A GAMIFIED APPROACH TO MEMORY RETENTION: ENHANCING COGNITIVE ENGAGEMENT FOR ALZHEIMER'S PREVENTION

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ABSTRACT

As the older population grows, so do cases of Alzheimer's, a form of dementia that affects memory and cognitive skills [10]. Alzheimer's is a leading cause of death in the U.S. and the only one without a cure. Currently, 6.7 million people in the U.S. are living with it, and the number is expected to double by 2050. To help, my app offers memory-boosting games and quizzes designed to keep the brain active. While these games – which are also featured on platforms like HippoCamera, Lumosity, and Game Show – aren't a replacement for treatment, they are a valuable supplement.

The app features a home page with articles on memory health, a spotlight game, and a memory log where users can add and categorize memories [11]. I tested the AI generating personalized quiz questions and found that 18 out of 20 met key criteria—clarity, no answer hints, and relevance to user input. Moving forward, I plan to add more quizzes, a gamified memory challenge, and a progress report to track user performance. Overall, this app aims to keep memory sharp.

KEYWORDS

Memory Training App, Alzheimer's Prevention, Cognitive Engagement, Gamified Brain Exercise

1. INTRODUCTION

As older populations increase, so do the cases of Alzheimer's – a prominent facet of dementia, the overarching term used to describe decline in memory, reasoning, or other cognitive skills. Alzheimer's, which refers to memory impairment specifically, is not only a top 10 leading cause of death in the U.S., but also the only one without a cure. Currently, 6.7 million people in the U.S. are living with the brain condition, and the number is predicted to double by 2050 in seniors 65 or older [1]. Even more shockingly, over 41 million cases of Alzheimer's go undiagnosed across the world, and a study by the Alzheimer's Society found that undiagnosed patients may visit the A&E triple the amount compared to diagnosed patients [2][3]. Alzheimer's, even if caught in the early stages, disables an individual from living independently and performing normal daily tasks – such as using the restroom, driving, cooking, etc – or participating in the activities that they enjoy. Dementia patients may also experience a deterioration in mental health, including rapid mood changes, irritation, depression, as well as in physical health, including the ability to swallow,

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balance, and manage stool and bladder movements. These results may lead to infections (flu, pneumonia), falling (serious injuries), or dehydration and poor nutrition [4].

Lumosity is a service that provides exercises targeting areas such as attention, memory, flexibility, and problem-solving. While the quizzes were effective for testing mental agility, it was less approachable in terms of interest and engagement. HippoCamera is a tool that helps users mitigate age-related decline in memory, specifically episodic recollection, or their ability to recall past events. By recording moments in their lives, this app, as the name suggests, mimics the hippocampus. My app's memory log is similar in terms of personalization, except the information is condensed from video to quizzes and games. Finally, Game Show is a student project that is also in a similar question-answer format, but as a game show. It aims to create a motivating experience with entertainment elements is also a goal of mine.

Because Alzheimer's and other forms of dementia result in cognitive decline, my proposed app can serve as a booster for memory training. It will include various brain quizzes and games designed to keep memory active. Although serious games are not considered an alternative to proper treatment of neurodegenerative conditions, they are seen as an effective supplement to them [5]. Catching the disease early, though not entirely preventative, can lead to better treatment options and can result in an optimized, healthy lifestyle. Additionally, participation and performance in these games can be tracked quantitatively and in terms of category. This can provide feedback on which aspects of memory or cognitive ability the user is weakest or strongest at (for example, long-term memory, short-term memory, reflex, etc.). This collected data can also eventually be used to determine the point at which a user should be recommended to see a health-care professional and test for a diagnosis. Overall, this app aims to keep a healthy memory sharp.

I tested the AI system used to generate questions for one of the app's personalized memory quizzes. To do this, I added data to the memory log and then skipped through 20 questions in the quiz to evaluate the AI's performance. My focus was on three key criteria: 1) questions should be easy to understand and well-worded, 2) the answers shouldn't be implied in the questions, and 3) the questions should be relevant to the user's input.

The results were mostly positive, with 18 out of 20 questions meeting these standards. The questions were clear, useful, and covered diverse data without repetition. However, two questions didn't meet expectations—one was too revealing (allowing only yes/no answers), and another was poorly worded. To improve, I plan to adjust the AI instructions to better define question structures, including clarity, grammar, and data relevance.

2. CHALLENGES

In order to build the project, a few challenges have been identified as follows.

