

# A usability study with healthcare professionals of a customizable framework for reminiscence and music based cognitive activities for people with dementia

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## ABSTRACT

The possibility of using serious games to stimulate people with dementia (PwD) has gained much attention in recent years. However, most of such games are not adapted to individual needs of such population in terms of the design of technology and its content. Thus, the desired therapeutic outcomes may not be achieved. Alternatively, more traditional approaches, such as the usage of music and reminiscence, have been shown to be able to lead to positive outcomes. Here, we propose a framework for serious games that allows healthcare professionals to customize music and reminiscence-based activities to stimulate PwD. It runs on an augmented reality setup, but also on PC, interactive table and tablet. Results from a usability study show that participants (1) were efficient in using the framework, (2) therapists are very interested in using it for stimulation purposes in PwD and (3) the usage of the framework was adequate in terms of effort and workload for PwD. Future deployments will be discussed in this article regarding the usage of the framework.

## CCS CONCEPTS

• **Human-centered computing** → **Usability testing**; **User interface design**; **User centered design**; • **Applied computing** → **Health informatics**.

## KEYWORDS

Dementia, Music, Reminiscence, Customization, Technological Versatility, Usability Testing

## ACM Reference Format:

Luis Ferreira, Sofia Cavaco, and Sergi Bermúdez i Badia . 2019. A usability study with healthcare professionals of a customizable framework for reminiscence and music based cognitive activities for people with dementia. In *23rd Pan-Hellenic Conference on Informatics (PCI '19)*, November 28–30, 2019, Nicosia, Cyprus. ACM, New York, NY, USA, 8 pages. <https://doi.org/10.1145/3368640.3368654>

## 1 INTRODUCTION

Dementia is a neurodegenerative and incurable disease that leads to gradual degeneration of brain cells and affects carriers cognitively and behaviorally [1]. Within dementia, different subtypes can be identified, such as Alzheimer's disease, Vascular dementia, Frontotemporal dementia, and mixed dementia [3]. Symptoms such as memory loss, agitation, depression, sleep deprivation, among other symptoms, are common in such population [1, 3, 22]. Such symptoms not only harm people with dementia (PwD) but also caregivers [21]; caregivers suffer emotionally and psychologically as they witness their loved one's decay over time, and physically as they will have additional responsibility in taking care of PwD.

Thus, to mitigate the symptoms of PwD and alleviate the stress felt by those closest and taking into consideration that pharmaceutical approaches have a limited effect [31], complementary approaches are necessary. Such approaches are being explored in the European funded project ISISEMB – *Intelligent system for independent living and self-care of seniors with cognitive problems or mild dementia* [20]. This project aims to enhance the quality of live of both carers and PwD by providing "innovative intelligent custom services" in private housing through information and communication technology (ICT) such as visual fall detecting systems [8].

On the other hand, serious games (SG) (or even transformational games [26]) have gained much attention in recent years. SG, as opposed to entertainment games, can be briefly defined as software applications that have a defined purpose that goes beyond pure entertainment [34]. A variety of SG have been developed to target the needs of both PwD and carers [16] through, for example, training/simulation [5], stimulation of physical exercise [24], training of memory and cognition [18, 28], cognitive screening and diagnosis tools [27, 29] and among other purposes (see review [19]).

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*PCI '19, November 28–30, 2019, Nicosia, Cyprus*  
© 2019 Association for Computing Machinery.  
ACM ISBN 978-1-4503-7292-3/19/11...\$15.00  
<https://doi.org/10.1145/3368640.3368654>

Unfortunately, the majority of serious games follow a generalized design approach in terms of software and technology, without taking into consideration individual needs of PwD [12, 25]. Thus, the desired therapeutic outcomes of SG may be hampered. Indeed, in a previous study, we performed a feasibility study about the usage of gamified activities in PwD (see Section 2.1) [2]. Although participants, in general, enjoyed doing the activities and were at ease in performing these, healthcare professionals shared concerns regarding the appropriateness of the content that was presented in the activities

