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The Effects of Playing the "We are Family" Brain Games in People with Mild Cognitive Impairment: A Feasibility Study

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Abstract

Background: Brain games are increasingly gaining attention as a non-pharmacological intervention to promote well-being and quality of life in people with cognitive impairment.

Objective: Herein we present the "We Are Family" (WAF) seniors mobile application and a feasibility study to evaluate its impact on the emotions of people in the spectrum of Alzheimer's disease (AD) ranging from Mild Cognitive Impairment (MCI) to AD. WAF includes 10 modules each one assessing different cognitive functions, such as memory, complex thinking, sustained attention, and short-term memory.

Methods: The feasibility study aims to investigate whether the current WAF app brain games and design has an impact on emotions of people with MCI and mild AD. The Positive and Negative Affect Schedule (PANAS) scale was used to evaluate the participants' emotional state before and after interacting with the WAF brain games. Additionally, we have collected information with regards to the preferences of the end-users about the application through a constructive questionnaire and open-ended tailored questions.

Results: Our findings demonstrated acceptance of the WAF app, with the participants referring to their experience as positive. A small increase in their overall positive emotions for the MCI group was noted and significant decrease for the negative emotion "Afraid".

Conclusion: These preliminary results show that people with MCI and mild AD experienced positive emotions while playing the WAF brain games, suggesting that people with cognitive impairment may benefit from using this type of software on a daily basis.

Keywords: Brain games; Alzheimer's disease; Mild cognitive impairment; Emotions; Brain stimulation

Introduction

AD is a neuro degenerative illness, which has an overwhelming impact on the patient, family and care givers [1]. Most research relating to People With Dementia (PwD) focuses mainly on the deterioration of cognitive abilities. Rarely does it take note of the remaining capacities of emotional and social intelligence, though many researchers suggest that these intelligences are much more reliable determinants of successful communication and relationships than mental intelligence [2]. Non-pharmacological interventions may improve patients' mental capacity, overall lifestyle and general wellbeing. The interventions often include physical and mental exercise sessions to stimulate brain functions and slow cognitive decline, aiming to prolong the rate of progression of AD.

Mental stimulation can be achieved *via* brain games as they activate various cognitive functions like memory, spatial relations, concentration and attention. In addition, games can promote psychological/emotional wellbeing e.g., through the feeling of accomplishment after solving a puzzle. When engaging and enjoyable, they can lead also to stress reduction [3]. Brain games as training applications hold their own unique and noticeable place within the category of non-pharmacological interventions for people with AD [3]. Additionally, mHealth apps and technological interventions in the form of brain games may improve diagnostic accuracy both in demented population as well as in preclinical stages, by assessing in real-time cognitive functions while allowing the healthcare professionals to compare their results with other evidence-based biomarkers [4]. The mHealth apps are accessible for the majority of people since they are generally affordable, can be easily installed on patients' phones and can be easily integrated with Electronic Health Records (EHRs) [5]. A plethora of apps including a large variety of games can be found (also online and free of charge), varying from word- or number-based to problem solving, and ranging in levels from easy to difficult. It is important to note that more studies are needed to investigate and evaluate the stimulation effects of the brain game apps [6].

Game apps specifically designed and developed for People with Dementia (PwD) are used in a wide spectrum (e.g., gamification/

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brain training, neurofeedback therapy), making the potential of such intervention tools evident. The benefits of using neurofeedback-based brain training games for enhancing cognitive performance in the elderly population are presented by [7]. The study showed positive and significant effects regarding visual memory, attention and visual recognition. The Altoida ADPS app consists of gamified versions of tests and constitutes a digital biomarker. The app differentiates between healthy controls and individuals in prodromal stages of AD and also between people with MCI who convert to AD and those who don't, serving as a valuable diagnostic tool [8,9]. Also, mobile Health applications (mHealth apps) relate to cognitive assessment, further supporting the potential of using alternative methods and technology for early detection of AD [10,11]. Moreover our recent feasibility study found that the COSMA App as a brain game can promote quality of life among people with cognitive impairment [12,13].

