Original Article

# Exploring AI-generated images as memory aids in elderly care:
## A preliminary study

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Abstract
The rapidly aging population in Japan presents significant challenges for elderly care, particularly in enhancing communication and memory retention for individuals with dementia. This preliminary study explores the potential of AI-generated images as memory aids to improve communication between caregivers and elderly individuals. Utilizing a Stable Diffusion AI model, we generated images based on personal episodes and assessed their impact on memory retention and comprehension. Initial experiments with university students highlighted the importance of image relevance and quality, leading to improvements in AI-generated images. Subsequent tests with elderly participants demonstrated that AI-generated images significantly enhanced memory retention and understanding of the episodes compared to text-only descriptions. Our findings suggest that AI-generated images can serve as effective memory aids, facilitating better communication and potentially improving the quality of life for the elderly. This study opens avenues for developing advanced AI-based tools to support caregivers and address the growing needs of an aging society.

Key words
AI-generated images, dementia, elderly care, memory aids, communication enhancement

## 1. Introduction

Aging populations are a significant global phenomenon, with many countries experiencing substantial increases in the number of elderly individuals. As of 2020, the number of people aged 65 and older worldwide reached approximately 727 million, accounting for about 9.3% of the global population (Sabiroh et al., 2022). This number is projected to more than double by 2050, reaching over 1.5 billion, or 16 % of the total population (Norrman, 2023; Bystroff, 2021). This demographic shift poses numerous challenges, particularly in the field of elderly care, where effective communication and memory support are critical issues (Abdi et al., 2019; Butler, 2022; Little and Morley, 2022).

Dementia, a condition characterized by declining cognitive functions such as memory, orientation, and judgment, is prevalent among the elderly. Currently, over 55 million people worldwide are living with dementia (World Health Organization, 2024), and this number is expected to rise to 78 million by 2030 and 139 million by 2050 (Nichols et al., 2022). Dementia not only impacts the patients but also places a considerable burden on caregivers, who often struggle with the complexities of communication and memory support (Giebel, 2020; Lindeza et al., 2024; Queluz et al., 2020; Larson and Stroud, 2021).

Traditional approaches to dementia care have included using physical memory aids and therapeutic activities to stimulate cognitive functions (Pappadà et al., 2021). However, these methods have limitations, particularly in their ability to engage patients effectively and consistently (Lariviere et al., 2021). Recent advancements in artificial intelligence (AI) offer promising new avenues for addressing these challenges (Shokrollahi et al., 2023). While there have been significant advancements in artificial intelligence (AI) and its applications, the direct application of AI-generated images to enhance visual communication and support memory retention in elderly care remains underexplored.

This study seeks to investigate the potential of AI-generated images, created using a Stable Diffusion model, to assist in communication and memory retention for the elderly. By converting verbal episodes into visual representations, we aim to provide a novel approach that could potentially improve the quality of interactions between caregivers and elderly individuals.

The objectives of this research are threefold: first, to develop a method for generating relevant and high-quality images using AI; second, to evaluate the impact of these images on memory retention and comprehension in elderly participants; and third, to assess the potential of AI-generated images to facilitate better communication in elderly care settings.

## 2. Related works

This study investigates the potential of AI-generated images as memory aids for elderly individuals, particularly those with dementia. The following sections summarize key related research in the fields of memory aids and visual communication for dementia care.

### 2.1 SenseCam as an external memory aid

Hodges et al. conducted a study using SenseCam, a wear-

able camera device, to enhance memory retention in individuals with amnesia (Hodges et al., 2006). Their findings showed that photos captured by SenseCam significantly improved the retention of episodic memories, even after extended periods without revisiting the events. The study highlighted the effectiveness of visual cues in maintaining long-term memory, which also facilitated improved communication between a dementia patient and their spouse.

### 2.2 Virtual agent user interface for memory support

Horiuchi et al. (2016) explored the use of a Virtual Agent User Interface (VAUI) combined with memory aids to support individuals with dementia. The VAUI provided interactive, voice-based assistance along with visual and textual information. The study demonstrated that incorporating visual elements like images and subtitles into the interface could make it more effective and user-friendly for dementia patients, thereby supporting their memory and improving their interaction with caregivers.

