Digital and Traditional Methods for Addressing Everyday Cognitive Failures: A Focus on Name and Face Recall

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Abstract
Cognitive lapses, which are minor disruptions that interfere with intended actions, are a common occurrence in everyday life. They affect individuals of all health statuses, including both those who are healthy and those with clinical conditions. Existing research in psychology and cognitive science has explored various strategies such as mnemonic devices and memory augmentation systems to address these failures. However, a notable gap in the existing literature pertains to the absence of digital training systems tailored to enhance name and face recall. To address this gap, this research proposes a novel digital training system designed based on the link mnemonic method to improve semantic memory in the case of name-face recall. Using our prototype system, we conducted a between-subject design to compare a traditional voice-based training system and our novel digital training system, both of which employ the same memory-enhancing strategy (i.e., Link mnemonic method). The primary objective of this study is to evaluate and compare the efficacy of these systems in addressing semantic memory lapses associated with forgetting names and faces.

Keywords
Memory augmentation, cognitive lapses, face-name mnemonics

1. Introduction

Everyday cognitive lapses often manifest as moments when the mind encounters temporary obstructions. Surprisingly, studies suggest that these lapses are not necessarily triggered by stress or anxiety; they frequently involve the elusive sensation of having information "on the tip of one's tongue" yet being unable to retrieve it [1]. Memory storage and retrieval are integral components of human cognition, alongside attention management, knowledge acquisition, problem-solving, risk assessment, and decision-making. While modern technology has surpassed human capabilities in numerous tasks, the quest to develop technology that enhances human cognition performance remains an enduring challenge [2].

On the flip side, psychology and cognitive science offer a rich repertoire of strategies proven to enhance cognitive performance, including the ability to store and retrieve information

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from memory. Mnemonics, a renowned approach, involves associating the target memory with something more likely to trigger its recollection. One variant, the Link method, which we will delve into later, has gained prominence. It shares the stage with other mnemonic techniques like the Peg and Loci methods, all of which have found practical applications. For instance, a recent success study involves the integration of the Link method with immersive technologies for vocabulary acquisition [3]. This innovative combination significantly improved the memorization and recall of new words.

In the course of an ordinary day, individuals grapple with various cognitive challenges, often unaware of the strategies that could ease their cognitive burdens. Clinch and Mascolo [2] have explored domains where technology could intervene to offer assistance, highlighting the potential for leveraging evolving technologies to address these challenges effectively. One particularly vexing issue is the inability to recall someone's name—a semantic memory lapse that ranks as the second most common. This lapse can lead to self-embarrassment and inconvenience in various social situations. To the best of our knowledge, there has been a paucity of studies addressing the challenge of forgetting names and faces through an efficient digital training tool that employs the Link mnemonics method. We hypothesize that such a tool could substantially aid individuals in mastering mnemonic systems. In this paper, we explore the digital and traditional methods for addressing everyday cognitive failures, elucidate the identified gap and propose a study design to bridge it.

2. Theoretical Background

The existing literature predominantly emphasizes interventions for individuals with medical memory impairments, addressing a crucial area of research [2, 4]. However, it is also valuable to investigate cognitive processes in healthy populations, as cognitive lapses are pervasive across both healthy and clinical populations [2].

Furthermore, the majority of existing tools primarily emphasize assistance systems, fostering dependence on technology, including those utilizing Computer Vision for face recognition [5]. Remarkably, there is a scarcity of solutions dedicated to memory training and empowering individuals to autonomously apply memory-enhancement techniques. This point is reinforced by Chan's comprehensive argument, as outlined in her memory augmentation systems taxonomy thesis [4]. In the subsequent section, we will delve into this taxonomy and elucidate the mechanics underlying the effectiveness of the Link method.

