English

Evaluation and comparative analysis of free applications geared to prevention of loss of memory in Alzheimer´s patients.

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Abstract

***Introduction**: Alzheimer's disease (AD) is one of the world's major public health problems, accounting for 70% of dementia cases. Currently, there is no drug capable of modifying the course of the disease or curing it. This situation has led to the emergence of new therapeutic strategies, where eHealth is making headway. Due to the increased number of mobile applications on health issues, it is essential to analyze their characteristics be able to evaluate their usefulness for patients, and it is necessary to have tools that facilitate the choice of apps according to the user's objectives and characteristics. The aim of this research was to analyze and evaluate the various free apps on the market (Android and iOs) aimed to prevent the loss of memory in Alzheimer's disease, making it possible to know which applications meet the necessary criteria to ensure patient improvement. **Method**: The validated iSYScore and MARS scales have been used to assess app indicators in different dimensions. **Results**: Although there are several free applications aimed to prevent memory loss, this study showed that, when evaluated with the scales mentioned above, the same results were not obtained in each of the different dimensions.*

***Keywords**: Research study; Alzheimer; Dementia; Memory; Application Evaluation.*

Resumen

Evaluación y análisis comparativo de aplicaciones gratuitas orientadas a prevenir la pérdida de memoria del paciente con Alzheimer.

***Introducción**: La enfermedad del Alzheimer (EA) es uno de los mayores problemas para la salud pública mundial, llegando a abarcar un 70% de los casos de demencia. Actualmente, no existe ningún medicamento capaz de modificar el curso de la enfermedad ni de curarla. Esta situación, potenció la aparición de nuevas estrategias terapéuticas, donde la eSalud se abre camino. Debido al aumento de aplicaciones móviles sobre temas de salud, es fundamental analizar sus características para poder evaluar su utilidad en los pacientes, siendo necesario contar con herramientas que faciliten la elección de apps en función de los objetivos y características del usuario. El objetivo de este estudio de investigación ha sido analizar y evaluar las diversas aplicaciones gratuitas del mercado (Android e iOs) orientadas a prevenir la pérdida de memoria en pacientes con Alzheimer, permitiendo saber qué aplicaciones siguen los criterios necesarios para asegurar una mejora del paciente. **Metodo**: Se han utilizado las escalas validadas iSYScore y MARS para valorar indicadores de las aplicaciones en diferentes dimensiones. **Resultados**: Este estudio ha mostrado que, aunque existen diversas aplicaciones gratuitas orientadas a prevenir la pérdida de memoria, al evaluarlas con las escalas comentadas no se obtienen los mismos resultados en cada una de las diferentes dimensiones.*

***Palabras clave:** Investigación; Alzheimer; Demencia; Memoria; Evaluación Aplicaciones.*

Resumo

Avaliação e análise comparativa de aplicativos gratuitos voltados à prevenção da perda de memória em pacientes com Alzheimer.

***Introdução**: A doença de Alzheimer (DA) é um dos maiores problemas de saúde pública mundial, sendo responsável por 70% dos casos de demência. Atualmente, não existe medicamento capaz de modificar o curso da doença ou curá-la. Esta situação promoveu o aparecimento de novas estratégias terapêuticas, onde a eHealth faz o seu caminho. Devido ao aumento de aplicações móveis sobre questões de saúde, torna-se essencial analisar as suas características de forma a avaliar a sua utilidade nos doentes, tornando-se necessário dispor de ferramentas que facilitem a escolha das aplicações com base nos objetivos e características do utilizador. O objetivo desta pesquisa foi analisar e avaliar os diversos aplicativos gratuitos existentes no mercado (Android e iOs) voltados para a prevenção da perda de memória em pacientes com Alzheimer, permitindo saber quais aplicativos atendem aos critérios necessários para garantir a melhora do paciente. **Metodologia**: As escalas validadas iSYScore e MARS têm sido usadas para avaliar indicadores de aplicação em diferentes dimensões. **Resultados**: Este estudo mostrou que, embora existam vários aplicativos gratuitos destinados a prevenir a perda de memória, ao avaliá-los com as escalas comentadas, não se obtêm os mesmos resultados em cada uma das diferentes dimensões.*