The acceptance of the mHealth apps by the elderly population and more specifically by PwD is still a challenging issue, while the investigation of preferable features and requirements constitutes an important topic in Information Technology (IT) and clinical research [14,15]. Investigating the PwD responses to a suggested mHealth app is of high importance in order to clarify and ensure technology acceptance by the patients. Through feasibility studies the impact and relevance of health research can be increased. As it has been highlighted by the Alzheimer Europe association, involving PwD and caregivers in dementia research is a "win-win for everyone involved" [16]. A lot of research has been done Investigating various aspects of health-related technologies, focusing on preferable features and traits that the elders would like to be incorporated in the suggested mHealth apps [17]. Also, the attitudes of elders towards different kinds of technologies ranging from brain games, smart home systems and remote monitoring and assistive technology, to general information that they would like to receive have also been explored [18,19]. In our recent feasibility studies, we developed a Human Factors and Technology Requirements Questionnaire (HFTRQ) which included ten dimensions in order to explore the beneficiaries' requirements towards using a wearable solution and the features they would like to be incorporated in remote monitoring technologies, while in another study we explored the potential adoption of particular mHealth apps through a questionnaire-based survey using Human Factors and Requirements for Interactive mHealth Applications including Reminders, Games, and Geolocation for People with Dementia, Caregivers, and Healthcare Professionals Questionnaire (HFIAQ) [20]. Currently feasibility studies examining Human Factors (HFs), acceptance and willingness of adoption of interactive systems and mHealth apps, such as brain games by the PwD with a hands-on experience are limited. The majorities of them is presented to the participants orally and assess the acceptance through questionnaires. Moreover, the emotions that might be affected in PwD after interacting with a mHealth app are scarcely explored. In this direction, the present feasibility study aims to address the need to examine the emotions of PwD after introducing to them a brain game app. In particular, it explores the intentions and preferences of people at a preclinical stage of AD such as MCI with respect to using an interactive mHealth app. Therefore, herein we present the We Are Family (WAF) Seniors App, a framework for people with MCI and early AD, designed to entertain them, maintain their engagement and strengthen their cognitive functions as they interact with the games on a regular basis. The app was designed and developed by ARX.NET SA. The aim of the study was twofold. Firstly, to collect usability feedback from the participants and their input, regarding the games and features of the app. Secondly, to assess the participants' emotional state and to investigate the impact the app could have on improving their overall mood. Feelings of depression, anxiety, guilt, grief are often observed in PwD with apathy usually following in more severe cases as the disease progresses. The WAF is personalized brain stimulating software for people with cognitive impairment (MCI, and mild AD). Evaluation of the WAF games assessed the overall acceptability of the app as well as the impact on the emotions of people with MCI and early dementia [21].

Materials and Methods

The study applied a mixed methods design including a feasibility trial and embedded qualitative interviews.

Participants and settings

The study was designed and supported by ARX.NET SA and conducted by the Centre for Research and Technology Hellas (CERTH-ETH.02/2019) in collaboration with the Greek Association of Alzheimer's Disease and Related Disorders following the declaration of Helsinki and is approved by the Scientific and Ethic's Committee of GAADRD (74/28-01-2022). The study was advertised to people with MCI and mild AD at the "Saint Helen" Day Centre of the Greek Association of Alzheimer's Disease and Related Disorders "Alzheimer Hellas" (GAADRD) in Thessaloniki, Greece. The inclusion criteria were determined as follows: people 50-80 years of age, being able to read and write, having basic computer skills, with a diagnosis of MCI [22]. People with visual impairment (correction with glasses and/ or color-blindness) were also considered eligible and able to participate. Memory deficits due to other neurological diseases like multiple sclerosis, Parkinson's disease, disqualified prospective participants from inclusion in the study, while illnesses like schizophrenia, serious respiratory and cardio/cerebrovascular disease, delirium, also had to lead to exclusion.

All participants were examined by neuropsychiatrists and neuropsychologists who completed their medical and psychological history, the results of their neurological and neuropsychological assessments as well as structural Magnetic Resonance Imaging (MRI) examination and neurological examination. Participants with AD fulfilled the National Institute of Neurological and Communication Disorders and Stroke/Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA) criteria for probable AD [23]. Moreover the Diagnostic and Statistical Manual of Mental Disorders (DSM-V) criteria for dementia of Alzheimer type were administered. On the other hand, the MCI participants fulfilled the Petersen criteria [24]. We tried to eliminate possible confounding factors based on blood tests (hormonal disorders, Vitamins deficiency etc.) and structural MRI (vascular/demyelinating lesions, tumors, anatomical variations etc.). All the above were taken under consideration for the recruitment process, since they could affect our sample performance and signal elicitation. Exclusion criteria included i) severe psychiatric, physical or other neurological disorder illness or any other somatic disorder which may cause cognitive impairment, ii) history of alcohol or drug and use of neuromodifying drugs except Cholinesterase Inhibitors or Memantine for the AD patients and iii) left handedness. Thirty participants were included in the study and played the WAF games: 15 people with MCI (3 Males, 12 Females) and 15 people with AD (4 Males, 11 Females). For the evaluation of the emotional response and shift, the Positive and Negative Affect Schedule (PANAS) questionnaire was administered to the participants (pre and post the WAF session). This self-reported questionnaire consists of two 10-item scales to measure positive and negative emotions [25]. Each of the listed emotions is rated on a 5-point scale with higher numbers indicating higher positive or negative affect (1=Not at all and 5=Very much). The PANAS questionnaire is often used to identify emotional shifts in people with MCI and AD [26]. The internal consistency, reliability, test-retest reliability, convergent and discriminant validity of the scale have been assessed [27].