2.1. Everyday Memory Lapses

Cognitive failures, as introduced by Broadbent et al. in 1982 [6], manifest as disruptions in intended actions, whether they involve mental or physical tasks, indicating a general vulnerability to lapses in cognitive control. Various measures, with the widely used Cognitive Failures Questionnaire (CFQ) at the forefront, gauge an individual's predisposition to cognitive failures, providing valuable insights into the subjective experience of such lapses. The CFQ itself delves into errors stemming from perception, memory, and misdirected actions. A comprehensive explanation of different memory failures can be found in Chan's work [4].

These memory failures encompass retrospective memory, which involves learning from past experiences, including semantic (fact-based), episodic (autobiographical), and procedural (skill-based) memory. In contrast, prospective memory concerns the recall of future plans and intentions. Extensive research has underscored the susceptibility of each of these memory systems to failures, often labelled as everyday instances of forgetfulness [4, 7].

In two diary studies focusing on self-reported memory failures [7, 2], prospective memory lapses were the most prevalent, closely followed by semantic memory lapses. Among prospective memory lapses, common occurrences included the inability to remember the location of objects or the failure to complete tasks like sending emails or purchasing items. However, in the second study, the most frequently reported type of semantic memory lapse was the ”failure to recall someone's name.” Spanning three weeks and involving 14 participants, this study yielded 82 documented semantic failures. An earlier diary study by Terry [8] featured 50 participants reporting memory lapses over several weeks, with 30 incidents of forgotten names recorded, contributing to the taxonomy of memory lapses.

Clinch's study recommends addressing frequently occurring memory failures with technology interventions, aligning with the focus of recent thesis work [4], which concentrates on prospective memory lapses. Chan approaches memory lapses by exploring two primary methods: **internal and external memory aids**. Internal Memory Aids involve mental strategies, like mnemonic techniques, to enhance memory recall. While they reside within our minds, they demand time and effort to employ effectively. External Memory Aids, on the other hand, encompass tangible tools and technologies designed to bolster memory, including digital or analogue calendars, lists, and reminders. They are dependable and user-friendly but may not always be accessible.

Regarding semantic memory lapses, some internal memory aids, such as those advocated by Lorayne [1], have been proposed. A limited number of external tools also exist. In the subsequent section, we aim to summarize efforts made in the realm of semantic memory failures and elucidate the rationale for our focus on the specific case of lapses related to names and faces.

2.2. Internal Aid: Mnemonic Devices

A mnemonic device can be defined as a strategy for organizing and/or encoding information through the creation and use of cognitive cuing structures [9]. The sole purpose of a mnemonic device is to enhance recall performance. As already introduced, some of the most effective mnemonic internal aids are methods such as the Loci method, and the Peg and Link method. According to the classification from 1981 [9], when the mnemonic devices were achieving more and more popularity, they can be classified into 2 main groups: Peg type and Chain type. The sub-categories of the Peg Type are Method of Loci and Peg-word Mnemonic, while the sub-categories of the Chain type are Story Mnemonic and Link Mnemonic.

The method of loci, an ancient mnemonic, was used by Roman orators[10]. It involved memorizing specific locations in a building, associating them with key speech elements as visual images, and mentally traversing these locations during the speech to recall the content. A related mnemonic, the peg-word technique, uses concrete objects as anchors for remembered images, often employing schemes like rhyming or encoding numbers to remember both the peg words and their order (”one is a bun, two is a shoe, three is a tree”). Both the method of loci and peg-word mnemonics, called peg-type mnemonics, yield similar recall results. They provide a cognitive cue structure permanently stored in memory for associating and later recalling information. This cue structure is typically memorized before employing the mnemonic.

The link mnemonic offers an alternative to peg-type mnemonics for remembering lists of items. It involves forming visual associations between each pair of consecutive words in the list, creating a chain of interconnected mental images. A similar mnemonic, the story mnemonic, involves incorporating each word in the list into a self-created story as they are presented. Surprisingly, when recalling the story later, it's not challenging to distinguish which words were part of the original list and which were added to the narrative. The story mnemonic doesn't necessarily emphasize visual imagery, unlike the link mnemonic, but the line between verbal elaboration and visual imagery can be blurry.

