze cue and an anthropomorphic avatar face generated with FaceGen for the stimuli. This study demonstrated that this intention tracking process has a measurable effect on receptive joint attention behavior. The work of (Heitzer et al. 2019) consisted in designing Cogstate; this is a computerized cognitive battery designed to monitor attention, memory, and processing speed in children with medulloblastoma. (Fan et al. 2019) created Densely Annotated Video Salient Object Detection (DAVSOD) to analyze the dynamic behavior of human attention by observing the phenomenon of visual attention switching.

Zainuddin and Ihsan focused on creating computerized tools that allow detecting and understanding the psychological condition of a child by applying tests based on learning games (Zainuddin and Ihsan 2013). Likewise, Szczesna, Grudzinski, Mikuszewski, and Debowski create psychotherapeutic games that allow control emotions in different types of situations, such as Master your fear (Szczesna et al., s. f.).

3. Methods

The mobile application development followed the Agile-SCRUM methodology (Kaleel and Harishankar 2013). This methodology consists of five phases: i) requirements analysis, ii) design and development, iii) testing, iv) product acceptance, and v) market release.

3.1 Requirements analysis

The objective of the computerized test is to identify the level of selective attention in school-age children. The test presents groups of three images resembling daisies with facial expressions, where two are identical, and one is different. The elements included in these color images simulate the mouth, eyes, eyebrows, and petals. In addition, they show facial features that sign anger, happiness, sadness, surprise, and fear emotions.

The mobile application requires showing these 30 groups of images and recording the user's selection of the images that she has identified as the images with differences. In addition, the application should store the time between selections and evaluate the responses to determine misses, omissions, and hits. All this information remains stored in

a local database on the mobile device, available when the evaluator requires it. Table 1 presents the variables that are stored.

Table 1. Stored variables.

Hits	Sum of the number of hits, which allows calculating to what extent the attentional percentile is fulfilled.
Misses and omission	Sum of misses and omissions. For the analysis, this value is considered as the number of misses.
Percentile	Score based on the number of hits obtained.

The minimal functional requirements for the computerized test include:

- Allow saving subjects' personal information, including date of birth, educational institution attended, and city of residency.
- Allow saving data collected during the subject testing (testing date, subjects' response for each group of images: hits, misses, and omissions, the time interval between answers for each question, the total time to complete the test)
- Allow reporting the results based on the standard scoring table according to the number of hits and subjects' age.

The use case diagram visually depicts the functionality of the application. Figure 1 shows the users: psychologists or professionals in related areas and evaluation subjects (school-age children).

Figure 2 shows the interaction of each user group and the processes related to the functional requirements defined.

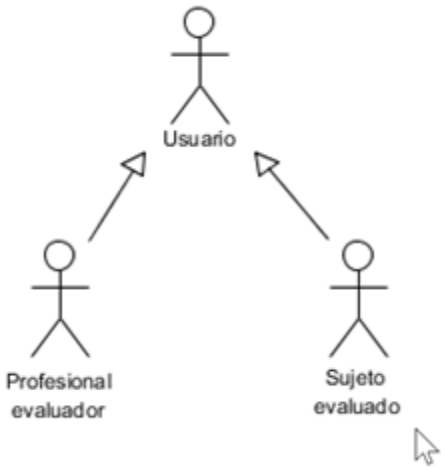

Figure 1. Application users

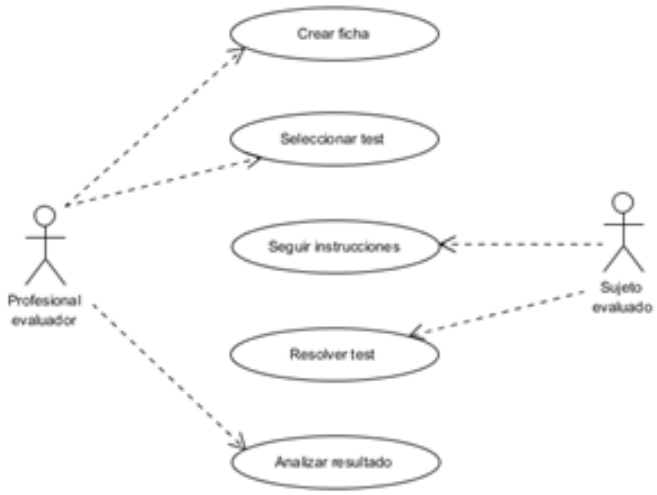

Figure 2. Use case diagram

3.2 Design and development

The mobile application was implemented with Java, the Android SDK, and the Eclipse IDE Kepler Release for mobile devices with a minimum size of 7 inches, with Android 3.0 operating system – API Level 11(Honeycomb) or higher and a screen resolution of 1024 x 600 WSVGA. The application stores the subject's personal information and the testing results. The information collected during the testing is stored locally in an SQLite database. Figure 3 shows part of the user interfaces for the identification of differences.