The "We Are Family" senior's app

The We Are Family App (WAF) senior's app consists of ten different brain games, promoting complex thinking, sustained attention and short-term memory. In this section, the games of the application are presented shortly and the instructions accompanying each game are given [28]. In Figure 1A screenshots illustrating the games are given. The WAF senior App includes the following games.

Correct order: The participant is asked to place the given numbers in the correct order starting from the smallest to the largest. The numbers appear scattered in random order and must be placed in ascending order in the boxes.

Guess the number: The participant is asked to observe the given numbers and locate the one missing in order to complete the sequence. For example, the number that follows is always twice the previous one (e.g., in Figure 1B one can assume that the missing number is 60.)

Remember the pattern: The goal of this game is to memorize the highlighted tiles and to reproduce the presented pattern after it disappears.

Memory match: This resembles the classic Memory game where the participant tries to find matches of identical images each time.

Photo quiz: In this game, photos of famous and well-known people are shown. The participant is asked to find the correct name of the depicted person choosing from three possible answers.

Find the differences: The two pictures given have ten differences. The participant is instructed to look carefully at the pictures, spot the differences and mark them. The time needed for correct completion is shown on the screen.

Fish: Different patterns of fishes are given, and the participant has to choose the arrow indicating the direction of the fish in the center of the formation. In Figure 1G the fish located in the center of the formation is swimming to the left, so the participant must choose the corresponding arrow indicating this direction (Figure 1J).