***Palavras chave**: Pesquisa; Alzheimer; Demência; Memória; Aplicações de Avaliação.*

Introduction

Alzheimer's disease (AD) is a neurodegenerative disorder that occurs in the central nervous system, specifically in the brain. The neuropathology of the disease involves chronic tissue inflammation, loss of synapses and neuronal death. Post-mortem diagnosis shows the appearance of insoluble intracellular aggregates of protein, neurofibrillary tangles mainly composed of Tau and β-amyloid protein, and extracellular plaques of β-amyloid.[1,2]

AD is the most common form of dementia, accounting for 70% of cases. According to the World Health Organization, "dementia is a syndrome involving impairment of memory, intellect, behavior and ability to perform activities of daily living." The main symptoms of AD - difficulties in memory, language, problem solving, performing daily activities, and other cognitive problems - appear years after the onset of the disease, and become progressively worse over time, leading to increased dependence of the patient and eventually death.[3,4,5]

Although some drugs are marketed for the symptomatic treatment of the disease, there is still no drug capable of modifying the course of the disease or of curing it. This situation has led to the need to search for new therapeutic strategies. Several studies have reported combined therapy or comprehensive treatments should be given to AD patients to keep the patient active for as long as possible, slow or stabilize the deterioration of affected cognitive functions, and maintain preserved cognitive functions.[6,7]

eHealth is making its way to make life easier for AD patients. We found various digital platforms that make everyday life more manageable for both AD patients and family members and professionals. Apps are one of the most widely used tools due to their great diversity, accessibility, and usability. These technological tools should be understood as a complement to the usual care. In addition, they have been attributed with the ability to reduce costs, overcoming the barriers of time and distance for follow-up of AD patients.[8,9]

Due to the increased number of mobile applications on health issues, it is essential to analyze their characteristics to evaluate their usefulness for patients, and it is necessary to have tools that facilitate the choice of apps according to the user's objectives and features. Despite being immersed for years in a digital and technological revolution, the incorporation of digital solutions in healthcare systems has not been implemented at the same speed as in other sectors. This work has a research purpose and was designed to perform an evaluation of free applications aimed at preventing memory loss in AD patients, something that can be useful and innovative.

Method

This study was conducted throughout 2022 and early 2023. It is a descriptive design study based on the evaluation of apps using validated weighting scales.

A literature search of studies was conducted in the electronic databases PubMed and Medline, using keywords such as "apps", "memory", "cognitive impairment", "rehabilitation", "cognitive training", "assessment", "Alzheimer's" and "dementia", encompassing articles in English and Spanish, to know the status of the topic in question.

Next, a search was conducted for apps, on iOS and Android operating systems, which could be used by healthcare professionals for memory treatment in neurological patients. To identify useful apps for patients with AD among those existing for the general population, we used a structured process, in which the following steps were carried out[10,11]:

- Search and identification of the type of application we want to use.
- Proof of appropriateness or suitability of the apps identified in accordance with our exclusion criteria:
  + Must be freely available and allow for downloading of free reduced versions.
  + Must be in Spanish.
  + Must be geared to patients with dementia.
  + That they apply, as a minimum, to 75% of variables requested by the evaluation tool iSYScore (10 of the 14 variables).
  + That they apply, as a minimum, to 75% of variables requested by the evaluation tool MARS (17 of the 23 variables).
- Make a final decision on which to use, recompiling those apps that appeared more frequently in the recommendation lists of manuals for patients, family members and care takers associations.[8, 9]

Four cognitive training-oriented apps that met our inclusion criteria were included in the analysis: Cognifit, Lumosity, Stimulus and Neuronation. These apps were then assessed according to some criteria, such as popular interest, trust, usefulness, engagement, functionality, aesthetics, and quality of information. To assess these and other characteristics, it was considered appropriate to use the validated scales: iSYScore and Mobile App Rating Scale (MARS).[12-18]

The present study did not raise ethical-legal issues of interest. No experiments were performed on humans or animals. No confidential user or patient data were disclosed or published. We declare that we have no conflicts of interest.

