"UNLOCKING MEMORIES, REIGNITING JOY": A FEASIBILITY STUDY ON PERSONALIZED INTERACTIVE GAMES TO ENHANCE REMINISCENCE FOR PEOPLE WITH ALZHEIMER'S DISEASE

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ABSTRACT

This paper discusses the significance of research focused on progressive dementia due to the pressing needs of an aging population. Technological solutions have been explored as useful tools to diagnose, manage and treat elderly patients with Alzheimer disease (AD). Interactive games have proven to be an effective therapeutic approach for individuals with AD, improving cognitive function and quality of life. An interactive game was incorporated in my-MOBAL app, a personalized digital memory book, was developed to enhance reminiscence and stimulate cognitive function in individuals with AD. A feasibility study was conducted with clinical experts, an elderly user, and caretakers to collect data via interview and direct observation. Qualitative data collected over 8 weeks showed that personalized interactive games tailored to specific user can promote a sense of familiarity and connection to identity, providing comfort and reducing disorientation in individuals with dementia. It also encouraged communication between the user and the caretakers. Incorporating personalized elements in the interactive games could help to promote autonomy and independence, which are crucial for maintaining self-identity in individuals with dementia.

KEYWORDS

Interactive Games, Alzheimer Disease (AD), Non-Pharmacological Therapy, Reminiscence Therapy (RT), Cognitive Stimulation Therapy (CST)

1. INTRODUCTION

The elderly population is rapidly increasing worldwide, with the number of people over 65 years old growing and expected to continue rising for the next 20 years (United Nations, Department of Economic and Social Affairs, Population Division 2019). Dementia is a syndrome that is associated with ageing factor (World Health Organisation 2021). Alzheimer's disease (AD) is the most common type of dementia, accounting for 60-80% of cases globally. By 2050, the number of people with dementia is projected to reach 135 million worldwide, with 23 million in the Asia-Pacific region alone (Alzheimer's Disease International 2019). According to the "National Dementia Registry Report 2020" by the Ministry of Health Malaysia (2020), there were 41,251 registered cases of dementia in Malaysia, with an average age of onset of 73.4 years. It also mentioned that Alzheimer's disease (AD) was the most common type, affecting 69.8% of cases.

AD has no cure or treatment to reverse its progress, but pharmacological and non-pharmacological interventions are available to slow its development. Nevertheless, pharmacological treatments have limitations such as side effects and limited effectiveness. This leads to the increased of interest in non-pharmacological interventions such as reminiscence therapy (RT) and cognitive stimulation therapy (CST) (The Lancet Neurology Commission 2020; Imtiaz, Khan & Seelye 2018; Lee et al. 2019; Cammisuli et al. 2022). There is a growing body of literature supporting the use of computer technology, including interactive games, as effective interventions to stimulate cognitive function (Nguyen et al. 2020; Kammrath et al. 2021; Li et al.

2022), social interaction and communication (Groenewoud et al. 2017) for people with AD and their caregivers. Interactive games can support AD patients by providing cognitive stimulation and engaging their attention, memory, and problem-solving skills which can improve their mood and quality of life. Besides pleasure, games also could be used as a communication tool among youngsters and adults (Yusof, Mohd Rias & Yusoff 2014).

Over the last few years, several video games were developed, and they focus on multiple perspectives as well as stages of dementia. McCallum and Boletsis reported that dementia games do have an effect on cognitive impaired patients. However, this field still needs to be explored and need more research (McCallum & Boletsis 2013). Further research and development in this area are necessary to improve the effectiveness of AD non-pharmacological therapies in diverse populations. Hence, the aim of this research is to conduct a feasibility study on the design features of our interactive game prototype in my-MOBAL app, a personalized digital memory book with some interactive activities to assess its potential as a culturally tailored intervention for AD patients from diverse backgrounds.

2. RELATED WORK

2.1 Dementia and Alzheimer's Disease

Dementia is a complex and multifaceted condition that affects various aspects of daily life. It is a general term that refers to a group of symptoms, including memory impairment, language difficulties, and changes in behavior and personality, that can interfere with daily functioning (Dementia of the ageing population in Malaysia, 2021). AD is the most common cause of dementia leading to the deterioration of cognitive and functional abilities. It is important to note that while AD is a specific type of dementia, not all cases of dementia are due to AD. Early detection and management of symptoms can help improve quality of life for people with dementia and AD. Caretakers and family members should aim to provide stimulating activities and social interactions to maintain their cognitive and social abilities and prevent isolation, which can negatively impact their self-confidence and overall wellbeing (Al-Khafaji et al. 2013).

