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Effects of a Synesthetic Visual Reminiscence Program on Cognition and Empathy in Older Adults

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Abstract

Purpose: This pilot study investigated the effects of a synesthetic visual cue-based reminiscence program on cognitive function and empathic expression in older adults residing in long-term care facilities. **Methods:** A total of eight sessions were conducted with an experimental group (n = 4) receiving a multisensory reminiscence intervention, and a control group (n = 4) receiving standard reminiscence activities. Pre- and post-intervention cognitive function was assessed using the Cognitive Impairment Screening Test (CIST). Empathic expression was evaluated through qualitative observation of verbal and non-verbal behaviors during sessions. **Results:** Compared to the control group, the experimental group demonstrated statistically significant improvements in attention, language, and executive function ($p < .05$). Additionally, participants in the experimental group exhibited increased frequency and intensity of empathic responses, including spontaneous sharing, facial expressions, and gestures. **Conclusion:** The findings suggest that a reminiscence program incorporating synesthetic visual cues may serve as an effective non-pharmacological intervention to enhance both cognitive performance and emotional engagement in institutionalized older adults. Despite the small sample size, results support the feasibility of integrating multisensory strategies into dementia care. Future studies with larger, more diverse samples are recommended to validate and expand upon these findings.

Keywords : Older adults in Care Facilities, Synesthetic Stimulation, Visual Cues, Reminiscence Program, Cognitive Function for Dementia Prevention

JEL Classification Code : I10, I12, I18, I31, J14

1. Introduction

As population aging accelerates, the number of older adults residing in long-term care facilities is steadily increasing. These individuals often experience cognitive decline and emotional withdrawal due to monotonous routines and insufficient stimulation in institutional environments (Cha, 2021; Kang, 2024). In particular, elderly individuals with dementia who have been institutionalized long-term frequently exhibit worsening cognitive function and behavioral issues due to reduced opportunities for self-expression, which imposes a

significant burden on the individual, family members, and caregivers (Jang, 2014).

According to the 2023 National Survey on the Elderly (Korean Statistical Information Service, 2023), 24.6% of Korean adults aged 65 and over exhibited signs of cognitive impairment, and the rate exceeded 30% among those aged 80 and older (Kang, 2024). Such widespread cognitive decline and dementia not only affect the quality of life for older adults but also pose substantial challenges to national caregiving systems and financial resources. Therefore, preventive approaches and early interventions to preserve

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cognitive function are urgently needed.

In this context, reminiscence therapy has emerged as an effective method not only for activating memory in older adults but also for promoting emotional interaction. A systematic review focusing on individuals with dementia found that personalized reminiscence stimuli significantly improved both cognitive functions and emotional responsiveness (Subramaniam & Woods, 2012). Reminiscence activities—by linking past memories with current emotions—have been shown to promote emotional stability, reduce depression, and improve self-esteem. These effects are often amplified when combined with group-based art or activity therapies (Lee & Jang, 2019).

A recent pilot study by Au-Yeung et al. (2024) demonstrated that reminiscence therapy produced stronger prefrontal cortex activation in older adults with mild cognitive impairment compared to cognitive training, suggesting the importance of memory encoding and emotional association in reminiscence stimuli. Similar cognitive responses were also observed in robot-assisted reminiscence interventions, indicating the potential for technological applications of synesthetic approaches.

Meanwhile, there is growing interest in using synesthetic visual cues as a mode of delivering reminiscence stimuli. Synesthesia refers to a neurological phenomenon in which one sensory stimulus triggers another sense; visual stimuli, in particular, have been reported to be effective in activating emotions, memories, and sensory recall (Yoo, 2015). Reminiscence content delivered through virtual reality has also demonstrated meaningful effects in stimulating emotional well-being and memory recall among cognitively impaired elderly individuals, by promoting visual immersion and emotional engagement (Pardini et al., 2025).

Visual cues, such as photographs and illustrations, not only help trigger past memories but also serve as tools for non-verbal communication, especially for older adults with limited verbal capacity (Kim, 2002). Autobiographical memory work that integrates visual stimuli with emotional content may simultaneously enhance immersion and cognitive concentration, eliciting positive psychological responses (Ha, 2018; Ha, 2024). Recent studies have reported that multisensory reminiscence environments (e.g., using music, scents, and visual materials) positively impact emotional expression and cognitive function in people with dementia (Mendrofa et al., 2025).