In [1], Lorayne, a professional mnemonist, introduces a successful application of the link mnemonic, also known as the *Link Method*, in various scenarios, including the recall of faces and names (Figure 1). The method involves several encoding phases:

1. **Attention:** Focus on both the name and the face.
2. **Feature Selection:** Choose a distinctive feature of the face.
3. **Keyword Association:** Select keywords that phonetically resemble the name.
4. **Integration by visualisation:** Connect the keywords to the chosen facial feature by visualizing the keywords interacting with the feature in a peculiar or eccentric manner.

To later retrieve the name from semantic memory, it's crucial to immediately identify the distinctive facial feature upon seeing the face. This underscores the importance of carefully selecting this feature during encoding. Subsequently, gazing at the distinctive feature triggers the visualization, which, in turn, brings forth the keywords constituting the person's name. Arranging these keywords correctly is essential.

This process isn't straightforward and necessitates practice before proficiency is achieved. As Chan argues, internal aids like this one are readily available but demand time and effort for effective use [4].

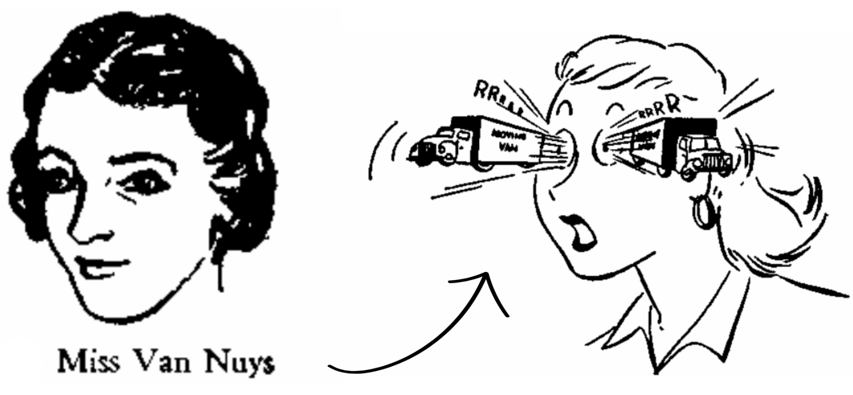

Figure 1: Link Mnemonic: Lorayne's example for Miss Van Nuys using the mnemonics *vans* and *eyes*.

2.3. External Aid: Memory Augmentation Systems

The development of new technologies has always had an effect on human memory. The magnitude and variety of external signals that may be preserved and used to jog one's memory have been profoundly altered by technological advancements. Such transformation is nothing new; throughout history, we have witnessed the shift from oral to written storytelling, from painted to photographed to digital imagery, and from private journals to public social media. However, in the past decade, separate strands of technology have developed to the extent that collectively they open up entirely new ways of augmenting human memory [11]. A memory augmentation system is a technology or set of tools designed to enhance and improve human memory. They are a result of extensive research and innovation in the domain of Human-Computer Interaction (HCI) [4]. The systems are used to support different parts of the memory and help in behaviour change, learning, failing memories, achieving selective recall and many more domains [11].

Memory augmentation systems use a wide range of approaches to support memory. Mainly they can be divided into **training systems and assistance systems**. The training systems are further divided into *process-based* and *strategy-based.* They stem from research in psychology that has developed and studied internal memory aids. The assistance systems are divided into *reminder systems, life-logging systems and just-in-time systems* [4]. They provide memory assistance to the user and have their roots in the idea of the 'memory prosthesis'.

Recent advancements in passive sensing, storage, machine learning, and wearable tech have sparked innovative ideas for enhancing human memory with assistance systems. These concepts go beyond traditional tools, envisioning "memory prostheses" seamlessly augmenting our cognition. While promising improved recall and freed cognitive resources, they also introduce a vulnerability: heavy reliance on this technology may lead to dysfunction when it's absent. In the worst case, it can irreversibly alter cognition, resulting in poorer performance without it, potentially manifesting as memory loss or distortions in remembered events, skills, or knowledge [12]. Conversely, training systems not only avoid the risk of cognitive degradation but can also reduce age-related cognitive decline and lower the risk of cognitive diseases like Alzheimer's [13, 4].