Results

We analyzed 4 cognitive training-oriented applications that met our inclusion criteria: Cognifit, Lumosity,

Stimulus and Neuronation. For the analysis we first used the validated iSYScore scale, which sets indicators of three dimensions (popular interest, confidence and usefulness), as shown in Table 1.

Table 1: Scoring of the validated iSYScore index indicators for different applications of the study.

	iSYScore Index			
	Neuronation	Stimulus	Luminosity	Cognifit
Popular Interest	**11**	**8**	**11**	**11**
Users scored the app positively	4	4	4	4
Available, as a minimum, on 2 of the platforms	3	0	3	3
Declared as being of interest by an association of those affected	4	4	4	4
Trust	**18**	**18**	**18**	**18**
Validated by a specialist, healthcare agency or scientific society	4	4	4	4
Fostered by an association of those affected	3	3	3	3
The app has a website associated to it (indicator of responsibility) and the commitment to comply with data protection:	4	4	4	4
Mentions sources of evidence	4	4	4	4
Names the organization in charge	3	3	3	3
Usefulness	**12**	**12**	**12**	**12**
Research on our small sampling of users (<30 users)	3	3	3	3
Statement from a scientific society or association of those affected	3	3	3	3
Provides information	0	0	0	0
Provides useful follow-up in health	3	3	3	3
Links with other affected people or users	0	0	0	0
Uses games to foster health	3	3	3	3
Total score	**41**	**38**	**41**	**41**

Our own drafting November 12, 2022.

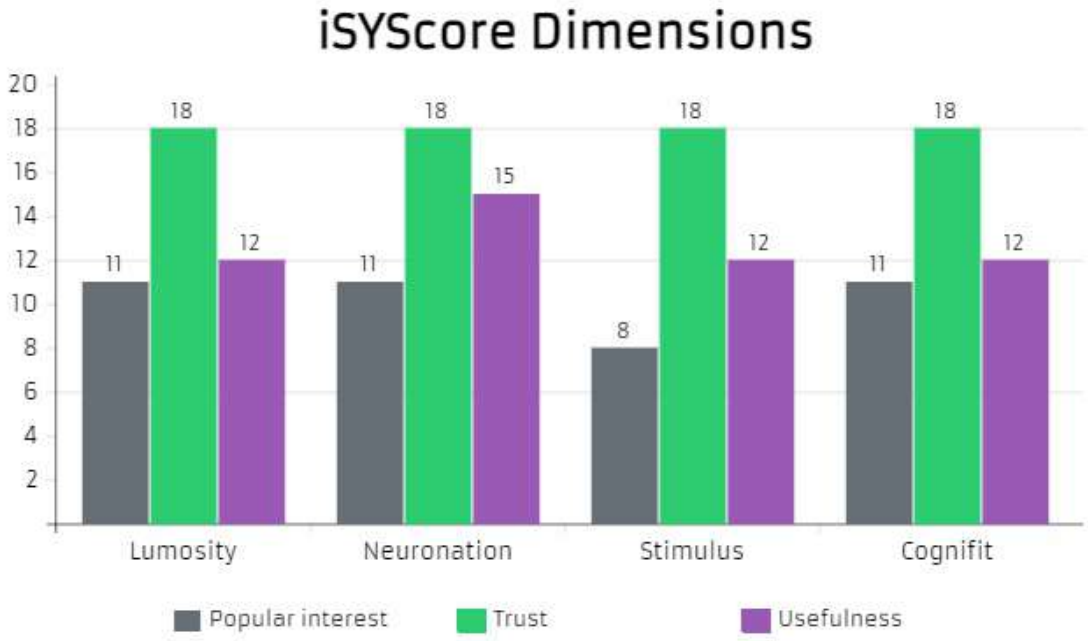
The values of the different indicators included in the iSYScore scale were assessed in absolute terms. The maximum value of the indicator was awarded in cases where the variable was met, while in the opposite case the indicator was scored 0. Thus, the values that an indicator could have ranged from 0 points (variables that were not met) to 3 or 4 points (varied according to the requirement exceeded).