Other alternatives, besides serious games, are considered to mitigate symptoms of dementia. For example, music and reminiscence related approaches have gained attention in recent years [9, 13]. Music has been shown to help to relax PwD as it stimulates a hormone called melatonin [6]. Other positive effects have been identified, such as enhanced autobiographical memories and communication [9]. Moreover, PwD appear not only to preserve musical memories but also the ability to discriminate wrong notes in music [7]. In a previous study, we developed a quiz game for the Samsung Galaxy Tablet, in which participants had to respond a question by selecting the correct answer among three wrong ones [10]. The answers were presented as images. To test our hypothesis that participants were able to discriminate wrong answers based on distorted music, we developed two conditions in which different feedback would be displayed – music distortion and visual distortion. In the music condition, if participants selected the wrong answer and pressed it for four seconds, the background music becomes distorted signaling that the answer is wrong. During that period, participants can change their decision making. After 4 seconds, the answer is locked. The same is valid in visual distortion condition but instead of distorting the background music, the answers' images became distorted. Preliminary results showed that participants performance in the music distortion condition was better than in visual distortion condition; participants were faster and were able to avoid more errors. However, more studies are necessary to understand how feasible this approach is with PwD. Conversely, reminiscence therapy [33] is characterized by stimulating PwD through the usage of physical objects, photos, and videos that are well known to the patient. Benefits such as the reduction of depressive symptoms, cognitive stimulation, improved mood, enhanced communication, and better life quality have been identified.[33] Despite the benefits identified previously regarding the usage of music and reminiscence, the scientific literature is still scarce regarding the effect that both therapies have in PwD [30, 32].

In this article we propose Musiquence, a cognitive stimulation games framework that uses the benefits of music and reminiscence based interventions, while allowing caregivers and healthcare professionals to customize activities to the patient's profile in terms of game content and deployment technologies (i.e. PC, Tablet, interactive tables and Augmented Reality). The novelty of the framework is that it allows overcoming some of the technological and software related limitations identified in the state of the art (i.e. lack of customization features to target individual needs in PwD [12], and poor inter-operable systems [25]); customizing activities to PwD interests can enhance motivation, which is important to ensure the success of cognitive stimulation [25]. For example, healthcare professionals can develop an activity that uses real objects, music

or sounds which has a special meaning for the patient. Another advantage in using this framework is that healthcare professionals can present the activities as a story-telling narrative [2]. By doing so, healthcare professionals can engage PwD in performing virtual activities. Moreover, considering that many PwD may not be familiarized with modern technologies [25], healthcare professional can develop activities according to the PwD skills and user experience as the framework is compatible with multiple platforms. As a result, the PwD can complete the same activities using different interaction inputs based on the technology used and patients user experience. The framework can also mitigate costs; the development of activities for PwD can be costly in terms of development and maintenance [15], healthcare professionals can use Musiquence to stimulate PwD while having full control over the technology, activities, content and flow. Finally, the use of this framework can be used to provide more evidence regarding the impact that music and reminiscence based cognitive games have in PwD.

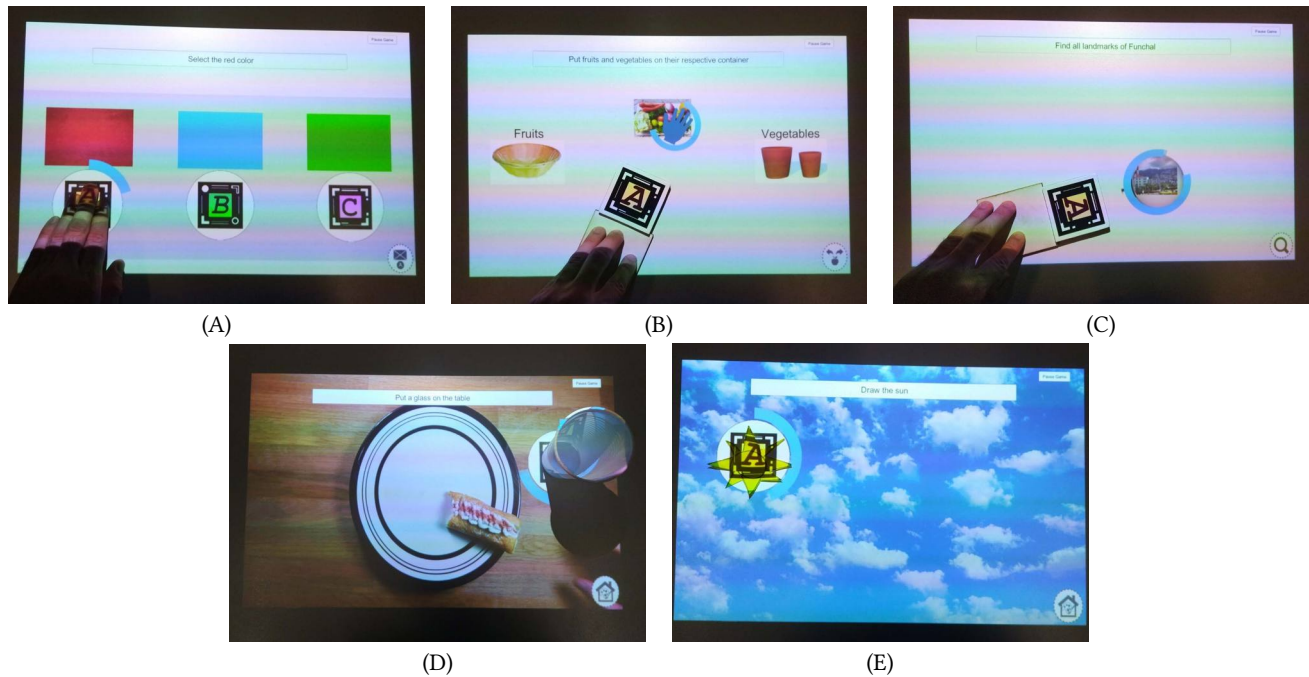
Before assessing the clinical impact of the framework, and to ensure proper functionality and quality, we conducted a usability study with healthcare professionals to test Musiquence. Throughout this paper we will (1) present and describe the framework, which allows healthcare professionals and informal caregivers customize music and reminiscence based cognitive activities for PwD (section 2); (2) discuss an usability study with healthcare professionals while using the framework to answer 3 research questions (RQ): RQ1. How proficient were healthcare professionals in creating activities? RQ2. How useful is the Musiquence Game Editor perceived by healthcare professionals to customize games for PwD? RQ3. How mentally and physically demanding is the interface? (more details in sections 3 and 4); (3) Summarize our findings by answering each RQs (section 5). Finally, we will conclude our findings as lessons learned and discuss how this project will go forward (section 6).