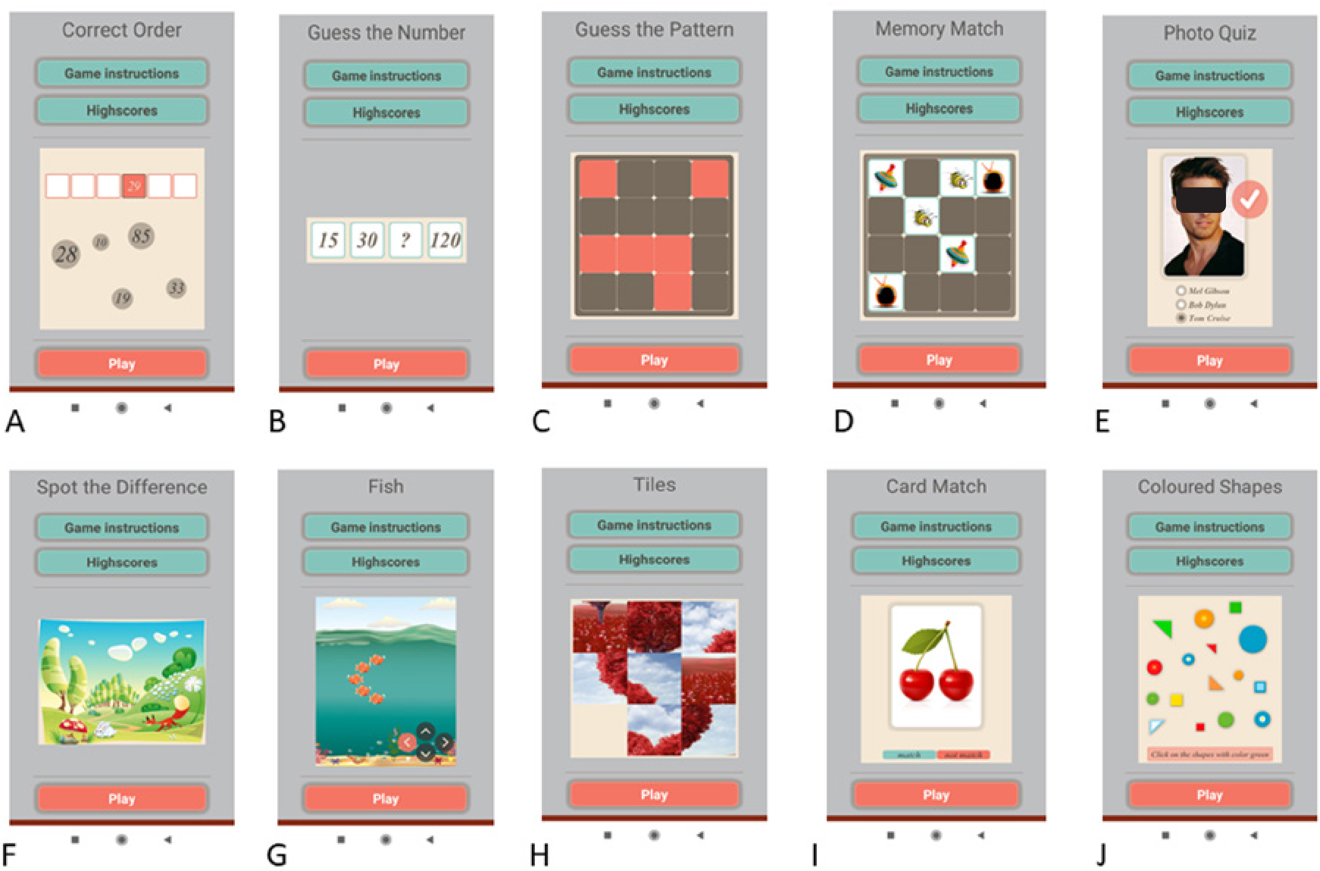

Figure 1: Screenshots illustrating the ten games of the WAF seniors app: A) Drag the numbers and place them in the boxes above in the correct order, B) Find the missing number and complete the sequence, C) Remember the pattern, D) Memory Match, E) Photo Quiz, F) Find the differences, G) Fish game, H) Tiles, I) Card Match and J) Colored Shapes.

Tiles: The tiles must be moved correctly in order to restore the distorted image (jigsaw puzzle).

Card match: Several cards pass on the screen. The participant should remember if the current picture is the same with the previous one and choose the corresponding button "match" or "no match".

Colored shapes: In this brain game, different geometrical shapes are depicted in various colors. Each time an instruction is given, e.g., "Click on the red colored shapes".

Sample size calculations

We note that for the present study, no sample size calculation was made and rule of thumb of 30 participants was considered adequate for the study. Similar and smaller numbers of participants have been included in other studies, and according to Anisimova "the samples with N's between 10 and 30 have many practical advantages" as the data are easy to analyze [1,29,30].

Results

Study design and procedure

For this research, participants had to fulfil a whole WAF game session in one visit. The module contained in total 10 categories as described in Section 2.2. The study was carried out in the Saint Helen Day Centre (Alzheimer Hellas) where the participants are familiar with the place, since they participate in weekly cognitive rehabilitation programs. After filling out informed consent forms, the eligibility criteria were determined, and the participants were assigned to a study group, MCI or AD. Afterwards, the participants were asked to fill out the PANAS questionnaire in a relaxed state guided by an experienced neuropsychologist. Thus, the "pre WAF session" emotional status of the participants was set (baseline). Next, the neuropsychologist introduced the WAF app (installed on a smartphone) and a short explanation was given on how to interact with the app and play the WAF games. The participants were instructed to try out all the ten games. Then, the participants were given a smartphone and the time to go through the app on their own. Participants played the games and interacted with the app in general (reading the Instructions etc.) for approximately 20-30 minutes. During the session, a clinician was present to assist the participants if needed. After the competence of the WAF game, the PANAS questionnaire was administered again to all the participants to detect any differences in the participants' emotional status between the two assessments, to investigate the positive and negative emotional impact the WAF session had on the target groups. Finally, the Usability Feedback Questionnaire was administered to assess the app's overall features [31]. The Usability Feedback Questionnaire (UFQ) consists of 25 closed-ended questions aiming to evaluate the app in a quantifiable manner, and three open-ended questions where the participant can comment freely on the various features of the app and its games [32].

	MCI pre vs. post WAF session	AD pre vs. post WAF session	MCI vs. AD pre WAF session	MCI vs. AD post WAF session
	p	p	p	p
Positive affect				
Interested	0.834	0.157	0.728	0.647
Excited	0.492	0.206	0.358	0.701
Strong	0.389	0.059	0.911	0.944
Enthusiastic	0.089	0.102	0.892	0.208
Proud	0.301	1	0.247	0.895
Alert	0.722	1	0.008	0.014
Inspired	0.134	1	0.302	0.373
Determined	0.942	0.034	0.647	0.074
Attentive	0.177	0.763	0.067	0.47
Active	0.552	0.206	0.722	0.03
Negative affect				
Distressed	0.891	0.108	0.027	0.846
Upset	0.722	0.101	0.018	0.649
Guilty	1	0.854	0.236	0.263
Scared	0.098	1	0.524	0.029
Hostile	0.593	0.317	0.261	0.085
Irritable	0.931	0.317	0.079	0.575
Ashamed	0.705	0.317	0.101	0.276
Nervous	0.831	1	0.015	0.021
Jittery	0.887	0.655	0.032	0.06
Afraid	0.046	0.102	0.004	0.663

Table 1: Positive and Negative Affect words in pre- and post-playing of WAF games in MCI and AD.