Graph 1 shows a comparison of the apps in terms of the different dimensions of the iSYScore scale. We could see that the four apps obtained an identical value for "Confidence", 18 points (100%). Regarding the "Popular interest" dimension, three of the apps scored similarly, 11 points (100%), namely Cognifit, Neuronation and Lumosity. However, we found that the Stimulus application obtained a lower score, 8 points (72.7%), as described above, because it did not score in the variable "Available, at least, in 2 of the platforms". The "Usefulness" of Lumosity, Cognifit and Stimulus reached 12 points (66.7%), while in the case of Neuronation, this dimension amounted to a higher value, 15 points (83.3%). This is mainly due to the fact that none of the 4 applications analyzed in this study complies with the variable "Link with other affected persons or users".

When comparing the total score, resulting from the sum of the three dimensions of the iSYScore scale, we found that Neuronation scored higher than the other applications, 44 points (93.6%). Both Lumosity and Cognifit scored 41 points (87.2%), while Stimulus scored slightly lower, 38 points (79.2%). This information is shown in Graph 2.

We will now proceed to comment on the results obtained from the second part of the analysis, which used the validated MARS scale and sets indicators in four sections: engagement, functionality, aesthetics, and quality of information. Unlike the iSYScore Index, the score given to each of the variables analyzed is gradual (not an absolute value), ranging from 1 (inadequate) to 5 points (excellent), with a final score for each section, as shown in Table 2. The number of variables per section is different, since the maximum score for each varies, and the sections of the same app are not comparable. Although the scale allows for

Graph 1. Comparison of the dimensions of the iSYScore scale for the apps used.



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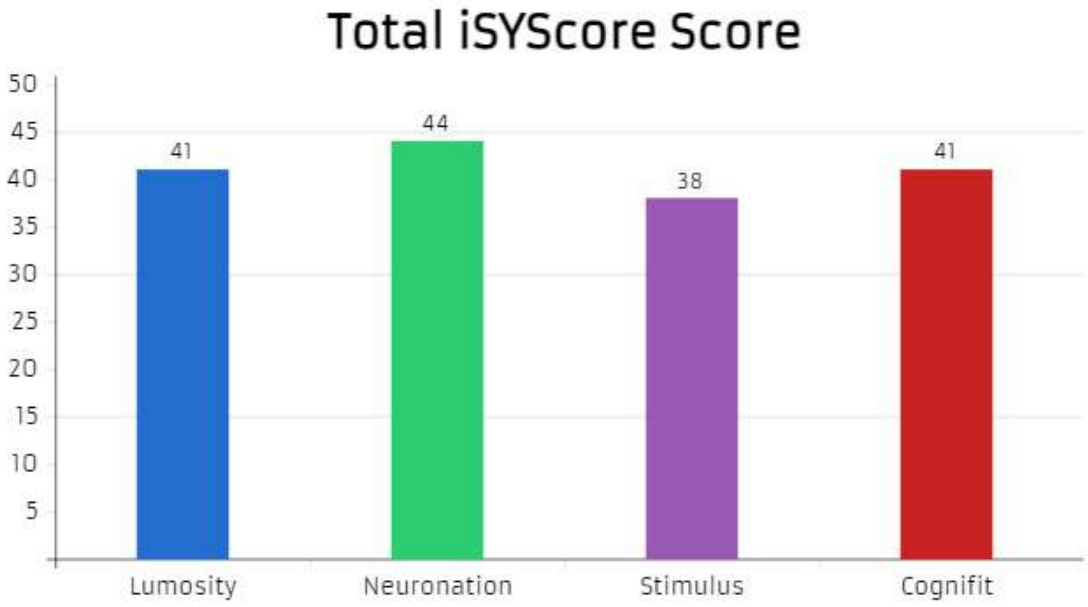
Graph 2. Comparison of the total iSYScore for the apps analyzed.