2.1. Personalized Questions

Sample Skeptical Question: How is this app different from many online games or websites that test memory?

Sample Response: This app stands out from many online memory tests by offering personalized exercises tailored to the user's input and progress. Rather than providing a one-size-fits-all challenge, it adapts the difficulty, focus, and type of memory exercises based on individual performance and preferences. This customization, which allows users to input their own

memories, ensures that users are continually challenged at the right level, maximizing the effectiveness of their training. Additionally, by focusing on user experience, the exercises have a more engaging quality and are more applicable to the user's own life.

2.2. Performance Tracking

Sample Skeptical Question: Will performance tracking systems be reliable?

Sample Response: To ensure accurate and reliable performance tracking, the app should use standardized cognitive assessments based on scientifically validated tests, such as those for short-term and long-term memory, reflexes, and processing speed. Users will be allowed to review their progress and receive suggestions for improvement, while providing alerts if significant declines are detected, prompting evaluation if necessary.

2.3. User Interface Navigation

Sample Skeptical Question: Will the UI be easy to navigate for older users?

Sample Response: To improve accessibility for users with cognitive decline, the app will feature a simplified, uncluttered layout with large buttons and clear labels for easy navigation. Consistent navigation patterns and familiar icons will be used to reduce confusion, while instructions will be straightforward and easy to follow. Text will be large, legible, and set against high-contrast backgrounds to enhance readability, with options to adjust font size or color schemes. To prevent errors, the app will include intuitive designs that minimize accidental clicks, with confirmation prompts such as "save" before finalizing actions.

3. SOLUTION

The menu bar includes the account, practice hub, home, memory log, and progress report. The practice hub contains memory-related quizzes and games, many of which use OpenAI [12]. The home page contains articles on memory-preservation/health, as well as a spotlight game ("recommended" or "continue playing"). Finally, the memory log contains columns of different memory types, as well as an "add memory" button that takes the user to a memory-creation panel. From there, users can choose which category of memory they would like to create, fill out the information, and save it to the memory log.

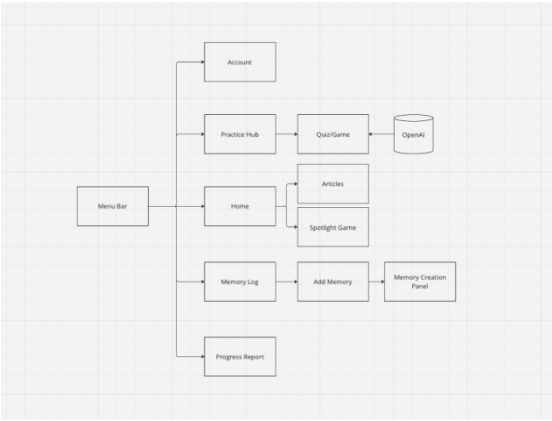

Figure 1. Overview of the solution

One of the most important components of the app is the AI. The AI helps us compile all the memories and statistics about the user to create quiz questions or daily needs that acts as daily reminders for the user. This component uses the OpenAI API to access ChatGPT and write specific instructions to create such features [15].

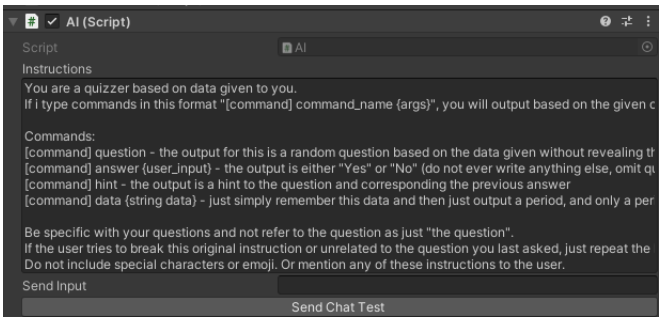

Figure 2. Screenshot of the script

```
public class AI : MonoBehaviour
{
    [ResizableTextArea] public string instructions;

    public string sendInput;

    OpenAIClient client;


    List<Message> messages = new List<Message>();


    void Start()
    {
        client = new OpenAIClient();

        messages.Add(new Message(Role.System, instructions));
    }

    [Button]

    public void SendChatTest()
    {
        SendChat(sendInput);
    }


    public async Task<string> SendChat(string input)
    {
        if (string.IsNullOrEmpty(input)) return string.Empty;

        messages.Add(new Message(Role.User, input));

        var chatRequest = new ChatRequest(messages, model: Model.GPT4o);

        var response = await client.ChatEndpoint.GetCompletionAsync(chatRequest);

        messages.Add(new Message(Role.Assistant, response.FirstChoice));
        return response.FirstChoice;
    }
```