In Malaysian society, dementia is often surrounded by stigma and misconceptions. The prevailing belief is that dementia is a part of normal aging or a type of mental illness. This can lead to a delay in diagnosis and inadequate treatment further causing isolation and discrimination for those with dementia and their caregivers. Research has shown that dementia carries a significant cultural burden in Malaysia, and there are cultural taboos around discussing death and end-of-life care, which can lead to underutilization of available resources and services (Kua 2017; Nadarajah See & Narayanan 2018; Ong et al. 2019; Zainal, Ismail & Ahmad 2020). Greater awareness and education about dementia are needed to address these cultural and social barriers and provide appropriate care and support to people with dementia and their families.

2.2 Non-Pharmacological Therapies

Non-pharmacological therapy, also known as psychosocial therapy, is becoming increasingly popular for treating people with Alzheimer's disease, aiming to enhance their quality of life, reduce symptoms, and avoid the limitations of pharmacological interventions. There are several types of non-pharmacological therapies available, including cognitive-based, psychosocial, movement, and sensorial therapies. For this study, reminiscence therapy and cognitive stimulation therapy were selected as practical and effective. RT involves discussing past experiences using artifacts such as photographs and videos to evoke memories, increase personal identity, and reduce stress for caregivers. In addition, CST promotes cognitive processing and enhances cognitive function through group activities centered on specific themes such as physical games, childhood, and categorizing objects. RT and CST have been the subject of numerous studies in the field of dementia care. For example, researchers found that reminiscence therapy reduced depressive symptoms and improved overall well-being (Damianakis et al. 2009) also increased communication, and personal identity and reduced caregiver stress (Spector, Woods & Orrell, 2008).

RT has been studied in various countries, including Malaysia. Recent study conducted in Malaysia explored the effects of RT on the cognitive function and depression levels of elderly individuals with mild cognitive impairment (MCI) (Chong et al. 2021). RT consists of discussions on various topics such as childhood memories, family, and cultural events. Another study conducted in Malaysia investigated the effects of group

reminiscence therapy on the quality of life and depression levels of elderly individuals with dementia (Roslan et al. 2021). The results showed that the experimental group had significant improvements in the quality of life and a reduction in depression levels compared to the control group. In addition, recent researchers showed the efficacy of CST that has also been studied extensively in the field of dementia care (Ranasinghe, Kane & Gillman 2020; Jøranson et al. 2021; van Alphen et al. 2021; Jeong et al. 2021; Vagnarelli et al. 2021). Hence, it can be summarized that CST was effective in improving cognitive function, behavioral and psychological symptoms of dementia, as well as reducing depressive and anxiety symptoms.

2.3 Interactive Game as a Therapy

There is growing evidence to suggest that interactive digital games can be a valuable tool in therapy for a range of health and mental health issues. Recent studies have provided further evidence of the potential of interactive digital games in dementia treatment. For example, a randomized controlled trial by Liao et al (2020) found that playing a virtual reality game improved cognitive function, mood, and quality of life in older adults with mild cognitive impairment. Similarly, a study by Sánchez-Cubillo et al (2021) found that a virtual reality game-based intervention improved cognitive and functional outcomes in patients with AD. Furthermore, a systematic review by Sezgin and Özdemir (2021) found that RT using digital games could improve cognition and psychosocial outcomes in patients with dementia. In addition, a study by Groenewoud et al (2017) suggests that video games can have positive effects on psychosocial aspects such as motivation, emotion, and social interactions, which are crucial in the context of mental health therapy. This is also supported by a study by Cipresso et al (2021), which found that playing a virtual reality game improved mood, attention, and executive function in patients with Alzheimer's disease. Similarly, the study by Yamagata et al (2013) found that using brain, memory and problem-solving games could help to stimulate the brain and lower the symptoms of AD. These findings support the use of interactive digital games as a valuable tool in dementia treatment and highlight their potential to improve cognitive, psychosocial, and functional outcomes in patients with cognitive impairments. As such, the integration of digital games into clinical practice could lead to improved patient outcomes and quality of life.