## 2 MUSIQUENCE

We developed a serious games framework called Musiquence (music + sequence) that allows the customization of cognitive activities to individual profiles of PwD while capitalizing on the benefits identified of music and reminiscence related approaches. The framework is divided into two separate applications: the Game Editor, that can be used by healthcare professionals to create and customize new activities to patients, and the Game Experience, that is used to display and execute the activities in sequential order. Musiquence supports several technologies and interaction inputs such as: PC (in which the mouse is used as input device), tablets and interactive tables (in which upper limb movements can be used to interact with the activities), and augmented reality (in which real objects, upper limbs, and the full body can be used as input devices). The framework was created using Unity 3D Game Engine (Unity Technologies, San Francisco) and C#.

### 2.1 Game Editor

The Musiquence framework includes the Game Editor. This application allows healthcare professionals to create and customize activities according to the patient's preferences and needs. Currently, the framework supports five different types of activities. The activities were tested in a previous study with PwD that were



**Figure 1: Game activities. (A) Knowledge quiz activity.** Participants must select the correct answers to a given question. **(B) Association activity.** Participants must categorize virtual elements to the correct container (i.e., fruits and vegetables to either basket or vase, respectively). **(C) Search activity.** Participants must find virtual objects using a virtual magnifying glass. **(D) Daily living activity.** Participants must set up the dinner table by adding physical objects (i.e. cutlery) to complete an activity of daily living. **(E) Creative drawing activity.** Participants can draw on physical paper and add on the projected markers to complete the paintings.

at at initial to intermediate stages of dementia and therapists [2]. Nevertheless, in the future, more types of activities can be added if desired. The currently supported activities are the following:

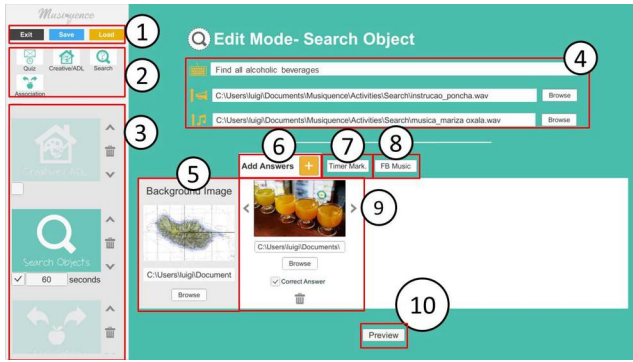
- **Knowledge quiz activity:** this is a simple activity in which PwD train memory skills by selecting the correct answer to a given question (Figure 1.A).
- **Association activity:** this activity aims to stimulate associative memory. Here PwD must associate fruits and vegetables to their respective container. (Figure 1.B).
- **Search activity:** this activity requires PwD to find objects that are hidden in the game and are only visible through a virtual magnifying glass. This activity aims to stimulate divided attention and executive functions (Figure 1.C).
- **Daily living activity :** this is a puzzle like activity which aims to train selective attention, memory and executive functions. Here, PwD must complete activities related to daily chores by placing the correct physical object on the marker (Figure 1.D).
- **Creative drawing activity :** this is another puzzle like a game in which PwD must complete a painting with physical drawings and place these on the markers. This activity aims to stimulate fine and gross motor skills and memory (Figure 1.E).