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it, it was not necessary to add the category "not applicable" in any of the evaluated fields of the four applications analyzed.

Graph 3 shows the comparison of applications in terms of the different sections of the MARS scale. Neuronation has the highest score for the "Engagement" section, 20 points (80%), followed very closely by Lumosity and Cognifit, 19 points (76%), and further behind by Stimulus, 16 points (64%). This is mainly because the latter provides hardly any internal options for configuration of sound, content, notification, etc. Regarding the "Functionality" dimension, Neuronation and Lumosity lead with the same score, 17 points (85%), followed by Cognifit and Stimulus with slightly lower scores, 15 and 14 points respectively (75% and 70%). In "Aesthetics" a similar trend to the other sections was observed, Stimulus was the app with the lowest score, 9 points (60%), followed by

Table 2: Scoring of the validated MARS scale indicators for the Neuronation, Stimulus, Lumosity and Cognifit applications.

Mobile App Rating Scale, MARS	Lumosity	Conifit	Stimulus	Neuronation
1. Entertainment: Is the app fun/entertaining to use? Does it use any strategies to increase engagement through entertainment (e.g. through gamification)?	5	5	5	5
2. Interest: Is the app interesting to use? Does it use any strategies to increase engagement by presenting its content in an interesting way?	5	5	4	5
3. Customisation: Does it provide/retain all necessary settings/preferences for apps features (e.g. sound, content, notifications, etc.)?	3	3	1	4
4. Interactivity: Does it allow user input, provide feedback, contain prompts (reminders, sharing options, notifications, etc.)? Note: these functions need to be customisable and not overwhelming in order to be perfect.	3	3	2	3
5. Target group: Is the app content (visual information, language, design) appropriate for your target audience?	3	3	4	3
A. Engagement mean score =	**19**	**19**	**16**	**20**
1. Performance: How accurately/fast do the app features (functions) and components (buttons/menus) work?	5	3	4	5
2. Ease of use: How easy is it to learn how to use the app; how clear are the menu labels/icons and instructions?	4	4	4	4
3. Navigation: Is moving between screens logical/accurate/appropriate/ uninterrupted; are all necessary screen links present?	4	4	3	4
4. Gestural design: Are interactions (taps/swipes/pinches/scrolls) consistent and intuitive across all components/screens?	4	4	3	4
B. Functionality mean score =	**17**	**15**	**14**	**17**
1. Layout: Is arrangement and size of buttons/icons/menus/content on the screen appropriate or zoomable if needed?	3	3	3	4
2. Graphics: How high is the quality/resolution of graphics used for buttons/icons/menus/content?	4	4	3	5
3. Visual appeal: How good does the app look?	4	3	3	5
C. Aesthetics mean score =	**11**	**10**	**9**	**14**
1. Accuracy of app description (in app store): Does app contain what is described?	4	4	3	4
2. Goals: Does app have specific, measurable and achievable goals (specified in app store description or within the app itself)?	4	4	4	4
3. Quality of information: Is app content correct, well written, and relevant to the goal/topic of the app?	3	3	3	4
4. Quantity of information: Is the extent coverage within the scope of the app; and comprehensive but concise?	3	3	3	4
5. Visual information: Is visual explanation of concepts – through charts/graphs/images/videos, etc. – clear, logical, correct?	4	4	3	4
6. Credibility: Does the app come from a legitimate source (specified in app store description or within the app itself)?	1	3	3	2
7. Evidence base: Has the app been trialled/tested; must be verified by evidence (in published scientific literature)?	4	4	4	4
D. Information mean score =	**23**	**25**	**23**	**26**
App quality mean Score (A+B+C+D) =	**70**	**69**	**62**	**77**