Ning et al (2020) described that in a study by Chang et al (2013), it is reported that by combining RT in games, it could help to restore the memories and cognitive ability of people with dementia. In Chang et al studies, they simulated the scene of buying food with Food Stamps that was set in the 1960s setting. While there is growing evidence to suggest that digital games can be an effective tool for dementia treatment, there is less research addressing the development of personalized digital memory books that embed cultural factors for reminiscence therapy in dementia patients. Personalized reminiscence therapy that incorporates cultural factors has the potential to improve the effectiveness of treatment for individuals with dementia, as cultural backgrounds and experiences can shape personal memories and influence the effectiveness of RT.

However, as noted by a recent scoping review by Cheng, Huang & Chang (2021), there is a lack of studies that have developed and tested personalized digital memory books that incorporate cultural factors in the context of reminiscence therapy for dementia patients. In addition, study by Sezgin & Özdemir (2021) found that a culturally sensitive reminiscence therapy program that incorporated music, food, and religious symbols improved cognitive function and quality of life in Turkish individuals with dementia. The study highlights the importance of incorporating cultural factors into reminiscence therapy for individuals with dementia. Additionally, a review by Kim et al (2021) found that using cultural-specific stimuli in RT could enhance the effectiveness of the therapy for individuals with dementia. The authors suggest that incorporating cultural factors into RT can improve the individual's emotional, psychological, and social well-being. This highlights the need for further research in this area, which could lead to the development of more effective and culturally sensitive therapies for individuals with dementia. Therefore, this project is aimed to further research and develop a personalized digital memory book that incorporates cultural factors in the context of RT for dementia patients.

3. METHODOLOGY

3.1 Study Design

A single study design was used in this research. Single subject study has been used by many researchers to assist people with Alzheimer's in their daily activities (Henley and Lusty, 1984; McPherson et al. 2001; Foloppe et al. 2018). Massimi et al (2008) also conducted on a single participant in their exploratory case study to improve the sense of identity for this target group. Using single case study could use the benefit of saving time, less expensive, help in creating high-quality theory and having a deep understanding of the exploring subject (Gustafsson 2017).

Though, it is not uncommon for focus group studies to have a small sample size of one participant, especially when the focus is on exploring in-depth experiences or perspectives of that individual. In this case, the study is designed to explore the effectiveness of a personalized digital interactive game in the context of the specific participant. By focusing on one individual, the study could gain a more comprehensive understanding of the participant's experiences and how the application impacted her cognitive and psychosocial functioning. Razak (2008) recommended that single case study could be used when we want to study a person or a group of people. Sometimes it is also possible to generalize from a single person. The findings of this small-scale study could also serve as a starting point for future research with larger sample sizes.

3.2 Design Process for the Personalised Digital Interactive Game

The personalized digital interactive games are part of my-MOBAL application. In this app, we developed two types of games with the purpose of stimulating cognitive function and enhancing the memory of the participant. We used the Mobile Application Development Lifecycle (MADLC) to design and develop the personalized digital mobile application (Vithani and Kumar 2014). After performing literature review for the design features, we began to design and develop the application. A few diagrams were sketched to assist with visualizing and understanding the process.

3.3 Screen Designs

Storyboards were drawn to visualize the layout of the game (Figure 1-2). The storyboards contained sketches of graphics, text, animation, audio, and other functional components such as buttons and production notes. Based on the literature study on designing application for people with Alzheimer's, it is essential that the games need to be simple and straightforward so that the user can easily view all items and understand all functions. Big buttons with vibrant colors were selected so that users could easily see the functions. In contrast, dark green was selected as a background color. The same background color was used throughout the whole application so that it gave a look of consistency.