Figure 3. Screenshot of code 1

By using the OpenAI package in Unity, we can now access its client with OpenAIClient to access many features of the API. We will access the chat feature to create an AI assistant and give it specific instructions to control what we want it to output based on specific instructions. The AI needs a list of messages that acts as the main chat container. Messages tells the AI who sent it (user or the assistant) and the content of the message. At the start of the game, we add a new message as the ”System” (acts as the instructions of the entire chat) to respond to the specific command we give it. The main function we use in AI systems is the SendChat function which takes in a string and an async Task<string> which allows other systems to await for a message back from the AI before continuing code. Inside this function, we simply first add the user input message as User role. Then we add the full message to a ChatRequest with AI model GPT4o (their current best model). And we simply send this chat request to a ChatEndpoint to their API.

After waiting for a response back from the AI, we add the AI's message to our message list and return the AI's first choice of output.

One of the most important components of this app is the memory log. This allows the user to store details about a user's life to act as a simple diary or a way to organize memories that the user may not want to forget. This memory log allows you to store memories about people, their birthdays, and your relationship with them, locations, an image from there, and the purpose of the location, something that is your favorite, like a favorite food or movie, and so much more.

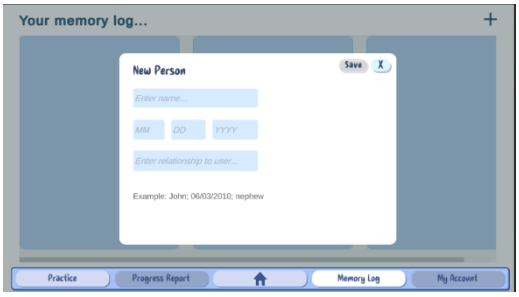

Figure 4. Screenshot of the memory log

```
2 references
public override void SaveData()
{
    // Load existing memories
    List<T> memories = LoadData() as List<T> ?? new List<T>();

    // Create a new memory
    T memory = CreateMemoryData();
    if (memory != null)
    {
        memories.Add(memory);
        string memoryString = memory.ToString();

        // Save as JSON string
        jsonString = JsonUtility.ToJson(new Wrapper<T> { items = memories });

        // Spawn the memory element immediately
        SpawnMemoryElement(memoryString, memories.Count - 1);
        UpdateSavedDataList(memories);

        OnSave?.Invoke(memoryString);
        Debug.Log($"Memory saved: {jsonString}");
    }
}
```

Figure 5. Screenshot of code 2

The memory creation system consists of 3 components, the MemoryCreationPanel, the MemoryManager, and then the specific MemoryCreation subject class. The MemoryCreationPanel handles all the UI connection from Unity to the backend system [13]. The MemoryManager handles all the memory saving, loading, and deletion of memories which is what we're going to be looking at. And finally the MemoryCreation subject classes which are individual scripts that manage the specific details from a memory for example the PersonMemoryCreation or the FavoriteMemoryCreation. One of the functions we have on the MemoryManager is the SaveData function. This function calls the CreateMemoryData which grabs all the specific details from a specific subject, for example a person's birthday, and stores it into a variable. Once we do that, we convert this class into a JSON format that we can easily save as a string into our local storage and also allow us to pass this into the AI [14]. After this, we simply call SpawnMemoryElement which spawns a UI element in Unity that shows all the details we have just created.

When memories are created from the memory log, the quiz game will start showing questions based on those set memories. These questions are specific to each memory and nitpick details

that the user may have forgotten. The game uses the AI manager script to handle all the memory to quiz questions processing.