In process-based training, memory exercises are repeated with increasing difficulty depending on the user's performance. Many digital cognitive training programs use the process-based training approach for micro-learning-styled memory training on computers and smartphone applications (apps). Digital strategy-based training systems make mnemonic strategies accessible on the-go and train users to apply these strategies. For example, in the method of loci strategy, individuals mentally associate physical objects (loci) in a familiar location with specific information for easier recall of the information[4]. This strategy has attracted the attention of quite a few researchers as in the Physical Loci [14], vMPeg [15] and NeverMind [16]. The example of vMPeg can be seen in Figure 2.

To the best of our knowledge, there is no training system that would train the users to apply the Link method to the case of name and face recall. Although the systems employing the Loci method can be used to train the semantic memory for encoding and retrieving facts, the Link method stands out as more fitting for encoding names [1]. And since the case of forgetting names and faces is the most occurring semantic failure, it makes sense to address it directly [2].

Lorayne's method was also tested in [17], where the method was *"explained"* to one group of students which performed significantly better than the control group. Implementing a digital training system to mediate this method would offer students a clearer understanding of its application, potentially leading to improved performance. Unlike traditional vocal instructions for mnemonic use, a technology system can simulate the Link method, akin to what has been achieved for the Loci method. While there are various assistance systems dedicated to name-face recall, such as the Google Glass solution [5], the advanced AI face recognition system Vimes [18], the wearable device Pal [19], and "Haven't We Met Before" [20], they come with a notable drawback. Users tend to become highly dependent on these solutions, and regardless of the proficiency of the face-recognition algorithms they employ, they do not bolster human memory. Instead, they can inadvertently encourage memory complacency [12].

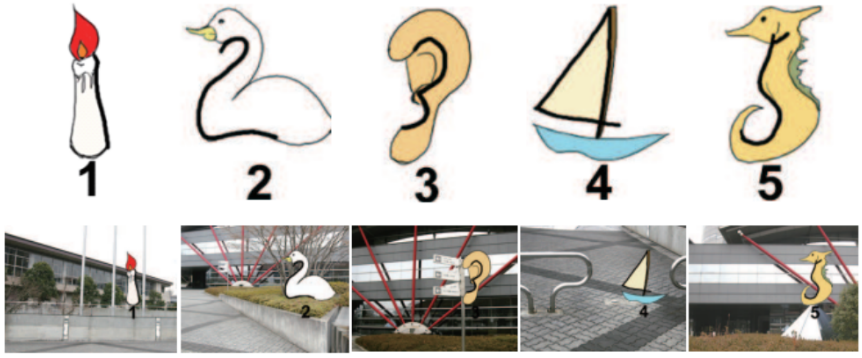

Figure 2: Memory Augmentation System using the Peg mnemonic [15].

3. Proposed Research Method

The link mnemonic method has shown an exceptional efficacy in aiding the recall of face-name associations [1, 17]. Additionally, recognising the well-established advantages associated with strategic training systems [4, 12], we have identified the following gap in current body of literature:

Currently, there is no strategy-based digital training system designed to enhance semantic memory with regard to the retrieval of name-face associations.

Thus, our research aims to bridge this gap by conducting a comprehensive study centered around the following research questions. (RQs):

RQ1: Can a digital training system that facilitates the application of the linked mnemonic method significantly enhance users' proficiency in utilising the mnemonic on their own compared to a conventional voice-instruction-based system?

RQ2: Which system, specifically, the digital adaptation of the link mnemonic or the traditional voice-instruction-based training system, generates higher user satisfaction?

3.1. Study Conditions and Design

We intend to utilize two distinct conditions, each employing a different variation of the representation method (Interface) within the training environment:

(i) A two-dimensional desktop interface that provides voice instructions to simulate the traditional method – voice-based training condition.

(ii) A two-dimensional desktop interface that combines voice-based training with realistic animated visuals – digital training condition.