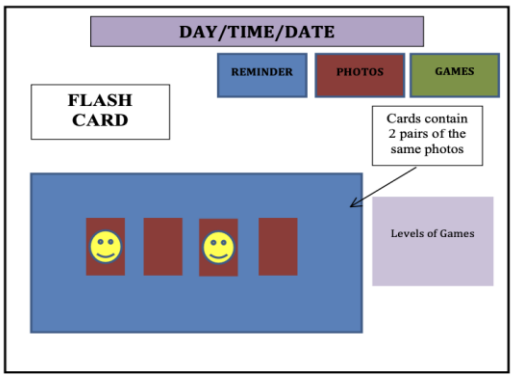

Figure 1. Memory card game for Level 1 screen design

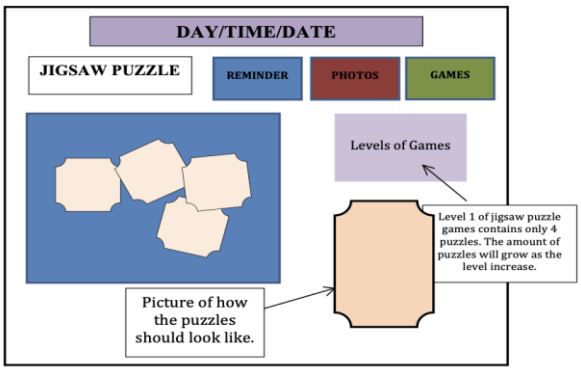

Figure 2. Jigsaw puzzle game for Level 1 screen design

For the media content in this study, photos related to the participant were used. These photos included pictures of family members, including the participant herself. All photos were carefully selected by family members to avoid evoking sad or bad memories of the participant. Mizen (2003) recommended selecting photos of the patient smiling. All photos were colored, but the quality was not very good. We edited the color in the photos to make them clearer and more recognizable. Photos of family members and familiar artifacts were used to assist in enhancing the participant's memory. As the participant did not keep many personal artifacts, only a few old photos were available for this research.

3.4 Personalised Digital Interactive Game Prototype

The my-MOBAL app application was developed using several tools such as Adobe Flash Air and Photoshop. It consists of daily activities and reminder page, reminiscence page that shows family members and events photos and games activities page (Figure 3), for cognitive training. The application for the personalized memory book introduces two games, namely the memory card games (Figure 4) and jigsaw puzzle (Figure 5). The games were designed in the participant's native language, Bahasa Malaysia/Malay Language, so that the participants can understand the game's requirements. These games offer a few levels. However, the purpose of these levels is not to challenge the user but to provide variety so that the games will be more fun and enjoyable. Memory card game comes with 2 levels of difficulty. The first level contains three pairs of photos (six cards), and second level contains four pairs of photos (8 cards). The user needs to find the matched pair by flipping the card one by one. If the photos do not match, the application will display messages that indicate the pair was not correct.

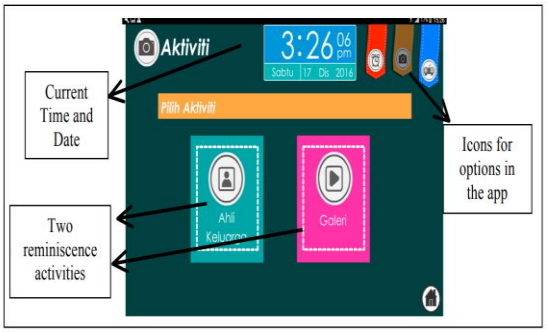

Figure 3. The games activities screen

Figure 4. Memory card game for Level 1 screen

Another interactive game included in this app is the jigsaw puzzle. To play this game, the participant needs to drag the puzzle pieces into the correct frame. The pictures used events that related to the participant. The first level has four puzzle pieces, and it was the simplest puzzle, which was a wedding picture - one of the participant's favorite events. The second puzzle was a picture of the graduation day, which has six puzzle pieces. The third puzzle was a bit different because it was not a picture of her family members, but a picture of a bouquet of flowers, specifically a tulip bouquet. For this part, we did not use any family pictures to observe how the participant would react to non-familiar content. These two games were designed in a way that the participant could easily navigate through them and be error-free. We also included audio feedback to compliment the user when they succeeded, as well as for motivational purposes. The user was free to choose which game she wanted to play and to stop playing. Although the games provided levels of difficulty, the user could jump to any level she would like to play. The user did not need to follow the order of the levels. my-MOBAL application has also included an event-logging tool that recorded patient’s activities during therapy sessions (Figure 6). These logs could assist the researcher to follow the patient’s activities even without the researcher’s presence by looking at the dates for every activity. Figure 6 displayed the date when the participant played the games and time spent to complete the activity. This information is valuable especially when the researcher was not present during the session.