Statistical analysis

We compared the two assessments 'pre WAF' and 'post WAF' between the two groups at the level of significance p=0.05. Statistical Analysis was performed using SPSS v25.0 for Windows (IBM Corporation, Armonk, NY, USA). For assessing the normality assumption for continuous and categorical variables we used the t-test and Mann-Whitney test. The PANAS scores obtained prior and post-play of the WAF games were analyzed and t-Paired tests were performed to determine the efficacy of the psychological measurement between the two target groups studied. We used also Spearman to compare DSRS and PANAS [33]. The descriptive statistics and the t-tests were presented as means ± SD (standard deviation). The usability feedback is presented in a descriptive statistic.

Usability feedback

The Usability Feedback Questionnaire consists of 25 closed-ended questions (6 questions in a five point Likert scale, 16 in Yes/No format, 3 multiple choice) aiming to evaluate the app in a quantifiable manner, and three open-ended questions where the participant can comment freely on the various features of the app and its games. The results of the Usability Feedback Questionnaire (UFQ) are presented for each group separately (Figure 2). The participants were overall pleased from their interaction with the app, rating their experience as positive (100%). Commenting on the time they had to interact with the app, 2/3 of the MCI group responded that it was sufficient while 1/3 of the AD group provided the same answer. The participants would choose to play the games during different times of day with the most popular answer being "Evening". The speed of the games was not considered too fast by the majority of the participants in both groups (73%). The time each game runs was debatable among the participants ["Would you like to increase the time each game lasts?" MCI: Yes 7/No 8, AD: Yes 6/No 9. 93% of the participants of each group responded "Yes" when asked if the instructions could be red well. Understanding the instructions of the games was perceived as more easy by the MCI group (Figure 2, Q9). The name of the games posed no issue with the participants answering unanimously that they were able to understand them. Log issues were reported by 27% of the MCI group. Experiencing issues when using the touch screen was reported by 20% in the MCI group and notably by 40% of the AD group [34]. Asking to evaluate the drag and drop ease on a scale from 1 to 10 (1 being easy and 10 difficult) the mean value for the MCI group was 2.93 and for the AD group 3.6. No issues with reading characters was noted (93% for both groups) or with the organization of the information. When asked how comfortable the participants felt while interacting with the app (Q22), only 2 participants (1 from each group) replied that they felt uncomfortable with the rest of the answers being "Comfortable" and "Very comfortable". The participants almost unanimously believe that the app is flexible to interact with. When asked if there is any skill required to use the software 73% of the MCI group replied "No" while 73% of the AD group replied with "Yes".

A problem with the sequence of the screens was observed by 53% of the participants in the AD group and only 13% of the participants in the MCI group [35]. The terminology used in the games was received well, with 90% of the participants in each group experiencing no difficulty with it. Asked to share if they noticed any issues with the position of the messages on the screen 47% of the AD group answered "Yes". All the participants from the MCI group responded "No" when asked the same question. No error messages were observed by 93% of the participants in both groups. When asked to note any feeling of inconvenience participants from the MCI group replied with Stress (N=1), Frustration (N=1), Nothing at all (N=11) and under "Other" the participants filled out curiosity (N=1), Tension (N=1), Interest (N=1) and Satisfaction (N=1). For the AD group, the emotions listed were Stress (N=1), Anxiety (N=2), Nothing at all (N=6) and under the self-reported emotions, seven participants noted "Joy/Fun". When asked to pick which game they liked better the answers of the participants varied with "Photo Quiz" and "Remember the Pattern" being mentioned more often. Only 9 participants provided an answer when asked to choose their least favorite game [36]. Interestingly, again, "Remember the Pattern" was mentioned three times with the comment "because the speed of the game was too fast". Further comments of the participants can be used to improve the app. A clear depiction of the performance/ game scores could be incorporated to motivate the participants, while also, different levels could be introduced, gradually increasing the difficulty of the games.