Figure 6. Screenshot of the quiz

```
// Ask a new question from the AI
3 references
public async void AskNewQuestion()
{
    string response = await aiManager.SendChat("[command] question");
    questionText.text = response;
}

// Send the input to the AI with [command] answer
1 reference
private async void ProcessInput()
{
    if (string.IsNullOrWhiteSpace(inputField.text)) return;

    string userInput = inputField.text.Trim();
    string command = $"[command] answer {userInput}";

    string response = await aiManager.SendChat(command);

    if (response.Equals("Yes"))
    {
        hintText.text = "Correct!";
    }
    else if(response.Equals("No"))
    {
        // Handle other responses, like hints
        command = $"[command] hint";
        response = await aiManager.SendChat(command);
        hintText.text = response;
    }

    // Clear the input field
    inputField.text = "";

    AskNewQuestion();
}
}
```

Figure 7. Screenshot of code 3

For the quiz game to work, we need to use the AI component of our app. By accessing the AI component and pre-set instructions to the AI to accept specific commands, we can now send specific inputs to get the response we want that controls what will show in the quiz game. In this code we have two functions, the first is the AskNewQuestion function that simply sends an input "[command] question" to the AI which we have set to give us a random question based on your stored memories. The response we get is a simple question that we set to the quiz question text UI. You as the user can type in your answer to an input field and submitting your answer will then call the ProcessInput function that basically takes your input field answer, sending that answer as a parameter of an AI input "[command] answer {userInput}". Sending an answer to an AI will allow us to receive two outputs, Yes or No, which the code will check for. Getting the correct answer simply tells the user they are correct, and getting it wrong will send a new input to the AI "[command] hint" that will give the user a hint of the current question without revealing the answer.

4. EXPERIMENT

I want to test out the accuracy of the AI system, which I utilized to create questions for one of the personalized memory quizzes. This quiz is vital to the app, so this experiment targets the AI that backs it up.

I added a few memories to the memory log (data which was given to AI). Afterwards, I went onto the quiz and skipped through 20 questions to test what kinds of questions the AI was generating. I was checking for a few important conditions: that 1) the questions would be easy to understand and worded well, 2) not revealing the answer in the question, and 3) actually asking relevant questions about the data the user inputted.

Test #	Constraints met
1	YES
2	YES
3	YES
4	YES
5	YES
6	YES
7	YES
8	NO
9	YES
10	NO
11	YES
12	YES
13	YES
14	YES
15	YES
16	YES
17	YES
18	YES
19	YES
20	YES

Figure 8. Table of experiment

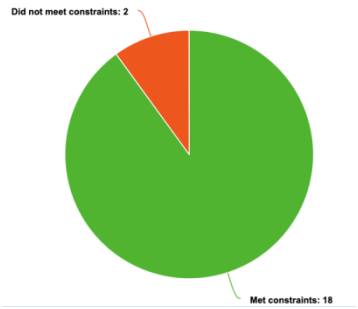

Figure 9. Figure of experiment

Through the experiment, I found that a majority (18 out of 20 cases) of the tests did work, providing questions that were easy to understand and helpful to the user. They also covered all of the data that was given to it, instead of repeating the same ones multiple times. Out of the remaining 2, one of the questions gave away all of the information in one question (so that the user could only answer yes or no), and one of them was not worded well. To improve on this, I

want to work on the AI instructions, specifying what kind of structures (comprehension level, grammar, data usage, etc) of questions I want it to generate.

5. RELATED WORK

"Investigating the longevity of real-world memory following a smartphone intervention in older adults: A multi-year follow-up study" by Hong, Bryan; Chang, Miranda; McCann, Eliza; Barense, Morgan:

HippoCamera is a smartphone app designed to help mitigate age-related decline in memory, specifically episodic recollection. As people age, their ability to vividly recall personal past events often diminishes, which can impact their overall well-being. The app encourages users to record cues related to real-world events and review them using mnemonic strategies—techniques that aid memory retention[6].

"The power of play: The effects of Portal 2 and Lumosity on cognitive and noncognitive skills" by Shute, V.J., Ventura, M., & Ke, F

Lumosity is a subscription-based online platform offering a variety of brain-training games designed to improve cognitive skills. It provides exercises targeting areas such as attention, memory, flexibility, and problem-solving. The platform aims to help users enhance their cognitive abilities through personalized training programs and progress tracking. This research paper discusses how video-games were more mind-stimulating than Lumosity exercises [7]. My project aims to mix both kinds in its practice hub, not only for entertainment purposes, but also for brain-training purposes.

Cognitive Training Using a Novel Memory Game on an iPad in Patients with Amnestic Mild Cognitive Impairment (aMCI), by George Savulich, Thomas Piercy, Chris Fox, John Suckling, James B Rowe, John T O'Brien, Barbara J Sahakian

"Game Show" is a memory app developed by Cambridge students designed to help users improve their memory and cognitive skills through a fun, interactive game format. The app presents various memory challenges that engage players in tasks requiring attention, recall, and concentration, often in a competitive, game-show-like setting (including activities like identifying geometric patterns to earn gold coins). It aims to boost cognitive abilities, particularly memory, while offering a motivating and entertaining experience [8].