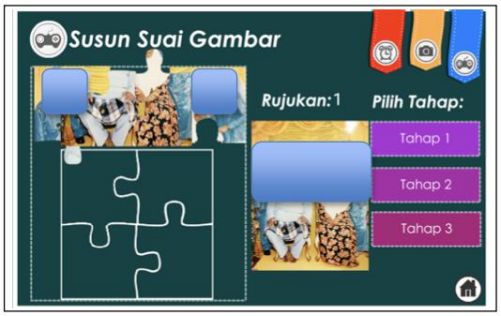

Figure 5. Jigsaw puzzle game for Level 1

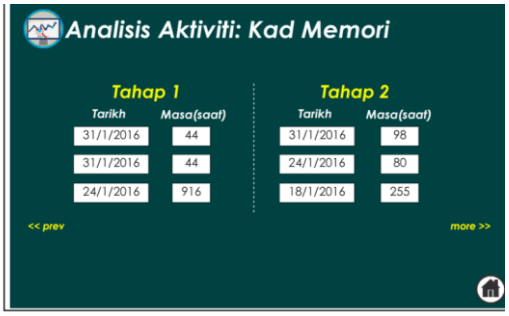

Figure 6. Analysis page on frequencies viewing the photos

3.5 Expert Review Assessment

An expert review technique was used to evaluate the application. Expert review is a form of evaluation where a group of domain experts evaluate a product or intervention. In this case of digital games for reminiscence therapy, domain experts would be individuals with knowledge and expertise in dementia, gerontology, psychology, and game design. We include expert review in this study because to ensure that digital games are designed to meet the specific needs and challenges of dementia patients and to ensure digital games are evidence-based and effective in improving reminiscence and cognitive function in dementia patients. Four (4) clinical experts participated in the interview to assess the usability and capability of the application, including the games elements. All the experts have more than 10 years of experience in the field of gerontology and psychology. To assess the concept and usability of the interactive games, six (6) related questions were asked. Those are as in table 1.

Table 1. Related questions on assessment of concept and usability of the interactive games

Numbers	Questions
Q1	Can computer-based past game activities enhance reminiscence for Alzheimer Disease (AD) patients?
Q2	Does computer-based games stimulate the cognitive function of AD patients?
Q3	Does using personal/family member photos in game activities help patients to reminisce?
Q4	Does repetition use of past or traditional games using application/computer enhance reminiscence for AD patients?
Q5	Can repetition use of the games stimulate cognitive function of AD patients?
Q6	Can different levels in game activities assist in reminiscence therapy and cognitive stimulation therapy?

Besides the expert review, for this feasibility study, we also recruited a person with mild Alzheimer's disease.

3.6 Participant's Selection

Prior to participant selection, this research has undergone the university's ethical approval process and has been granted approval from Universiti Kebangsaan Malaysia (UKM) as a research collaborator (UKM 1.5.3.5/244/NN-102-2014) to carry out data collection with elderly individuals with dementia. The recruitment of the participant was through a friend's referral. A few meetings were carried out with the caretakers and the participant to establish a good relationship with the participant. The participant was 74 years old, female and was from Malay race. She has no major health issues, and her level of education was until primary school. The participant has two caretakers that will take turns to look after her. Prior to the recruitment of the study, the patient visited Memory Clinic and underwent two assessments, MMSE (Mini Mental State Exam) and CDR (Clinical Dementia Rating Scale). Her score for MMSE was 19/20 and for CDR was 1.0. For this study, the assessments were carried out before and after using the application. MMSE for this study was in Bahasa Malaysia (Malay language) because of the participant's mother-tongue language and suitable for the culture of Malaysian.

During this study, the interactive games were tested by the participant during her therapy sessions. The testing was carried out at the caretakers' house. According to O'Conner et al (2009), the presence of family

members could give a positive result in therapy sessions. For this study, the sessions took place twice weekly for eight weeks which lasted between 30 to 45 minutes per session. During the sessions, the researcher would take notes and observe the participant. All the interviews with the expert reviews, AD participants and their caretakers were analyzed using content analysis.

4. RESULT AND DISCUSSION

4.1 Feeback From the Experts

Based on the expert review interviews, all of them agreed that the interactive games in my-MOBAL application could help in enhancing reminiscence and stimulate the cognitive function of people with AD. They also agreed that using personal artifacts related to the patients could assist in reminiscing. Using personal/family member photos in game activities can help patients to reminisce. It provides a more personal and emotional connection to the memories being recalled, which can enhance the effectiveness of the therapy. Whereas the repetition use of past or traditional games using application/computer can enhance reminiscence for people with AD. Repetition has been found to be an effective way to reinforce memories and improve cognitive function. They further commented, the brain responds well to repetition and reinforcement, and this can lead to improved cognitive function. In addition, according to the experts, different levels in game activities can assist in reminiscence therapy and cognitive stimulation therapy. The experts also agreed that different levels of difficulties in the games should not be used to challenge them, but to provide more options to solve the games and make the games more attractive.