Emotional assessment

As the focus of the study is to introduce and investigate the effects of the WAF app on participants' emotions, comparisons were made in pairs between the pre and post assessment of MCI and AD groups. Furthermore, Spearman Correlation test was used to compare neuropsychological tests and specific parameters which

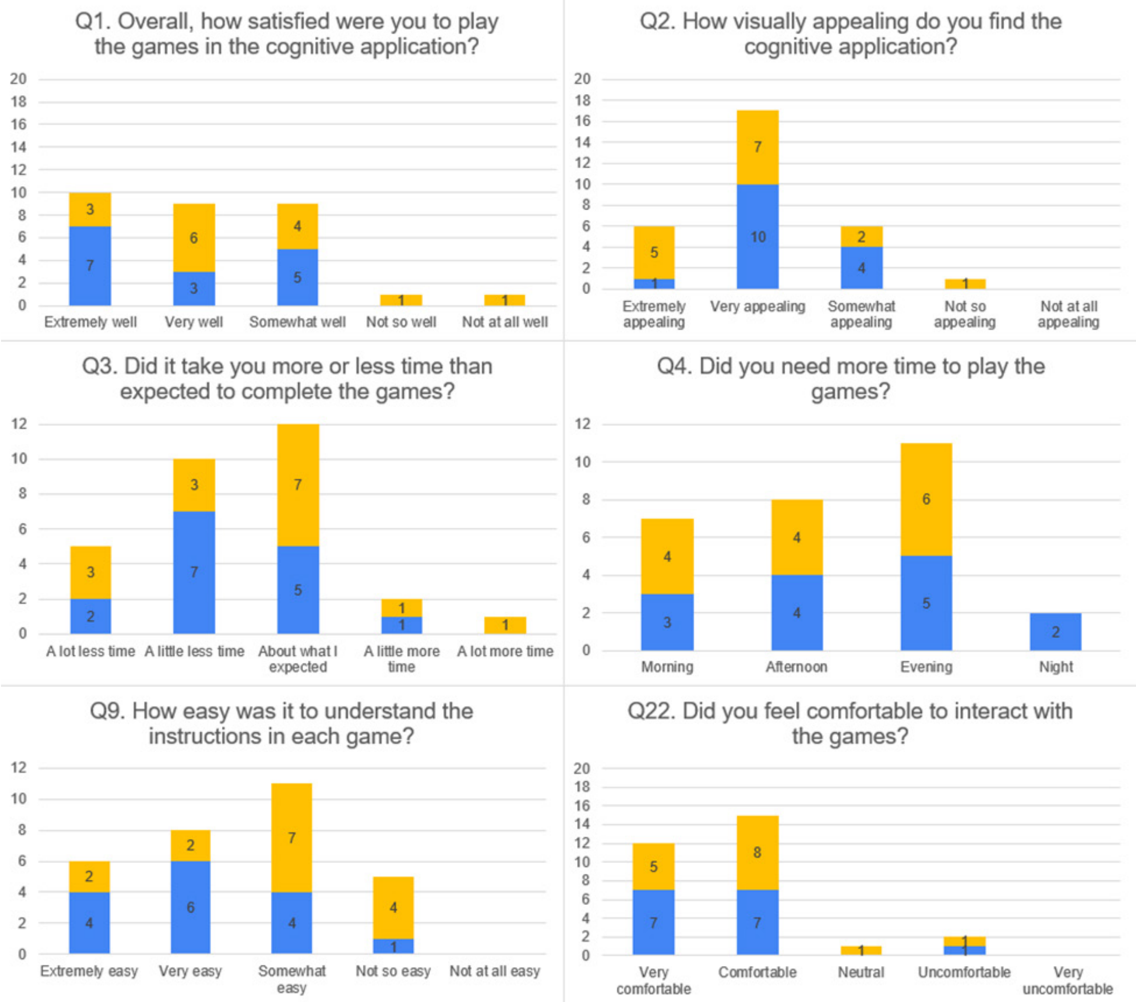

Figure 2: Usability Feedback after playing WAF games. In blue the answers for the MCI group are presented and in orange the answers for the AD group.

were obtained from the system between groups. The paired sample and the independent Student t-test for the two assessments were used for intragroup comparison. P-values less than 0.05 were considered statistically significant in Table 1.

The emotional impact of the WAF games as assessed with the PANAS scale can be seen in Figures 3 and 4a-4d. No statistical significant difference could be found in the emotional state of the participants between the pre and post WAF session assessment. After the WAF session, the MCI group showed an increase in their Positive Affect (pre mean 34.73 ± 8.25 vs. post mean 37.47 ± 8.00). Examining the emotions in more detail, for the MCI group we can find the percentage change before and after the WAF session was +24.00% for Enthusiastic, +12.24% for Proud, +25.53% for Inspired and +17.65% for Attentive. Regarding the Negative Affect, even though there is a percentage change of -31.43% for Afraid (and slight change for Distressed, Upset, Guilty and Irritable), a percentage change of +33.33% and +14.29% is noted for Scared and Hostile respectively.