### 2.3 Individualized memoir videos

Yasuda et al. (2009) examined the impact of individualized memoir videos, which combined personal photos with narration, background music, and visual effects like panning and zooming. Their research found that these videos garnered more attention from dementia patients compared to conventional television programs. The personalized videos proved to be effective in reminiscence therapy, suggesting the potential benefits of personalized visual stimuli in dementia care.

### 2.4 Impact of media types on stress and communication quality

Iwamoto et al. (2015) investigated how different media formats, such as photographs and videos, affected stress levels and communication quality between young individuals and elderly patients. Their study concluded that showing photographs could lead to longer and more meaningful conversations, indicating that visual stimuli can enhance communication and reduce stress in interactions with the elderly.

### 2.5 AI-generated images for memory retention

While previous studies have shown the efficacy of real-life photos and interactive interfaces in supporting memory and communication for dementia patients, the use of AI-generated images remains relatively unexplored. This research aims to fill this gap by assessing whether AI-generated images, which are created based on narrative episodes, can be as effective as traditional photos in aiding memory retention and improving communication in elderly care.

Through these investigations, we seek to determine the potential of AI-generated images as a novel tool for enhancing memory and communication among elderly individuals, thereby contributing to the development of innovative support systems in dementia care.

## 3. Preliminary experiment

### 3.1 AI image creation procedure

#### 3.1.1 Stable diffusion

Since its release in 2022, Stable Diffusion has become widely recognized for its ability to generate images from textual descriptions (Zhang et al., 2023). This study utilized the AUTOMATIC1111 version of Stable Diffusion WebUI to create images. The model, enhanced with the "yayoi_mix" for realistic Asian-style images, was used to generate visuals based on selected episodes (Kotajiro, 2024).

#### 3.1.2 Episode selection

Episodes were selected based on their potential to evoke personal and relatable memories, ensuring they covered a range of emotional and situational contexts common in elderly individuals' lives. The four types of episodes included:

- Family Experiences (EP1): For example, "During my 5th grade summer vacation, my family of four went on a trip to Guam. My father, mother, sister, and I enjoyed snorkeling in the sea."
- Friend Interactions (EP2): For example, "In 3rd grade of middle school, I often played baseball with two close friends during breaks. Despite losing the match, it was a memorable experience."
- Memorable Enjoyable Experiences (EP3): For example, "Immediately after graduating from high school, I went on a class trip with ten classmates to a nature center, where we had BBQ and made fun memories."
- Adverse Experiences (EP4): For example, "In my second year of university, I broke my leg while participating in extracurricular activities and had a long surgery. The pain after the anesthesia wore off made it a very tough experience."

We chose these categories because they represent significant and easily recallable events in most people's lives, which are crucial for testing memory retention. Each episode description was kept under 200 characters in Japanese to maintain simplicity and clarity, facilitating easier recall and communication.

#### 3.1.3 Image generation

The images were generated using a PC with the following specifications:

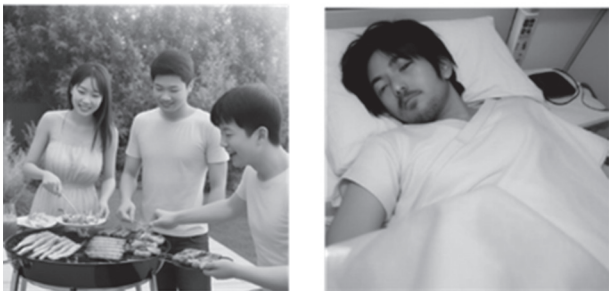
- CPU: 11th Gen Intel Core i7-11700
- Memory: 16GB
- Disk: SAMSUNG MZVL2512HCJQ-00B00
- GPU: NVIDIA GeForce RTX 3060

Stable Diffusion's text-to-image (txt2img) functionality was employed, and specific prompts ensured accurate and relevant image generation.

#### 3.1.4 Generated images

The images depicted in Figure 1 are based on emotionally and situationally rich episodes, which are particularly significant for memory retention, especially in elderly individuals. According to the research (Williams et al., 2022), episodic memories hold the power to bring past experiences into the present, allowing for the recall of detailed experiences and influencing current mood, thoughts, and behaviour. This aligns with the design of the selected episodes ("family memories," "interactions with friends," "enjoyable experiences," and "challenging experiences"), which represent key life events that are disproportionately recalled due to their emotional intensity, as noted in the research on emotional memories.