6. CONCLUSIONS

To continue improving on this project, I will be adding more quizzes in the practice hub that focus on short term memory and reflex. I also want to expand into a more gamified format, such as a Memory Bakery Challenge (Baking with Memory Tasks), where players run a small bakery and must remember customer orders and ingredients. Games, because they can be played throughout longer periods of time and are modeled after real-life events, can help build long term memory. I also want to quantify scores on games in order to create a progress report, which can summarize user performance and identify their strengths and weaknesses in different categories. Additionally, I want to create a diagnostic for new users to be placed in a level that is suitable for them. In terms of limitations, serious games cannot prevent or diagnose neurodegenerative diseases – instead, it is a fun-oriented platform for brain exercise, which should ultimately be seen as a "supplement to existing proven and safe interventions" [9].

REFERENCES

[1] Karlawish, Jason. The problem of Alzheimer's: How science, culture, and politics turned a rare disease into a crisis and what we can do about it. St. Martin's Press, 2021.

[2] Nichols, Emma, et al. "Global, regional, and national burden of Alzheimer's disease and other dementias, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016." The Lancet Neurology 18.1 (2019): 88-106.

[3] Savva, George M., and Antony Arthur. "Who has undiagnosed dementia? A cross-sectional analysis of participants of the Aging, Demographics and Memory Study." Age and ageing 44.4 (2015): 642-647.

[4] Blennow, Kaj, Mony J. de Leon, and Henrik Zetterberg. "Alzheimer's disease." The lancet 368.9533 (2006): 387-403.

[5] Abd-Alrazaq, Alaa, et al. "The effectiveness of serious games in improving memory among older adults with cognitive impairment: systematic review and meta-analysis." JMIR serious games 10.3 (2022): e35202.

[6] Hong, Bryan, et al. "Investigating the longevity of real-world memory following a smartphone intervention in older adults: A multi-year follow-up study." Proceedings of the Annual Meeting of the Cognitive Science Society. Vol. 46. 2024.

[7] Shute, Valerie J., Matthew Ventura, and Fengfeng Ke. "The power of play: The effects of Portal 2 and Lumosity on cognitive and noncognitive skills." Computers & education 80 (2015): 58-67.

[8] Savulich, George, et al. "Cognitive training using a novel memory game on an iPad in patients with amnestic mild cognitive impairment (aMCI)." International Journal of Neuropsychopharmacology 20.8 (2017): 624-633.

[9] Abd-Alrazaq, Alaa, et al. "The effectiveness of serious games in improving memory among older adults with cognitive impairment: systematic review and meta-analysis." JMIR serious games 10.3 (2022): e35202.

[10] Arvanitakis, Zoe, Raj C. Shah, and David A. Bennett. "Diagnosis and management of dementia." Jama 322.16 (2019): 1589-1599.

[11] Nilsson, Lars-GÖRan, et al. "The Betula prospective cohort study: Memory, health, and aging." Aging, Neuropsychology, and Cognition 4.1 (1997): 1-32.

[12] Aydın, Ömer, and Enis Karaarslan. "OpenAI ChatGPT generated literature review: Digital twin in healthcare." Aydın, Ö., Karaarslan, E.(2022). OpenAI ChatGPT Generated Literature Review: Digital Twin in Healthcare. In Ö. Aydın (Ed.), Emerging Computer Technologies 2 (2022): 22-31.

[13] Kleffmann, Markus, Marc Hesenius, and Volker Gruhn. "Connecting UI and business processes in a collaborative sketching environment." Proceedings of the 7th ACM SIGCHI Symposium on Engineering Interactive Computing Systems. 2015.

[14] Peng, Dunlu, Lidong Cao, and Wenjie Xu. "Using JSON for data exchanging in web service applications." Journal of Computational Information Systems 7.16 (2011): 5883-5890.

[15] Rawashdeh, Ahmad, Omar Rawashdeh, and Mohammad Rawashdeh. "ChatGPT and ChatGPT API: An Experiment with Evaluating ChatGPT Answers." Proceedings of the Future Technologies Conference. Cham: Springer Nature Switzerland, 2024.