In addition, the expert reviewers provided us with some suggestions on how to enhance the interactive games of the my-MOBAL app. Three experts recommended that we use cultural language for the mobile application's overall content. By doing so, we can ensure that the games are culturally appropriate and sensitive to the needs of the population. Currently, the content language is focused on Bahasa Malaysia (Malay language), which may only be relevant to a single race, even though it is the national language. Therefore, it is important to consider using other languages such as English, Tamil, and Mandarin, as these languages represent the races in the Malaysian community. Furthermore, two experts suggested using symbols and imagery in the computer game activities. This can help create a sense of familiarity and connection with the targeted population. Additionally, they recommended that the app should provide options for customization of the games to accommodate individual cultural preferences and differences. This can enhance the user's experience and make the games more appealing to a wider audience.

Lastly, the experts recommended that we conduct a feasibility study of the prototype with various races. This can be achieved through feedback from different races, caregivers, and healthcare professionals to gauge the effectiveness of the games and identify possible cultural elements for the content creation. This will help us to understand the specific needs and preferences of our target population and make necessary adjustments to the app. In summary, the expert reviewers provided valuable suggestions to enhance the interactive games in my-MOBAL apps. By incorporating cultural language, symbols, imagery, and customization options, we can create a more culturally sensitive and appealing application. Conducting a feasibility study will enable us to evaluate the effectiveness of the games and gather feedback from different stakeholders, which can help us to improve the application and better meet the needs of our target population.

4.2 Feedback from Participant and Caretakers/Family Members

Based on the researcher’s observation, the 74 years old female participant with mild AD had positive experience with the personalized digital memory book application. The observation revealed that the participant's mood varied and was often affected by her environment and surroundings. Additionally, the participant's physical condition influenced how the therapy sessions went. For instance, if the participant tired, she would prefer shorter sessions.

The participant usually accompanied by her grandchildren who were also curious about the app in those sessions. The grandchildren will ask the grandmother if she knew how to play the games. Example of the conversation be like:

Grandchild 1: *Grandma, do you know how to play this game?* (Since the game also showed pictures of past events, the grandmother would tell the story of the event while playing the games).

Grandchild 2: *Grandma, who is this?* (Grandmother replied, "*this is your mother*")

From the observation, when she surrounded by her grandchildren, she could go for more than 45 minutes and thoroughly enjoy the sessions. It is worth noting that a participant's mood and environment can significantly affect the outcome of therapy sessions. Therefore, it is essential to take these factors into consideration when planning therapy sessions. In addition, the bonding between the grandmother and the grandchildren indicates that the app has the potential to bridge the generational gap and promote intergenerational interaction.

The exchange between the participant and grandchild 2, where the participant identified a picture of their grandchild's mother, demonstrates the potential for the app to facilitate communication and strengthen family bonds. It also highlights the importance of family members' involvement in reminiscence therapy and the potential benefits it can have for both the participant and their family members.

Participant (Feedback 1): *How am I going to play this game? What should I do?*

Another interesting observation, the app not only enhances the participant's memory but also stimulates their cognitive function. In participant's feedback 1, she showed her readiness to learn new skill. In the first few sessions, she was not sure what she supposed to do. Since the participant also not familiar with computer technology, she was quite unsure what she should do with the games. She was curious and kept asking what she should do. However, after a few sessions, she stopped asking, and just played with the games once it appeared on the screen. The caretakers were quite shocked and very pleased with the improvement. This is because the participant has never used a computer or any mobile devices previously.