(a) EP1 (b) EP2



(c) EP3 (d) EP4

Figure 1: Generated images in each episode

### 3.2 Preliminary experiment with students

#### 3.2.1 First experiment

A preliminary experiment was conducted with five university students to evaluate the effectiveness of AI-generated images in aiding memory retention and comprehension. Two sets of episodes were prepared:

- Set A: Episodes 1 and 4 included images, while episodes 2 and 3 did not.
- Set B: Episodes 2 and 3 included images, while episodes 1 and 4 did not.

Participants were given three minutes to memorize the episodes, followed by a brief distraction task involving simple arithmetic. They then answered questions about each episode to assess their memory retention.

(a) Evaluation method:

Participants were given three minutes to memorize the episodes, followed by a brief distraction task consisting of 12 simple arithmetic problems to prevent memory rehearsal of the episodes. They then answered five questions for each episode, with answers scored on a scale of 0 to 2 points per question.

The five questions were as follows:

- Qa1. When did the episode take place?
- Qa2. Where did you go?
- Qa3. How did you get there? (means of transportation)
- Qa4. Why did you go there?
- Qa5. What did you do there?

The scoring was as follows:

- 2 points: The answer exactly describes the episode.
- 1 point: The answer is approximately correct but lacks detail.
- 0 points: The answer is incorrect or not provided.

The maximum score for each episode was 10 points. The average scores and standard deviations were calculated for comparison.

After the experiment, participants completed a questionnaire to provide feedback on their experience. The questionnaire included the following items:

- Qb1. AI images make it easier to remember episodes.
- Qb2. AI images make it easier to understand episodes.
- Qb3. AI images help to associate with episodes.
- Qb4. AI images are appropriate for the episodes.
- Qb5. AI images increase empathy towards the episodes.

Each item was rated on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

(b) Results and Discussion

Initial results showed no significant difference in memory retention between episodes with and without images. Several issues were identified, including the quality and relevance of the generated images, as well as the test format itself. For instance, some images did not accurately reflect the episode content, leading to confusion.

#### 3.2.2 Improvements of Experiment

Based on the findings from the first experiment, we made the following improvements to address specific issues:

(a) Enhanced image quality

- Issue: Some images were of low quality or did not accurately depict the episode content, leading to confusion.

- Improvement: We used the "face restoration" and "high-resolution assist" features to enhance image quality. For example, faces in the images were made clearer and more recognizable, reducing the potential for misinterpretation.

(b) Adjusted prompts
- Issue: Some images did not align well with the episode narratives, causing participants to misremember details.
- Improvement: We refined the text prompts to better match the content of the episodes. For instance, we ensured that the number of people and specific activities in the images accurately reflected the described scenarios.

Figure 2 shows the improved images of each episode generated by Stable Diffusion.

(a) EP1 (b) EP2

(c) EP3 (d) EP4

Figure 2: Improved images of each episode generated by Stable Diffusion

In the preliminary experiment to refine Stable Diffusion prompts, specific improvements were made to enhance the images' relevance and clarity. For EP1, the swimming activity is now clearly depicted. In EP2, the background is a baseball field, indicating the episode relates to baseball. EP3 shows a larger group at the BBQ, highlighting the event's scale. For EP4, the bed is clearly a hospital bed, making the hospitalization evident. Additionally, across all episodes, the unnatural appearance of faces has been reduced.

#### 3.2.3 Second experiment

The improved experiment was conducted again with five university students, using the same episodes and evaluation methods. Participants memorized each episode individually for one minute, followed by the same distraction task and memory test.

(a) Results and discussion

The second experiment showed an improvement in the scores for episodes with images, indicating that higher quality and more relevant images were more effective in aiding memory retention. The average scores for episodes with images were consistently higher than those without.

(b) Questionnaire feedback

Participants completed a questionnaire after the experiment to provide feedback on the effectiveness of the AI-generated images. Most participants found that images helped them remember the episodes better and made the content more engaging.

## 4. Experiment with elderly participants

### 4.1 Participant overview

The experiment was conducted with a group of ten elderly participants, aged between 70 and 85 years old. All participants were recruited from the Kyoto City Silver Human Resources Center and screened to ensure they had no severe cognitive impairments that would preclude them from participating in memory and comprehension tasks. The participants included five males and five females, with varying educational backgrounds and life experiences.

### 4.2 Evaluation method

The evaluation method for the elderly participants was based on the preliminary experiment conducted with university students but adapted to suit the cognitive and physical capabilities of the elderly. The procedure was designed to ensure consistency while accounting for the unique challenges faced by older adults.