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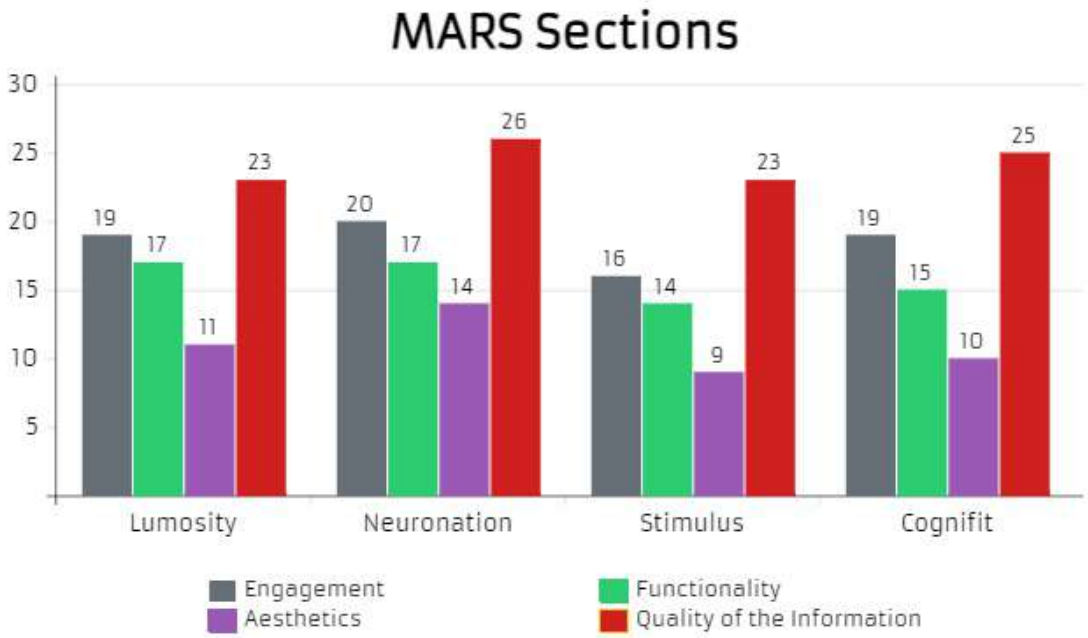
Cognifit and Lumosity, 11 points (73.3%), while Neuronation outperformed the rest of the apps in this dimension by quite some distance, 14 points (93.3%). The latter app has superior design, graphics, and visual appearance than the rest. Quality of information" was higher in Neuronation, 26 points (74.3%), followed by Cognifit, 25 points (71.4%), and Lumosity and Stimulus with the same score, 23 points (65.7%).

Graph 3. Comparison of the dimensions of the MARS scale for the apps analyzed.