Healthcare professionals can create new activities from these five types and customize them. For each newly created activity, it is

possible to (1) write a question, (2) upload music, (3) upload verbal instructions (which must have been previously recorded), (4) add answers; when an answer is added, images can also be uploaded and checked as a correct or incorrect answer. Also, users can change the order of the answers add and delete them as needed, and (5) add an activity timer (in which case the activity must be finished within a certain time window, otherwise it will transit to the next activity automatically).

Also, healthcare professionals can (6) change the response time of the markers, (7) assign auditory feedback, and (8) preview the activities. As new activities are created, the user can (9) change the execution order the activities as well as (10) delete the activities created. All the information displayed in the framework is in English. Figure 2 shows the Game Editor window with details on the supported actions. In the end, if healthcare professionals are satisfied with the activities created, these can be exported as a serialized file with the extension (.musiquence) so that it can later be used to execute the activities in the Game Experience application. If further modifications are required, healthcare professionals can upload the file in the Game Editor and continue working on it.

Depending on the activity, additional features can be applied. For example, in the Search, Creative drawing, daily living, and Association activities, healthcare professionals can position the game



**Figure 2: Game Editor.** (1) The user can save a new activity, load an existing activity, or exit the application. (2) The user can create new activities. (3) All activities created are presented in sequential order. (4) Users fill input fields to add a question, upload voice instructions, and music. (5) The user can upload a background image to the overall activity. (6) Users can add several answers to the activity. (7) The user can change the response time of an answer. (8) Music-based feedback can be added to an activity. (9) As answers are added in an activity, the user can add an image, and define it as a correct or incorrect answer. The answers can also be deleted. (10) The user can preview the activity before exporting it for later use.

elements – markers and images – at any position of the game canvas. Moreover, in the Association activities, healthcare professionals can add images for each designated category (Figure 3.D).

Considering music is one of the main features of the framework as PwD appear to have preserved musical memory and the ability to discriminate musical notes (see Section 1), we developed a feedback system based on musical distortions. This mechanism was inspired by a single case study done by Cuddy et al.[7] in which a person with severe dementia was able to distinguish between music that was altered in terms of pitch and non-altered music. Similar studies have been performed with PwD in which they had to identify manipulations in songs such as, for example, in terms of rhythm and timbre [14]. With Musiquence, it is possible to add musical feedback to some of the activities such as knowledge quiz, association and search activities; the user can add musical distortion by changing musical parameters in terms of pitch, pitchshift and rhythm (see Figure 3.B). Moreover, among the activities mentioned previously, different mechanisms have been developed to introduce musical feedback during erroneous decision making. For example, while the music gets distorted when selecting the wrong answer in the knowledge quiz activity, both search and association activities apply musical distortion incrementally as the distance between player’s current position and the correct answer increases (i.e. in the search activity, as the distance between the virtual magnifying glass and the correct answer increases, the stronger is the musical distortion).

## 2.2 Game Experience

This is an application that executes the activities that have been created with the Game Editor. To execute those activities, the user

only needs to upload the file created with the Game Editor. To use projection based Augmented Reality technology, it also integrates the Analysis and Tracking System (AnTS, available at <https://neurorehabilitation.m-iti.org/tools/>).

In terms of software architecture, we used a state machine. When the activities are being performed, the state machine evaluates the player’s input as the activities are being completed. Figure 4 shows the state machine. The state changes according to the user’s input. "A" represents the current activity that is active. "B" represents the question of the activity. "C" represents the feedback provided to the player: If a correct answer is selected, verbal confirmation – “very good!” is played. Contrarily, if the answer is, incorrect “oh, try again” is activated. The transitions between states only happen if certain conditions are fulfilled. Transition 1 happens when the player selects an answer (user input). Transition 2 verifies if the question has more correct answers. If “Yes”, the state machine triggers transition 3. Otherwise, it triggers transition 4. The latter occurs only if the user selected all correct answers and more activities exist. Transition 5 is activated if an activity timer has been defined (if applicable) and more activities exist. Transition 6 happens if all activities are completed.