#### 4.2.1 Introduction and consent

The Kyoto City Silver Human Resources Center was informed of the details of the experiment, and healthy elderly individuals who voluntarily wished to participate were selected. Prior to the experiment, the study's objectives and procedures were explained again to each participant. It was emphasized that their participation was entirely voluntary, and they were informed that they could withdraw from the experiment at any time without losing their compensation. Additionally, participants were assured that no personally identifiable information would be included in any publications or reports resulting from the study. With these conditions clearly stated, participants gave their informed consent to take part in the experiment.

#### 4.2.2 Training session

A short training session was conducted to familiarize participants with the experiment's flow, including how to

memorize episodes and respond to questions. This session aimed to minimize anxiety and ensure that participants were comfortable with the experimental procedures.

#### 4.2.3 Episode presentation

Participants were presented with a series of episodes printed on papers. Half of the episodes were accompanied by AI-generated images, while the other half were text-only. In total, four pages of episode papers were created for each pattern. In the A pattern, images were attached below the text for episodes EP1 and EP4, while in the B pattern, images were attached below the text for episodes EP2 and EP3. Participants were randomly assigned to either the A or B pattern, and the presentation order was randomized to control for order effects. Each episode was carefully selected to cover common life experiences (family, friends, enjoyable experiences, and adverse experiences) that elderly individuals could relate to, thereby increasing the relevance of the content.

#### 4.2.4 Timing and procedures

Participants were given one minute to memorize each episode. Participants were instructed to accurately memorize the text-based episodes. In cases where images were provided, they were told that they could use the images as memory aids. This was followed by a brief distraction task involving 12 simple arithmetic calculations to prevent rehearsal, lasting approximately one minute. After the distraction task, participants answered five questions (Qa1 to Qa5) regarding each episode, with responses scored on a scale of 0 to 2 points. The questions focused on key details such as time, place, transportation, purpose, and activity. Regarding the memory test, participants were asked to write their answers with a pen on printed sheets containing the questions. No time constraints were imposed for the responses.

#### 4.2.5 Evaluation method

The evaluation method used in this experiment, including the scoring method, was consistent with the approach used in the preliminary experiment.

The scoring method was as follows:

- 2 points: The answer exactly describes the episode.
- 1 point: The answer is approximately correct but lacks detail.
- 0 points: The answer is incorrect or not provided.

The maximum score for each episode was 10 points. Average scores and standard deviations were calculated for comparison between episodes with and without images.

#### 4.2.6 Questionnaire for AI-generated images

Following the memory test, participants were asked to complete a questionnaire (Qb1 to Qb5) evaluating the AI-generated images. They rated items such as how much the images helped them remember and understand the episodes on a 5-point Likert scale. Regarding the questionnaire, participants were asked to write their answers with a pen on printed sheets containing the questionnaire. No time constraints were imposed for the responses.

#### 4.2.7 Data collection and analysis

Data was collected for both the memory test scores and the questionnaire responses. Statistical tests, including t-tests, were conducted to determine the significance of differences in recall performance.

For the questionnaire responses, which included participants' subjective evaluations of the AI-generated images (questions Qb1 to Qb5), a descriptive statistical analysis was performed to summarize the distribution of responses. The responses were rated on a 5-point Likert scale (1: strongly disagree to 5: strongly agree), and the percentage of positive, neutral, and negative responses was calculated for each item. Additionally, chi-square tests were conducted to assess whether there were statistically significant differences in the distribution of responses across the different items. These analyses provided insights into participants' perceptions of the relevance, clarity, and emotional impact of the AI-generated images.

### 4.3 Results

#### 4.3.1 Memory test with and without AI-generated images

Figure 3 shows the average scores for each episode (EP) with and without AI-Generated Images.

- EP1: Both the "w" (with AI-images) and "wo" (without AI-images) groups had a mean score of 9.2. The standard errors were 0.522 for "w" and 0.438 for "wo." There was no significant difference between the groups, indicating that AI-generated images did not impact participant ratings for this episode.
- EP2: The "w" group had a mean score of 8.0 ($SE = 0.283$) while the "wo" group scored 6.8 ($SE = 0.522$). The difference between the groups was significant ($p < 0.05$), suggesting that images enhanced participant ratings.