Visual representations of both conditions can be seen in Figure 4. The study has been structured as a between-subject design.

3.2. Participants

In the initial study, we aim to recruit 50 undergraduate students or young adults aged between 18 and 25. This age range has been selected to address potential age-related biases. Research has suggested that face-name recall tends to decline with age, making age a relevant factor [21]. Participants will be randomly assigned to one of the conditions in the between-subject design. There should be gender balance to avoid potential result biases, as indicated in studies [22].

If the initial study proves successful, we can subsequently replicate it with an older adult cohort. Comparisons can then be made within each age group and between the two age groups, potentially leading to new research questions.

3.3. Protocol

Upon assignment to their respective conditions, participants will be presented with a consent form for signature. Before commencing the training phase, participants will be required to complete the Cognitive Failures Questionnaire (CFQ) [6]. They will be then instructed to watch a short instructional video guiding them on how to use the training application.

Each participant will be provided with a laptop device equipped with the training application. There will be no time constraints, and participants will be tasked with using the application to memorize 10 faces.

Following the completion of the initial training iteration, a post-test will require the participants to use the Link mnemonic on their own. A performance questionnaire will follow asking for names of the people on the provided images.

Participants will also be asked to fill out the Imagery Ability Questionnaire, based on the Ease of Imagination Scale by Ellen and Bone [23]. Subsequently, they will be requested to complete the NASA-TLX Questionnaire [24], the System Usability Scale Questionnaire (SUS) [25], and the User Experience Questionnaire (UEQ) [26].

Two additional training iterations will be conducted, each separated by a one-week interval. In these iterations, the performance questionnaire will include faces from the previous iterations as well.

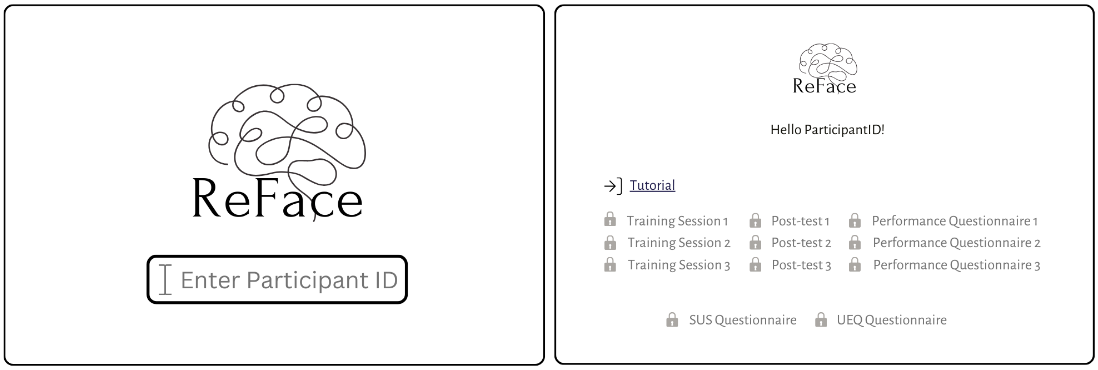

Figure 3: *ReFace*: The desktop prototype for the study, encompassing tutorial, training, post-tests, and questionnaires.

3.4. Data Collection

CFQ would help us provide insights into an individual's cognitive functioning in real-life situations. Participants would respond on a scale from ”never” to ”very often” or from ”not at all” to ”frequently”. The responses are then scored to provide a quantitative measure of cognitive lapses, with higher scores indicating a greater frequency of cognitive failures.

In order to measure the task completion time, the time stamp data (start time and end time) will be logged by the system in both training and post-test. The system will also log the counted numbers of hit and miss during the performance questionnaires.

The Imagery Ability Questionnaire will asses the vividness of the mental image formed, based on the ease of imagination scale by Ellen and Bone [23] by the example of [27]. The participants will need to rate the vividness of the visualisations from the post-test Link mnemonics with five response options: no image at all, vague and dim, moderately clear and vivid, clear and reasonably vivid and perfectly clear.