## 3 METHODS

In order to evaluate healthcare professionals proficiency, perceived usefulness and difficulty in handling the Game Editor while creating a variety of tasks, we performed a usability study of this application (Section 3.1). The heterogeneity of the sample reflects the different backgrounds of healthcare professionals interacting with PwD in the health institution. The study focused on answering the research questions presented in Section 1: RQ1, RQ2 and RQ3 (more details in Section 3.2). 10 healthcare professionals (8 females and 2 males) from 25 to 42 years old from a mental health center (Casa de Saúde São João de Deus) participated in the study; the study took place at the same mental health center. All participants had experience in interacting with dementia patients. Participants’ demographics are summarized in Table 1.

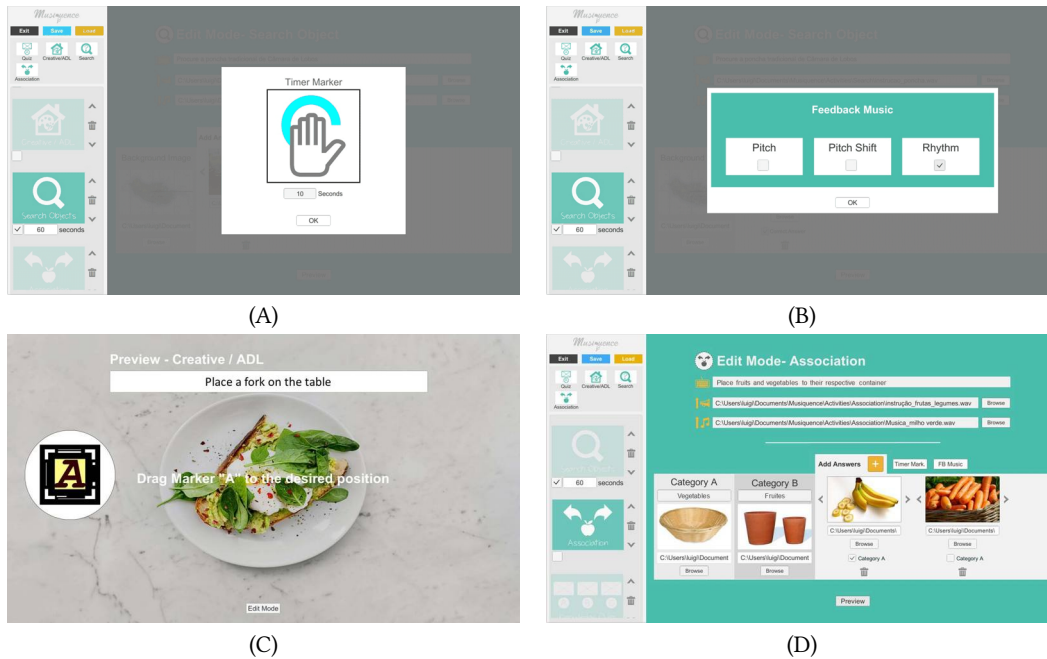
**Table 1: Participants Demographics**

ID	Age	Gender*	Occupation	Experience**
1	28	F	Social Educator	6
2	32	F	Psychologist	5
3	30	F	Nurse	1
4	25	F	Junior Psychologist	1
5	26	F	Psychologist	3
6	39	M	Teacher	15
7	29	F	Occupational Therapist	4
8	28	F	Nurse	4
9	42	M	Teacher	16
10	25	F	Psychology student***	-

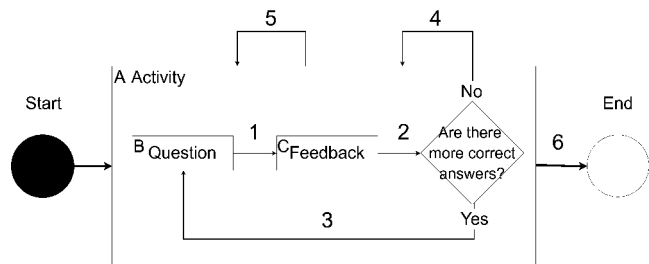
\* F-Female, M-Male

\*\*Work experience in years

\*\*\* This participant had no actual work experience but had interacted with PwD during her clinical internship



**Figure 3: Game Editor’s features. (A) Users can specify how long a participant must wait before “submitting” an answer. (B) The user can add musical-feedback based on distortions to aid PwD avoiding erroneous decision making (see Section 2.1). (C) The user can preview the activity and drag the markers to the desired position. (D) For the categorization activity participants can define images to identify Category A and B.**



**Figure 4: The Game Experience application’s state machine. Letters represent states, and numbers represent transitions between states.**

### 3.1 Procedure

Before the beginning of the experiment, all participants signed an informed consent form. During the experimental trials, participants’ performance was filmed using the NVidia GeForce Experience screen recorder (Nvidia corporation, California USA).