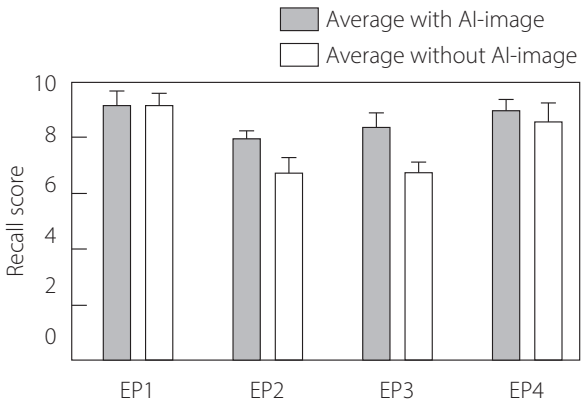



Figure 3: Average scores for each episode

- EP3: The "w" group scored 8.4 ($SE$ = 0.456) and the "wo" group scored 6.8 ($SE$ = 0.335). There was a significant difference between the groups ($p < 0.05$), indicating the images had a positive impact.
- EP4: The mean score for the "w" group was 9.0 ($SE$ = 0.400) and for the "wo" group, it was 8.6 ($SE$ = 0.669). No significant difference was found, suggesting the images had a minimal impact on ratings.

Across all episodes, the "w" groups generally had higher and more consistent ratings than the "wo" groups. The overall significant difference ($p < 0.05$) between "w" and "wo" groups supports the hypothesis that AI-generated images enhance memory and understanding. The standard errors indicate more consistent responses in the presence of images.

Particularly focusing on EP3, when using the unmodified image in Figure 1, the average score of the five students was 8 points without the image and 6 points with the image. However, after using the modified image in Figure 2, the average score was approximately 5 points without the image and 8 points with the image, indicating a reversal in results. A similar result was obtained in an experiment with 10 elderly participants. By depicting the scale of the BBQ party in the image, it can be said that it led to more accurate recall of the episode.

In conclusion, AI-generated images appear to positively influence participant ratings, suggesting that they may serve as effective memory aids. Further research with larger samples and diverse groups is recommended to confirm these findings and explore additional benefits.

#### 4.3.2 Analysis of response categories: Positive, neutral, and negative feedback on AI-generated images in survey responses

Each question was rated on a 5-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree). The responses to each question were categorized into Positive, Neutral, and Negative based on the following criteria:

- Positive: Ratings of 4 or 5
- Neutral: Rating of 3
- Negative: Ratings of 1 or 2

Figure 4 shows the percentage of responses in each category (Positive, Neutral, and Negative) for each question (Qb1 to Qb5). The chart illustrates that Positive responses dominate across most questions.

The observed counts for each category across all questions and participants are:

- Positive: 39
- Neutral: 7
- Negative: 4

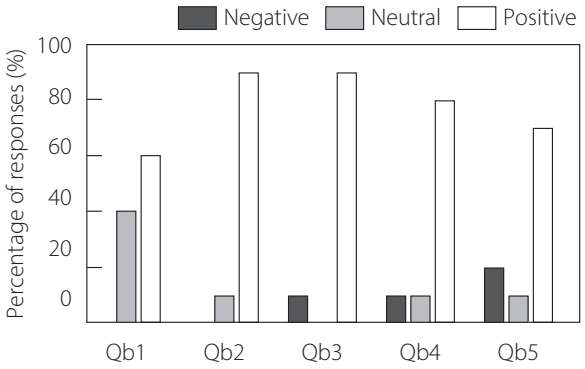



Figure 4: Percentage of the responses to Qb1 through Qb5

To determine if there are significant differences in the proportions of Positive, Neutral, and Negative responses, a chi-square test for independence was conducted. Pairwise chi-square tests were also used to identify which specific pairs of categories exhibit significant differences.

A chi-square test was used to compare the observed frequencies of Positive, Neutral, and Negative responses against the expected frequencies assuming equal distribution. The overall chi-square test for independence showed a significant difference in the proportions of Positive, Neutral, and Negative responses ($\chi^2 = 20.67$, $p < 0.0001$).

To identify specific differences between categories, pairwise chi-square tests were conducted between:

- Positive vs. Neutral
- Positive vs. Negative
- Neutral vs. Negative

This approach aimed to determine if there are significant differences in the distribution of responses across these categories.