During the session, the participant also expressed her enjoyment in using the app especially when the grandchildren or other family members involved in the sessions. The used of pictures of past events seems to have triggered the participant's memories, prompting her to share stories of these events while playing the interactive games. According to the caretaker, her mother is usually a very quiet person. However, during the sessions, her mother became more talkative. Their mother loves to talk about the event in the photographs especially when she is in the picture. She also showed more motivation to play the games with the presence of her grandchildren. There are quite a few times when her grandchildren were able to join the sessions, and usually those sessions would take more than 40 minutes to end. In a few sessions, the caretakers were impressed and said that they had never seen their mother talked so much and still remember some of the events. This suggested that the app could be an effective tool for reminiscence therapy, a technique that uses the recollection of past events and experiences to improve psychological wellbeing. It also could be used for cognitive stimulation therapy as the games could be used to encourage cognitive processing in order to improve cognitive function of the participant. This positive feedback is a good sign that the app is engaging and useful for the participant.

Furthermore, it is important to note that cultural elements should also be considered in the design of non-pharmacological therapy apps. In the case of the participant in this study, she accompanied by her caretakers and grandchildren who were likely to be from the same cultural background as her. In fact, my-MOBAL app was developed in a native language which is Bahasa Malaysia where both parties could understand it well also the symbols and imagery used in the content are relevant and familiar to the participant's cultural background. While the study provides valuable insights into the potential benefits of using a personalized digital memory book app for psychosocial therapy in individuals with mild AD, it is important to note that the findings cannot be generalized to other races or cultural backgrounds. The participant in this study and her grandchildren were from a specific cultural background and spoke a specific language, which may have influenced their experience and interaction with the app. The use of language, symbols, and imagery in the app's design that are relevant and familiar to the participant's cultural background may not be as effective or engaging for individuals from different cultural backgrounds. Therefore, it is important to consider cultural elements in the design of reminiscence therapy apps for future enhancement to ensure their effectiveness and relevance for individuals from diverse cultural backgrounds. Conducting similar studies with participants from different cultural backgrounds can help to determine the generalizability and effectiveness of reminiscence therapy apps for diverse populations.

5. CONCLUSION

This study aimed to test the feasibility of a digital interactive game that is embedded in my-MOBAL, a personalized digital memory book, that is a tool for non-pharmacological therapy. We wanted to explore further the app design features whether it is viable and practical for use in a larger study or clinical setting in the future. As this is the first version of the prototype, we wanted to gather preliminary data on the potential, challenges and limitations of the app from the design perspectives.

The preliminary data gathered from this study revealed the need for the app to be culturally sensitive and appropriate. The current version of the app lacks cultural elements such as varied languages, symbols, and imagery relevant to the participant's cultural background, which may limit its effectiveness for individuals from different cultural backgrounds. The limitation in this study is that we only manage to test and interview one participant from a single race and the design of the mobile application content is prone towards one single race influence including the language usage that resulted a positive response from the participants. We believed that it might not be the case for other races, which probably have culturally appropriate and sensitive content preference and tolerance in which we must investigate further. Therefore, the findings from this research cannot be generalized and represent the entire view of elderly with dementia as our conclusions are based on one person study. However, this finding will serve as the future development of my-MOBAL prototype enhancement which will incorporate designs that resemble multi-cultural metaphors. Furthermore, we plan to test the prototype with different races.

In addition to the limitations regarding cultural generalizability, we noted the importance of considering the potential impact of user impairment on the use and effectiveness of personalized digital memory book apps for individuals with AD. Alzheimer's disease is a progressive neurodegenerative disorder that can lead to cognitive and functional impairment, making it difficult for individuals to learn and use new technologies. While the participant in this study had mild AD, individuals with more severe forms of the disease may struggle to use digital memory book apps effectively or may not be able to use them at all. It is also important to consider the potential impact of user impairment on the efficacy of reminiscence therapy using digital memory book apps. Individuals with advanced AD may have difficulty recalling past events or experiences, making reminiscence therapy less effective. Furthermore, individuals with AD may experience agitation, confusion, or frustration when trying to recall past events, which could negatively impact their experience with the app and their engagement in reminiscence therapy.

Therefore, future research should also consider the potential impact of user impairment on the use and effectiveness of digital memory apps for reminiscence therapy in individuals with Alzheimer's disease. This could involve testing the app with individuals at different stages of Alzheimer's disease or with different levels of cognitive impairment to determine the app's effectiveness and usability across a wider range of individuals with AD. Additionally, it may be necessary to develop specific adaptations or modifications to the app to ensure its effectiveness for individuals with more advanced Alzheimer's disease. Therefore, it is important for app developers and therapists to consider cultural elements in the design and implementation of reminiscence therapy apps to maximize their potential benefits as well as test it with a different user background and capabilities.

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