Participants were invited, one at a time, to sit in a quiet room. In the room, only the researcher and the participant were present. The researcher read a document with instructions and that contained contextual information and examples (for example, it illustrates why healthcare professionals may want to create an daily living activity, for PwD) and all the steps that participants must complete to finish the proposed tasks.

Before beginning the experimental trial, participants were briefed (1) regarding the purpose of the study (which is to test the customization application to develop activities for PwD), (2) were asked to think aloud throughout the tasks completion, (3) were informed where to find multimedia content in tasks that required uploading of music and images.

Additionally, participants were shown print screens (only once) with the outcome of the tasks and were asked to recreate these. We define *tasks* as assignments given to the participants by the researcher. A task can be a complex assignment such as creating an association activity or completing a simple and more direct instruction. For example, when the researcher says, “Write the following question for this activity: Select the red color.” The participant must write, “Select the red color.” in the appropriate input field.

Regarding the more complex task assignments, participants were required to create an activity from each type and interact with all features as described in Section 2.1. All participants performed the activities using the same sequential order, and started with the quiz knowledge activity. Afterwards, participants were asked to save the activities in a file and upload it again to edit the activities. After uploading the file, the participant had to (1) change the order of the activities, (2) add an activity timer in one of the activities and (3) change the order of the answers in a knowledge quiz type activity.

Participants were required to complete the tasks alone. If participants either asked for help or struggled in completing a task, the researcher would intervene by providing clues.

### 3.2 Instruments and metrics

To answer the RQ1 (healthcare professionals' proficiency), we measured the following variables:

- Number of issues: we counted the number of issues that participants encountered during task performance. The number of issues were counted by watching the video recordings.
- Time (tasks per activity): we measured the average time (in seconds) that participants needed to finish the tasks.
- Time (tasks per editing): we measured the average time to edit the activity (see Section 3.1 Procedure)

The time was manually withdrawn with a stopwatch. We started counting once the researcher finished reciting the task's instructions and stopped the time when that task was completed.

To answer RQ2 (perceived usefulness of the Game Editor to customize activities for PwD), we invited the participating healthcare professionals to answer some validated questionnaires:

- Intrinsic Motivation Questionnaire (IMI) [17]: IMI questionnaires evaluate users subjective experience related to an activity. Among the available IMI questionnaires, we used the Activity Perception Questionnaire, which has a 7-point Likert scale and evaluates participants interest/enjoyment, value/usefulness, and perceived choice of activity.

To answer RQ3 (How demanding is the application?), we asked the participants to fill the following questionnaires:

- Nasa TLX [11]: this is a 21-point questionnaire that evaluates participants workload in terms of mental, physical, and temporal demand, effort, performance, and frustration during an activity.
- System Usability Scale (SUS) [23]: this is a 10-item Likert scale that ranges between *strongly disagree* to *strongly agree*, and that evaluates system usability.

We also did an interview to gain a more detailed insight regarding RQ2 and RQ3.

- Interview: healthcare professionals answered an interview regarding (1) usage of previous technologies with PwD, (2) overall experience with the framework, (3) interest in using the framework to stimulate PwD and (4) additional feedback regarding the overall experience. Some questions were answered with a 7-point Likert scale, while others were open questions.

## 4 RESULTS

All participants finished the proposed tasks, completed the interview and filled the validated questionnaires (see Section 3.2). Due to technical issues, data on the number of issues for participant 6 and 7 were missing. We used IBM SPSS Statistics Version 24 (IBM, New York, United States of America) for statistical analysis. Descriptive statistics are presented as means (M) and standard deviations (STD).

### 4.1 RQ1. How proficient were healthcare professionals in creating activities?

To evaluate the proficiency of healthcare professionals, we counted the number of issues encountered and time needed to complete each task. The activity that led to more issues was the knowledge

quiz type activity ( $M=3.25 \pm 2.12$ ) while the activities that led to fewer issues were the daily living activity ( $M=0 \pm 0$ ) and the search activity ( $M=0 \pm 0$ ). In the creative drawing and association activities, we found an average of ( $M=0.88 \pm 1.73$ ) and ( $M=0.5 \pm 0.76$ ) issues, respectively.