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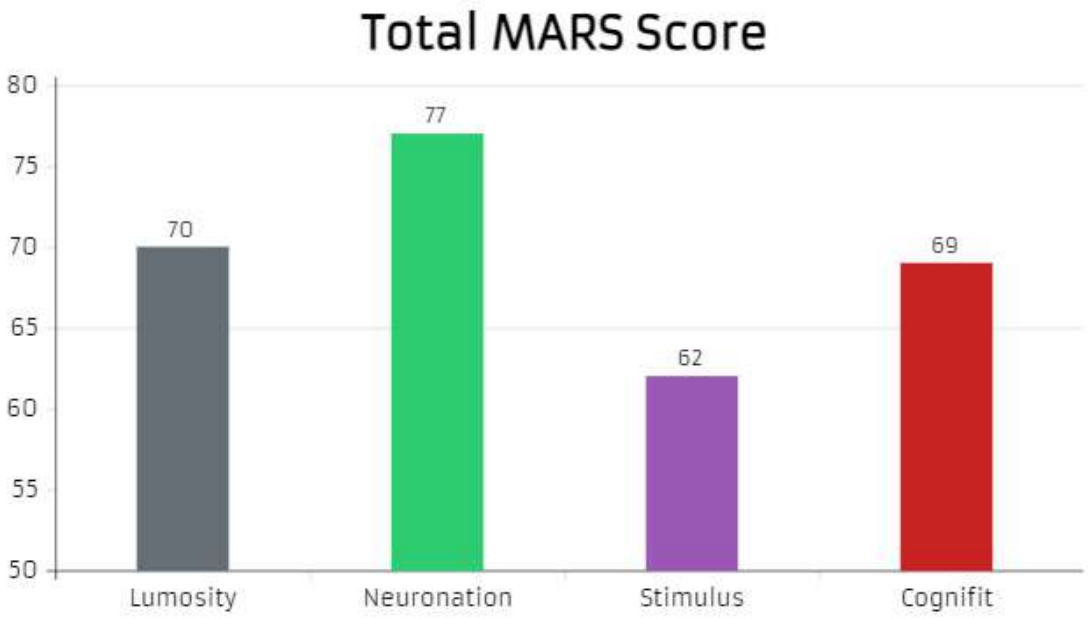
When comparing the total score of the MARS scale, the sum of the four sections, we found that Neuronation had a higher score than the other applications, 77 points (81.1%). Lumosity ranked second, with a score of 70 (73.7%), followed by Cognifit by a single point, 69 (72.6%). Stimulus came in last place with 62 points (65.3%), as can be seen in Graph 4.

Graph 4. Comparison of the total MARS score for the apps analyzed.



Our own drafting November 28, 2022.

Discussion

In recent years, several health app evaluation tools have been designed and validated; among others, we find the following scales: (mERA) checklist, NHS App Library, Royal College of Physicians checklist, criteria,

ORCHA, QoE, AQEL, Distintivo Appsaludable, AQuAS-UOC mHealth evaluation model, etc. We have used two of the most widely recognized frameworks for this evaluative purpose that use scoring: MARS and iSYScore.[19]

As indicated in the systematic review by M.T. Sánchez Rodríguez et al., professionals, patients, family members and caregivers should have clear criteria and indicators that can help them select the optimal apps for their specific needs. In addition, it is extremely important that all these agents involved in AD have access to clear and reliable information about health apps.[20]

When analyzing the results obtained using the validated iSYScore scale, we can see that the differences are not remarkable. Specifically, the largest difference was observed between Neuronation (44 points, 93.6%) and Stimulus (38 points, 79.2%) applications. This is possibly due to the small number of applications evaluated or to the fact that the inclusion criteria we have used in the selection of apps are too stringent, leaving out applications that would score lower. By including as an inclusion criterion "that can be applied to at least 75% of variables requested by the iSYScore evaluation tool", many apps are left out of the analysis, with the range of possible values that an app could reach in our app analysis study covering 47 points (maximum, 100%) to 31 points (minimum achievable, 65.96%).

Simultaneously, when analyzing the results obtained using the validated MARS scale, we observed slightly more striking differences. The range of total scale scores goes from 77 points (81.1%) obtained by Neuronation to 62 points (65.3%) for Stimulus. This greater variation is due to the fact that this scale does not evaluate the sections of the scale in an absolute manner, as there may be a gradation of each of the indicators. It may also be due to the greater number of indicators included in this tool. For example, indicators are set for two sections that do not appear in the iSYScore scale: functionality and aesthetics.