The NASA Task Load Index (NASATLX) [24] will be used to measure participants' subjective level of mental effort. Participants will rate five of its six dimensions (mental demand, physical demand, temporal demand, effort and frustration) on a 20-point scale ranging from 0 (very low) to 20 (very high). The endpoints of the sixth dimension (own performance) are success and failure. Finally, the overall workload/mental effort will be calculated across these six dimensions.

To measure the usability of the system, we will use the System Usability Scale (SUS), a ten-question questionnaire originally created by Brooke, 1996 [25], on a five-point Likert scale, ranging from “Strongly” agree at 1 to “Strongly disagree” at 5. For measuring the user experience we will use the short version of the User Experience Questionnaire (UEQ-S) [26] with eight items/questions, reported on a 7-point Likert scale. The first four represent pragmatic qualities (Perspicuity, Efficiency and Dependability) and the last four hedonic qualities (Stimulation and Novelty) [26].

4. Proposed Prototype Design

To facilitate the study, we will develop two distinct desktop applications, each corresponding to one of the study conditions. The primary purpose of both applications is to display faces and mimic the Link method. The applications will also incorporate the post-test and performance questionnaire components.

During the training sessions, we will implement all the steps outlined in Lorayne's mnemonic method, as detailed in Section 2.2 of this study. Specifically, users will receive explicit instructions to focus their attention on the names they hear. To present the faces, we are considering two formats: images and video. The latter offers a more immersive and realistic interface.

On the displayed faces, a key feature will be automatically detected and highlighted for the user's attention. Subsequently, appropriate keywords will be generated for each name, aiding in memory retention. In the intervention condition, the visualization of these keywords will be presented. However, this feature will not be available in the control condition.

The applications will be developed using Unity due to its seamless support for object animations, a crucial component of our project.

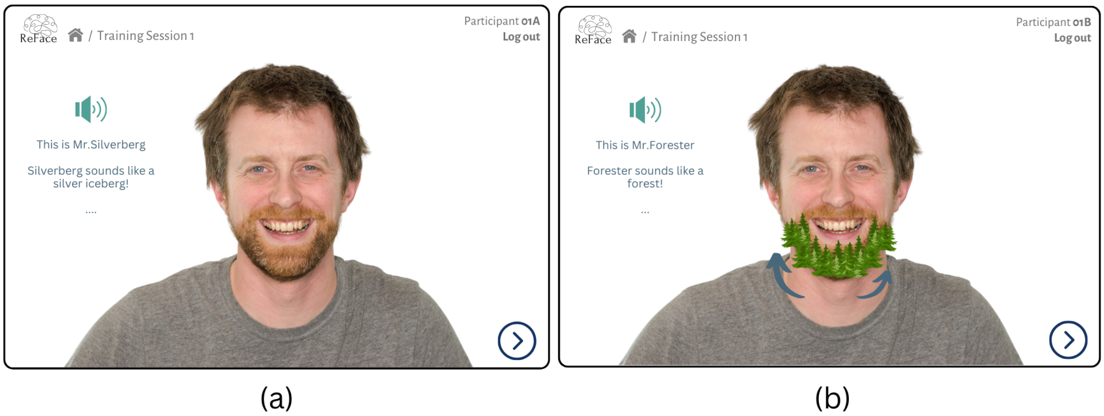

Figure 4: ReFace (a) voice-instructions-based and (b) visualisation-based desktop prototype. Each prototype corresponds to one study condition. In the second prototype we see how Mr. Forester would compound the keyword *forest* and how we can visualise it. In the real prototype the visualisation is animated.

4.1. Voice-based Interface for Training

To replicate the traditional training scenario, where a mnemonic specialist personally explains the method to participants, our plan is to create a 2D desktop application (Figure 4a). This application will incorporate actual images of faces, potentially generated by artificial intelligence, and voice output that mimics the guidance of a specialist. The instructions provided by the virtual specialist will be comprehensive, covering all aspects of the method up to the point of generating visualizations.