In terms of time required to complete the tasks, healthcare professionals were faster to complete the daily living activity ( $M=43.33 \pm 10.72$ ). In contrast, the knowledge quiz type activity required the most time to be completed ( $M=95.97 \pm 48.14$ ). The time for the search activity was ( $M=43.70 \pm 9.76$ ), for the creative activity was ( $M=48.49 \pm 15.70$ ) and for the association activity was ( $M=75.62 \pm 20.95$ ). Regarding the time needed to edit the file, participants required ( $M=128.53 \pm 59.89$ ).

### 4.2 RQ2. How useful is the Game Editor perceived by healthcare professionals to customize games for PwD?

During the interview (see Section 3.2), some participants mentioned having used technology for cognitive stimulation purposes. Three participants wrote that they used PCs with additional software such as Power Point to stimulate PwD with images, music, and cognitive exercises. Nevertheless, none of the participants knew a framework that supported customizing activities. As for the 7-point Likert scale in the interview, participants unanimously agreed that Musiquence is very useful to customize activities for PwD ( $M=6.70 \pm 0.48$ ). They also were generally interested in using the framework with PwD (or other pathologies) ( $M=6.60 \pm 0.97$ ) and, despite the results were slightly above the average, they were willing to pay for the framework ( $M=4.80 \pm 1.75$ ). Indeed, the Activity Perception Questionnaire revealed very high interest/enjoyment ( $M=6.36 \pm 1.00$ ), values/usefulness ( $M=5.85 \pm 1.68$ ), and perceived choice ( $M=5.61 \pm 2.32$ ) by the participants while using the Game Editor.

During the interview we also asked them if there was any additional feature that they would like to have in the framework. Most participants said that there was no need for additional features; yet one participant recommended to add more information regarding the "sequencing" of the activities created. While another participant requested more keyboard shortcuts (i.e. press "Enter" to confirm inputs.)

### 4.3 RQ3. How demanding is the application for healthcare professionals?

By using the NASA TLX questionnaire, we evaluated how demanding the application is for participants while developing activities for PwD. Results show that the interface did not lead to any stressful experience in any of the parameters measured ( $M=6.24 \pm 5.71$ ). The results of each parameter measured were: *Mental Demand* ( $M=7.70 \pm 5.01$ ), *Physical Demand* ( $M=5.20 \pm 6.37$ ), *Temporal Demand* ( $M=7.40 \pm 6.55$ ), *Performance* ( $M=6.00 \pm 4.69$ ), *Effort* ( $M=8.10 \pm 6.26$ ) and *Frustration* ( $M=4.00 \pm 5.25$ ). To complement the previous questionnaire, we asked participants to rate the Game Editor using the SUS. The results revealed that, in general, participants rated the interface as *good* ( $M=79.75 \pm 14.46$ ) [4].

Finally, in the 7-point Likert scale in the interview, participants found that the icons and written information were self-explanatory

( $M=5.50 \pm 1.51$ ), and that navigation of the framework was intuitive ( $M=5.80 \pm 1.14$ ). However, some participants mentioned in the interview that the information displayed in the framework should be in Portuguese. Although there is some margin for improvements, overall results show that the framework was clear and not demanding.

## 5 DISCUSSION

The main purpose of this usability study is to ensure proper functionality and quality of the framework's Game Editor. We also tried to understand if the approach of customizing activities for PwD is a viable approach for healthcare professionals.

Answering RQ1, the results from the study show that, in general, participants were proficient as the Game Editor's interface led to few issues, and that they were able to complete the tasks independently. As all activities share some basic functionalities described in Section 2.1, once they completed the first few tasks, participants felt more comfortable while completing the remaining tasks. For example, two participants were able to perform the tasks before the researcher was able to finish reciting the task.

Regarding the time measured for participants performance, the activity that required more time to complete was the knowledge quiz type activity, which was expected, since this was the first activity being done and participants were still learning how to use the interface. The activity that required less time to complete was the daily living activity. Although participants were relatively fast in performing the tasks, the overall time to finish an activity depends on the amount of features that each activity has. Some activities required more user input than others. For example, the association activity requires participants to upload images to identify the categories. In addition, as new answers are created, participants need to associate the answers to the respective category; afterwards, participants must upload an image for each answer, drag/drop and position several of the answers in the game canvas. In contrast, the creative drawing and daily living activities were simpler since it required the participant to create only one answer, upload an image, drag/drop and position the answer in the game canvas.