In the overall Positive Affect, the AD group noted a slight decrease (pre 35.67 ± 4.91 vs. post mean 34.60 ± 3.98). The percentage changes before and after the WAF session was +8.51% for Excited, +7.69% for Enthusiastic, while other emotions remained unchanged and a negative percentage change were noted for Interested, Strong, Determined and Active. Regarding the Negative Affect, only a percentage change of -11.11% was found for Ashamed, while other emotions remained unchanged (Scared, Nervous) or showed an increase (Distressed, Upset, Afraid, and Irritable).

There was a statistical significant alteration in the MCI group with respect to the emotion "Afraid" (p=0.046) showing that the WAF session had a positive impact on the participants regarding this negative feeling. In the AD group, the PANAS score for "Determined" showed an undesirable significant decrease (p=0.034).

Furthermore, Spearman's correlation revealed a negative correlation between the DSRS scores of the participants and their PANAS Positive Affect, post WAF session scores, showing that more positive emotions were experienced by healthier participants (p=0.023). In the same direction, Mann Whitney test for the PANAS scores (pre WAF session) using as a grouping variable the participants' diagnosis shows that the MCI group also experiences more intensely negative feelings (PANAS Total Negative p=0.024 and in detail emotions: Distressed p=0.027, Upset p=0.018, Nervous p=0.015, Jittery p= 0.032, Afraid p=0.004). Also, for the emotion "Alert" significant difference was observed between the groups (p=0.008). For the post WAF session emotions "Alert", "Scared" and "Nervous" continued to show statistical significant difference between the groups. The feeling "Active" was also more intense for the MCI group after the WAF session.

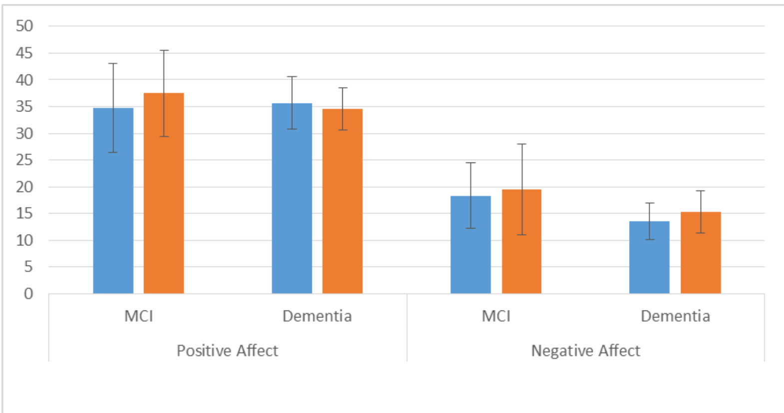

Figure 3: Emotional impact of WAF games as assessed with PANAS scale. **Note:** (■) pre WAF session, (■) post WAF session.

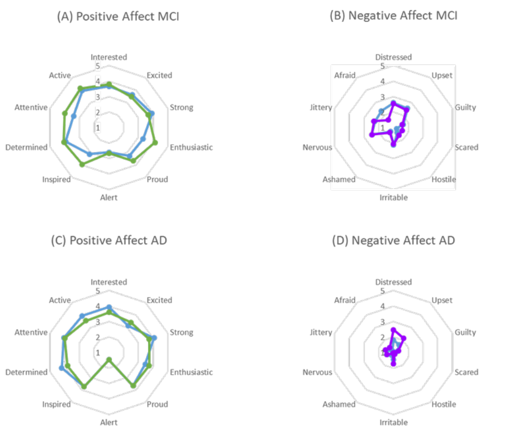

Figure 4: Emotional impact of WAF games as assessed with PANAS scale. **Note:** (—●—) pre WAF session, (—●—) post WAF session, **B:** (—●—) pre WAF session, (—●—) post WAF session, **C:** (—●—) pre WAF session, (—●—) post WAF session, **D:** (—●—) pre WAF session, (—●—) post WAF session.

Discussion

The present feasibility study ascertains the overall acceptability of the WAF games, perceives the ease of use and aims to detect features that could be refined in order to make the app more user friendly. The study also investigates the influence of the games on the emotional status of the participants. The results of the feasibility study confirm that the WAF app was acceptable and interesting for both groups, MCI and AD. The participants were overall satisfied to play the games, felt comfortable in their vast majority and found the app visually appealing. All participants rated their experience as positive. These findings are supported by the fact that all participants completed the study. Some differences could be noted between the groups and how they perceived their interaction with the app. The AD group reported experiencing issues with the touch screen, the drag and drop gesture, screen sequences and the position of the messages on the screen. When asked if they believe that there any skills required to interact with the app, 73% of the AD group answered with "Yes", further supporting these findings [37]. The technical difficulties the AD group faced indicate the need for these technology acceptance studies in order to further understand and lift the barriers technology poses to elderly people. The results of the emotional assessment show that the WAF games can trigger emotional responses. In the MCI group the WAF games triggered specific positive responses whilst decreasing certain negative responses. The WAF games showed an improvement on the emotional impact on the MCI groups' PANAS positive affect scale while there was a decrease noted for the emotion "Afraid".