Figure 3. User interface

3.3 Tests

The functional testing performed ensured the implementation of the main software functionality. UI testing checked UI elements display correctly, the screen's size and location. Security testing ensured that the sign-in and forgot password functionality was working. Before and after release, checks on release candidates were performed to check the full software functionality.

Four psychologists from the University of Azuay and twenty-one children attending an educational institution in Cuenca tested the mobile application. Table 2 shows the scenario suggested for applying the test.

Table 2. Scenario suggested for applying the test

Sequence	Action	Description
1	Log in into the mobile app.	The evaluator runs the mobile app and sign in into the Margaritas Test.
2	Create a subject personal record	The evaluator selects the Take Test option, selects the subject's name, and uses the instructions on the screen to guide how to take the test.
3	Select taking test option	The evaluator selects the Take Test option, selects the subject's name, and uses the instructions on the screen to guide how to take the test.
4	Follow the instructions	The app shows on screen the instructions on how to solve the test. The app allows practice selecting the daisy that is different from the others and using the navigation elements on the screen.
5	Solve the test	The app shows the first set of daisies; the subject selects the image that is different from the other two. Repeat the process for the remaining 29 sets of images. When the test finishes, The mobile is returned to the evaluator.
6	Show results	The evaluator selects the Results option to check the final results of the test for the subject.

The research team established the steps presented in Table 1 to maintain standardization in the test application process. The results from the testing led to several design recommendations implemented later.

3.4 Product acceptance

Expert judgment assessment and a pilot test were conducted to ensure the instructions and test mechanics were comprehensible.

3.5 Release to the market

The application was delivered to professionals in the psychology area of the University of Azuay in order to apply them in educational institutions at local and national levels.

4. Results and Discussion

The final result was the Margaritas Test mobile application. Considering the traffic light color theory, the colors that prevail in the user interfaces are yellow, green, and red.

Figures 5, 6, 7, and 8 depict some Margaritas Test screenshots. They show the sequence of using the mobile application: the creation of the evaluation subject's record, the instructions and training for the test, the execution of the test, and the results obtained.

Figure 4. Creation of the child's file

Figure 5. Instructions for test application.

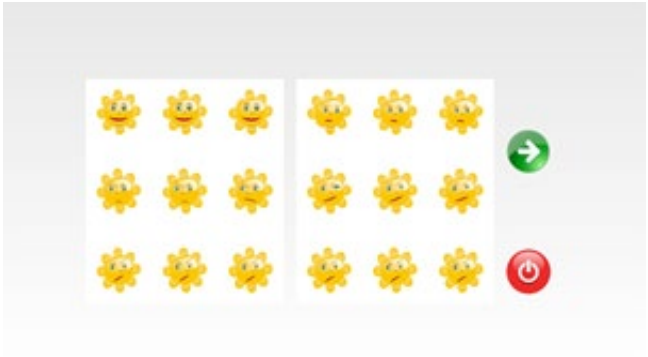

Figure 6. Application of the test.

Figure 7. Results of test application.

The reliability and validity verification phase was conducted following the construction and validation of the tests process according to APA of 2012 (APA). The following activities were performed:

- The assessment by expert judgment and a pilot test demonstrated understanding of the instructions and the execution of the test. The pilot test included a sample of 15 children of both genders.
- Evidence-based on the response process: the analysis of the pilot test results shows no differences between the results of female and male participants but between ages, which was expected due to the stage of the development process.
- External sources of evidence consist of analyzing various groups related to the aspect to be evaluated. The experts performed a test and retest on a sample of 40 children.
- Factorial and item analysis: the Kuder Richardson method was applied due to the binomial nature of the variables (correct answers, incorrect answers), yielding a value of 0.90, with a sample of 1011 children.

5. Conclusion

Information technologies, specifically mobile devices, make it easier for professional psychologists and pedagogues to apply the test due to the ease of interaction of children with this type of device and the ease of mobilizing resources to different geographical areas.

The evaluation of selective attention in children through the computerized Margaritas Test improves time and use of resources.

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