In terms of editing the file, participants, in general, required almost 129 seconds; participants spent a great amount of time when asked to (1) delete and to (2) add a time condition to an activity. Indeed, these two tasks led to more issues during file editing as these features were not noticeable enough. For example, to add a time condition, participants must click on a check box which was displayed under a created activity. This led to confusion among participants when trying to complete the task. As for deleting an activity, participants missed the "trash" icon that was displayed on the right sight of a created activity.

Concerning RQ2 (usefulness of the Game Editor), participants subjective experience - as measured in the Activity Perception Questionnaire - in using the Game Editor was high. We asked participants if they had any knowledge about a framework that allows personalized content for PwD, and none of them had any knowledge of such a framework. Nevertheless, all participants agreed that the possibility in customizing activities is very useful for interventions. Similar results of the Activity Perception Questionnaire and opinion

were shared in a previous study by another set of healthcare professionals [2]; therapists rated the previous version of the games with slightly higher scores in terms of interest/enjoyment ( $M=6.54 \pm 0.78$ ), usefulness ( $M=6.44 \pm 0.80$ ) and perceived choice ( $M=6.46 \pm 1.69$ ). The results of this study are encouraging as we are not assessing the enjoyment of the games themselves but rather the tool used to create them. Additionally, therapists said that it is important to use appropriate content to engage PwD in performing the tasks. Certainly, participants were interested in using the framework to stimulate PwD, and reported some willingness to pay for it. One participant would like to use the framework, if his institution would assume the costs, while another participant reported willingness to pay the full price. Only one participant would not invest in such a framework at all. The hesitation among participants in purchasing such tools can be due to the initial and longstanding maintenance costs that reassure the proper functioning of the framework. Also, there are concerns regarding the short-term usefulness of SG as they can become inadequate over time. [16]. Nevertheless, as stated in previously (see Section 1), healthcare professionals can use Musiquence and adapt technology and content to the current profile of PwD. When asked whether they wished to see additional features in the framework, most participants did not feel the need for more features. However, one participant requested more information regarding the sequence of the activities. while another participant said that there should be more keyboard shortcuts, such as able to press "Enter" to confirm inputs.

In our final research question (RQ3 - how demanding the application is), the Game Editor's interface was rated as "good" according to the SUS. Vallejo *et al.*'s study obtained identical results [29]; participants in both studies rated the interfaces as easy and simple to use (SUS,  $M = 79.75 \pm 14.46$  and  $M = 80.62 \pm 11.55$  respectively). Also, in both studies, the participants did not feel stressed in using the Game Editor according to the NASA TLX; SG were not demanding in terms of workload (Nasa - TLX,  $M = 6.24 \pm 5.71$  and  $M = 4.22 \pm 0.53$  out of 21 points respectively). A low demanding interface is important for healthcare professionals to mitigate their workload and increase interest and motivation in using the framework to stimulate PwD. Yet, in our study, some participants suggested that the framework should support other languages such as Portuguese.

## 6 CONCLUSION

In this article we presented a framework that allows healthcare professional and caregivers to customize music and reminiscence-based activities to stimulate PwD. In order to validate the framework's Game Editor, we performed an usability test with healthcare professionals. The results showed that in general, participants were efficient in completing the proposed tasks without major problems and were fast in doing so. They also showed interest in using the framework to cognitively stimulate PwD as it allows easy creation and fast customization of activities. Moreover, the Game Editor did not lead to any stressful experience for participants. Overall, participants rated the usability of the Game Editor as *good*, despite the language barrier and minor functionality issues. One of the major results retrieved from the experiment is that participants recognized the usefulness of the framework to customize activities for PwD. As stated previously (see Section 1), most of the existing

software and technology platforms follow a generalized design approach that does not take into consideration the individual needs of PwD. Presently, we are improving the Game Editor based on the participant's input, minimizing interface related issues. In the future, we aim to make the framework publicly available so that healthcare professionals and informal caregivers can access to such tools to stimulate PwD. Additionally, we will begin the longitudinal study to add novel knowledge to scientific literature regarding the usage of music and reminiscence in PwD.

## ACKNOWLEDGMENTS

We want to thank Yuri Almeida and Eduardo Gomes for their technical support during the development phase of the platform. Also, we would like to thank the health professionals of Casa de Saúde São João de Deus for their feedback during the usability study of Musiquence. This project is supported by the Portuguese Foundation for Science and Technology under project NOVA-LINCS (PEest/UID/CEC/04516/2019), supported by ARDITI under the scope of project M1420-09-5369-FSE-000001 Ph.D. Studentship and supported by project Larsys UID/EEA/50009/2019.

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