In the AD group no positive affect could be observed by analyzing the pre and post WAF session PANAS scores. As their disease progresses, people with AD often experience entwined emotions of fear and anxiety, for that reason these results can be expected. Furthermore, the lack of significant change in the participants' overall emotions can be attributed to apathy, which constitutes one of the most common neuropsychiatric symptoms of AD [38]. This could be further supported by the finding showing that the MCI group experienced positive and negative emotions more intensely. However it is interesting to note that the AD group had the most self-reported positive emotions when asked in an open ended question to note any feeling of inconvenience, as 7 of 15 participants answered that they felt joy. Further research is needed to identify if and for how long the observed emotional states are sustained.

The current feasibility study suggests that participants in both groups, MCI and AD can interact with the novel smartphone based WAF brain games [39-42]. Serious games, designed with the input from unique needs of PwD in mind, are acceptable, accessible and engaging for people with moderate and advanced dementia [28]. This was demonstrated by the observed enthusiasm and participation of both MCI and AD patients with the game system, and by the usability data presented. Thus, the current study suggests that the use of WAF games designed with the unique needs of PwD in mind can facilitate expression of emotions and thus open doors for communication for PwD and their caregivers [43,44]. Finally, it seems that the use of a touch-screen, smartphone-mediated, serious game can enhance cognitive functions that may be partially preserved in MCI and AD. Additionally, the WAF app constitutes a tool for assessing cognitive functions and contributes to reverse decline since it can be applied even when the participants are loose, perky and not stressed, instead of being nervous and conceivably feeling anxious by a formal cognitive battery. The games and the overall experience of the WAF app need to be assessed to a greater extent. Improvements could be made in order to further address the emotional impact and promote the positive affect.

While this study has benefits due to it being a mixed methods study, including rich qualitative data, as well as many research assistants involved in doing the testing, it has limitations as well. The major limitation of these results is the small number of participants included in the study, yet no different than common in published research in the field [45]. More research should be done to better understand how to maintain, exercise and utilize remaining capacities in AD and to explore further technologies in various settings.

We are convinced that a critical factor in the success of the intervention was the presence of the clinician. Despite that the WAF app was designed as a tool to help the patient to train outside the clinical consultation, the periodic supervision of the clinician is necessary to explain the functioning to the patient, keep track of the evolution of the performance, adapt the intervention step by step to the patients' changing needs and maintain the motivation [46-48]. For instance, it could be easily employed to track the evolution of executive functions, semantic memory, logic, short-term memory and attentional deficits overtime while playing the WAF games. Furthermore, due to its playful nature, it may be particularly adapted to patients whose performance is strongly influenced by test anxiety [49,50]. For example, a heavily impaired performance at the classical tests associated to preserve functioning, in the WAF activity may prompt the clinician to be more cautious in the interpretation of the test results. Another limitation is the fact that the study was carried out in a dementia day care center. We hope in future studies to test the effect of playing the WAF games in a home setting as well [50].

Conclusion

The feasibility study showed that the WAF app was well received by the participants, with their overall interaction being considered as positive. Emotional shifts could be observed with the MCI group showing an increase in their positive affect. The AD group showed no significant positive change in their emotional status after interacting with the app, highlighting the plethora of psychological aspects that can be associated with the various stages of cognitive decline and also emphasizing the need to improve the WAF app in order to positively affect participants' emotions. Taking into consideration the participants' feedback and the overall study observations, meaningful improvements will be done to the WAF app. Further assessments will determine the impact of the WAF app on the emotional status of the participants, their cognition and their overall mood when interacting frequently with the app in a longer period of time in a home setting.

It therefore appears that there is an increasing scientific interest that can produce rapid gains in an entertainment-oriented technology that is also beneficial: more user-friendly game interfaces, the interest of older people in brain games, and their interest in games marketed to improve cognition and mood. Research in the efficacy of games for older adults is relevant to the implementation of games to encourage cognitive health. Positive findings could additionally encourage digital game companies to partner with cognitive scientists to develop health games that enhance cognition with design principles and narratives that specifically engage older adults. Improving or helping older adults maintain their cognitive abilities and their emotional status, could reduce the risk of dependency.

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