Regardless of the scale used, the scoring of the four apps follows a similar behavior, that is, the ordering is identical when classifying the apps according to the score obtained. This allows us to establish a possible ranking of the apps, according to the analysis performed of their dimensions, to adequately advise or recommend to AD patients, which would be: Neuronation would rank first (with 77 points on the MARS scale, 81.1%, and 44 points on iSYScore, 93.6%); Lumosity would rank second (with 70 points on the MARS scale, 73.7%, and 41 points on iSYScore, 87.2%); Cognifit would be third (with 69 points on the MARS scale, 72.6%, and 41 points on the iSYScore, 87.2%), and in last place we would find Stimulus (with 62 points on the MARS scale, 65.3%, and 38 points on the iSYScore, 79.2%). Thus, we have seen that not all apps score equally, and that both scales, despite not analyzing the same dimensions of the applications, seem to follow the same trend when evaluating.

At present, despite the existence of the evaluation tools mentioned above, the evaluation, if conducted at all, is usually partial, taking into consideration only some sections of the applications. For this reason, we considered it appropriate to complete the evaluation of the applications by using two tools in parallel, which would allow us to increase the number of dimensions evaluated. Regarding the format of the final app evaluation results, some of these tools work as checklists and the others use some kind of scoring system; MARS and iSYScore, as we have seen, belong to the latter group.[19]

Most of these free download applications have multiple ads, since they are really initial free download versions, it being necessary to pay to get the full or premium version of the application itself. We consider that the appearance of advertising that lacks relevance within the app considerably worsens its usability, understood as the ease with which users can interact with the application and make use of it. Moreover, due to the condition of the target users of the app - AD patients, usability is a very influential factor in its success since the appearance of advertising screens spontaneously hinders the possibility of navigating the platform without complications. We have found it necessary to comment on this condition about invasive advertising in this discussion because of its considerable importance, and because we have not taken it into account in our analysis nor is there any direct reference to advertising in any of the scales we have used.[21]

On the other hand, I would like to point out there is scarce evidence that cognitive training is useful to prevent AD, and even less that it delays the progression of AD in its early clinical stages. Some systematic reviews accept that there is little evidence, and that it is of inferior quality in most studies related to cognitive training, although these findings should be interpreted with caution because the included studies had low quality evidence. For this reason, the authors of these reviews themselves emphasize the need for higher quality studies.[20,22,23]

However, apps are a useful and valuable tool in AD patient management, slightly improving memory in elderly patients. Specifically, systematic reviews and meta-analyses by Alaa Abd-Alrazaq et al. and by Samantha Dequanter et al. found positive effects of cognitive training technologies on patients' cognitive functioning, and these technologies are more effective than conventional exercises in improving verbal memory and working memory. For this reason, we believe that it is important to continue creating applications that go beyond recreational games, which are designed and developed by multidisciplinary

teams and that have specific objectives aimed to improve the health of the user-patient.[24,25]

In short, the four applications included have obtained a good score on both scales. We believe that this is because I selected them as they were recommended in some of the AD or dementia guidelines and previously passed all inclusion criteria. In addition, the four apps have been on the market for years, having been adapted to achieve greater evidence of results. For this reason, we believe that any of them can be used at the preventive level of AD or in its early stages. However, the use of these apps does not replace or modify what is recommended for the patient: that they should have the earliest possible diagnosis, pharmacological treatment, and indications for non-pharmacological treatment (physical exercise and cognitive training) by the professional who monitors them. The information contained in an app should never be understood as a substitute for a health professional, being always recommended the evaluation, treatment, and supervision by the same.

Future work should continue towards the path of analyzing the applications that are most effective for cognitive training of AD patients and to understand which variables are the most appropriate for analysis of mobile applications focused on this disease.

Limitations

The analysis presented in this study was performed individually, so the results have not been contrasted by a third party. For this reason, we believe that a more comprehensive study is needed, in addition to regulating and standardizing the evaluation of health apps by multidisciplinary teams that include the patients themselves. However, we believe that conducting studies with AD patients is complicated due to the symptoms of the disease, the fact that it is usually diagnosed in advanced stages, and the fact that the disease evolves in quite diverse ways in each patient, with behavioral disorders often making it difficult to monitor training.

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