4.2. Visualisation-based Interface for Training

In the visualisation condition, the application will provide training to users on the process of generating visualizations (imagery component of the Link method visible in Figure 4b). The objective is to ensure that these augmented visualizations are exceptionally lifelike and precisely align with the prominent facial features. To attain this level of realism and precision, the animated visualizations will be static, meaning they will be pre-generated.

4.3. Post-test Interface

The post-test interface will be identical for all participants, regardless of their assigned condition. Participants will be presented with faces along with their corresponding names. Subsequently, they will be required to independently apply the Link method to remember the names (Figure 5a).

4.4. Performance Questionnaire

During the performance check, only the faces will be displayed to the user (Figure 5b). Their task will be to type in the corresponding names. It's important to note that minor phonetic variations will not be considered as mistakes. The system will record both the time taken to complete the task and the number of names correctly and incorrectly guessed by the user.

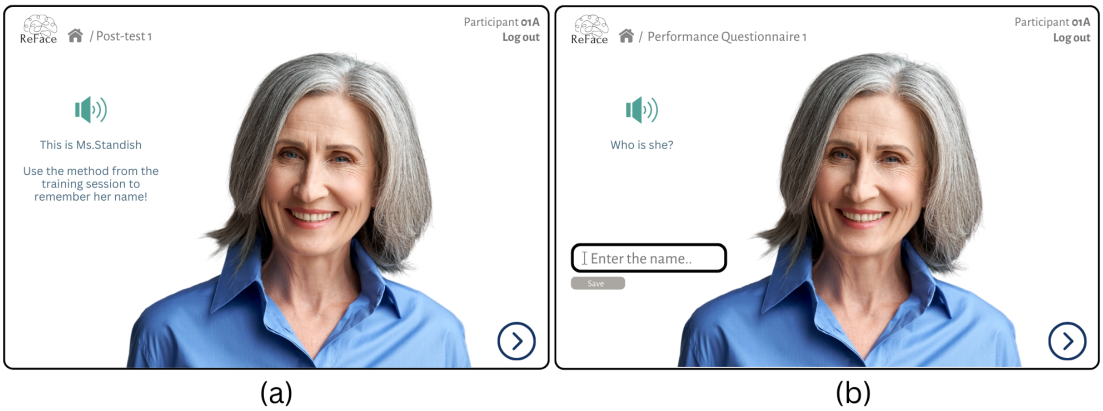

Figure 5: ReFace (a) post-test example and (b) performance questionnaire example. The same samples will be used for both conditions.

5. Conclusion and Future Work

In this research endeavour, we have identified a significant gap in memory training systems, specifically pertaining to the application of the Link method for name and face recall. While various assistance systems exist for name-face recall, including AI-driven solutions and wearable devices, they often inadvertently foster user dependency and do not strengthen human memory. To address this issue, our approach focuses on augmenting human memory through training and mediation of mnemonic methods, offering users a path to self-improvement. Our desktop applications will guide users through the Link method. In contrast to traditional vocal instructions, we envisage a technology system capable of simulating the Link method, paralleling the advancements made for the Loci method. This system would allow students to navigate the method with ease, potentially leading to improved performance.

In terms of future work, we intend to expand the reach of our training system by replicating the study and involving elderly participants. This demographic often grapples with memory-related challenges, and assessing the effectiveness of mnemonic training in this context is of paramount importance. Additionally, we intend to venture into the realm of Augmented Reality (AR) for memory enhancement. In an upcoming study, we would compare the efficacy of our current 2D desktop system with an immersive AR system. In this immersive AR environment, visualizations would be integrated into the user's field of view, on top of someone's face. This shift may offer a more dynamic and engaging training experience, potentially enhancing memory retention. Furthermore, we are intrigued by the idea of empowering users to generate their own visualizations using AI prompts. Allowing users to create personalized mnemonic cues could significantly impact memory retention. This approach provides users with a higher degree of customization and agency in their memory enhancement efforts.

Through these studies, we aim to contribute to the field of memory augmentation systems and technology-mediated memory augmentation.

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