(a) Positive vs. neutral
- Chi-square value: 11.13
- P-value: 0.00085 (significant difference)

(b) Positive vs. negative
- Chi-square value: 15.18
- p-value: 0.000098 (significant difference)

(c) Neutral vs. negative
- Chi-square value: 0.046
- p-value: 0.83 (no significant difference)

These results indicate a clear preference among participants for using AI-generated images in understanding episodes. The significant number of Positive responses highlights the strong acceptance and satisfaction with AI-generated images in this context. These findings suggest that AI-generated

images are effective tools for enhancing the understanding of episodes, as they are well-received and positively perceived by the majority of participants.

## 5. Discussions

The results of our study indicate that AI-generated images can significantly enhance memory retention and understanding of personal episodes in elderly individuals. These finding are consistent with previous research on the use of real-life photos as memory aids (Hodges et al., 2006), suggesting that the visual representation of episodic memories can facilitate better recollection and communication. The significant improvements observed in episodes with high emotional content, such as family experiences, may be attributed to the stronger emotional connections these episodes evoke, enhancing memory encoding and retrieval processes.

However, the effectiveness of these images varies depending on the type of episode. For instance, episodes with high emotional content, such as family experiences, showed more substantial improvements compared to others. This finding aligns with research indicating that emotional arousal plays a crucial role in memory processes. According to the article (Tyng et al., 2017), emotional experiences enhance memory encoding and consolidation by activating the amygdala and its interaction with other brain regions. Similarly, the article (Liu et al., 2024) emphasizes that emotionally significant events are more likely to be encoded and stored due to their affective and motivational importance. In addition to emotional significance, these findings highlight the importance of considering both the relevance and clarity of the images used. The study (Buckley and Nerantzi, 2020) discusses how images that are both clear and contextually relevant can significantly enhance understanding and recall. These insights highlight the need for further research to refine the generation of AI images, ensuring both emotional resonance and contextual relevance are maximized.

Future studies should explore the differential impact of various types of episodes and the potential role of emotional salience in memory improvement.

## 6. Limitations

One of the primary limitations of this study is the small sample size, which limits the generalizability of our findings. The student participants and elderly individuals from a single senior center may not be representative of the broader population. Additionally, the quality and relevance of AI-generated images varied, which could have influenced the results. Future research should focus on improving the image generation process and testing these improvements with larger and more diverse samples. Moreover, while our study demonstrated short-term memory improvements, the long-term effects of AI-generated images on memory retention and communication remain to be explored.

## 7. Conclusions

Our preliminary study was conducted with healthy elderly individuals, but its ultimate goal is to explore the potential of AI-generated images as memory aids for individuals with dementia. The results from this study show that AI-generated images can significantly enhance memory retention and understanding of personal episodes in healthy elderly participants. Notably, episodes with high emotional content, such as family memories, showed substantial improvements in recall. These findings align with previous research on real-life photos as memory aids, suggesting that visual representations can support episodic memory recall and improve communication.

However, the study revealed that the effectiveness of AI-generated images varies depending on the type of episode. Emotional engagement appeared to play a crucial role, with episodes that invoked strong emotional responses showing more substantial memory improvement. In addition, the relevance and clarity of the images were critical factors in determining their effectiveness. Well-aligned and high-quality images led to better memory retention compared to less relevant or unclear visuals, reinforcing the need for precision in AI-generated image content.

Although this study was conducted with healthy elderly individuals, the insights gained here lay the groundwork for future research targeting individuals with dementia. The relatively small sample size in this study limits the generalizability of the findings, and further research with larger, more diverse populations is necessary. Additionally, while short-term memory enhancement was demonstrated, the long-term effects of AI-generated images on memory retention remain unexplored. It is also important to consider whether these images could contribute to the improvement of the quality of life (QOL) for elderly individuals, as enhancing memory retention and recall may lead to better communication, increased social engagement, and overall well-being.

Future research should focus on expanding the sample size, examining a wider range of episodes, and investigating the application of AI-generated images to dementia care.

In conclusion, while our current study focused on healthy elderly individuals, it provides a foundation for the eventual application of AI-generated images as memory aids for individuals with dementia. Future studies should refine the image generation process, particularly by considering emotional resonance, clarity, and contextual relevance, to optimize the effectiveness of these images. Additionally, integrating AI-generated images with other assistive technologies may offer a comprehensive approach to improving the quality of life and communication for individuals with dementia, based on the insights gained from this study with healthy elderly participants.

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