Most existing research has examined the effects of reminiscence therapy, art therapy, and visual cues independently. However, there is a notable lack of

experimental studies evaluating the combined effects of these interventions from a synesthetic perspective. Moreover, traditional reminiscence programs may lose participants' interest and engagement over repeated sessions, suggesting the need for a more integrated and multisensory approach that can simultaneously stimulate cognitive functions and emotional involvement (Jang & Han, 2025).

Accordingly, this study aims to experimentally examine the impact of a reminiscence program that incorporates synesthetic visual cues on the cognitive function of older adults living in care facilities. By comparing the characteristics of cognitive responses between groups based on the mode of visual stimulus delivery, the study seeks to offer foundational data for developing an integrated reminiscence intervention model suitable for institutional settings.

The purpose of this study is to experimentally verify the effects of a reminiscence program utilizing synesthetic visual cues on the cognitive function and emotional responses of older adults in care facilities. By comparing inter-group differences based on how visual stimuli are presented, the study aims to provide basic evidence for developing an integrated reminiscence intervention model.

To achieve this objective, the following research hypotheses were established.

Hypothesis 1. The experimental group participating in the reminiscence program incorporating synesthetic visual cues will show statistically significant post-intervention improvement in cognitive function compared to the control group receiving general reminiscence stimuli.

- H1-1. Attention scores will show significant improvement.
- H1-2. Language function scores will show significant improvement.
- H1-3. Executive function scores will show significant improvement.

Hypothesis 2. The experimental group will demonstrate a higher frequency of verbal and non-verbal empathic expressions (e.g., facial expressions, gestures, emotionally expressive language) during sessions compared to the control group.

2. Theoretical Backgrounds and Literature Review

2.1. Cognitive Decline in Older Adults and Subdomains of Cognitive Function

As societies enter the era of population aging, cognitive decline in older adults has emerged as a growing social and economic concern. Older adults residing in long-term care facilities are particularly vulnerable to accelerated cognitive deterioration due to repetitive, low-stimulation environments and limited opportunities for social interaction.

Cognitive decline adversely affects overall quality of life by impairing daily functioning, communication, and emotional regulation, thereby necessitating early diagnosis and intervention. Lee (2025) reported that volunteering experience positively influences various subdomains of cognitive function in older adults. During the aging process, cognitive abilities—including attention and executive function—typically decline, and this deterioration negatively impacts language ability as well (Lee et al., 2024).

In this study, the focus is placed on three key subdomains of cognitive function: attention, language function, and executive function. These domains are central components of the Montreal Cognitive Assessment (MoCA) developed by Nasreddine et al. (2005), a tool known for its sensitivity in the early screening of dementia and mild cognitive impairment. Rather than being a singular ability, cognitive function is composed of multiple interrelated domains, and this research concentrates on the following three:

Attention refers to the ability to selectively focus on external stimuli and sustain information over a given period. It is one of the earliest cognitive domains to deteriorate with age and affects overall information processing speed and cognitive efficiency. Language Function encompasses the capacity to comprehend and express language. It is frequently impaired in the early stages of dementia and contributes to reduced social interaction. Declines in attention and executive function are particularly evident in verbal tasks such as naming exercises and become even more pronounced under conditions involving complex stimuli (Lee et al., 2024).

Executive Function involves higher-order thinking skills such as goal setting, planning, problem-solving, and task-switching. It plays a critical role in maintaining autonomy in daily life (Lee & Jung, 2021).

These three cognitive domains (e.g. attention, language function, and executive function)—have been identified as core areas closely related to decision-making capacity and cognitive decline in older adults. They are especially effective as sensitive indicators in the early detection of dementia (Wu et al., 2025). A recent systematic review found that in cognitively healthy adults, these domains were

particularly responsive to dietary interventions and lifestyle modifications (Sultan et al., 2025).

These cognitive subdomains are widely used as key assessment criteria in the screening of dementia and mild cognitive impairment and are frequently utilized as sensitive indicators of intervention efficacy (Nasreddine et al., 2005). Lee, et al. (2022) reported that a remote cognitive play-based program improved cognitive function and emotional stability among older adults in care facilities.

In the present study, the effects of a reminiscence program incorporating synesthetic visual cues will be empirically examined in relation to these cognitive subdomains, with the aim of determining their responsiveness to the intervention.

2.2. Cognitive Effects of Reminiscence Therapy and Synesthetic Visual Stimulation

Reminiscence Therapy (RT) is a well-established psychosocial intervention that encourages individuals to recall past experiences, events, and emotions in order to enhance self-identity and promote emotional stability. This approach has been widely applied to older adults and has been reported to be effective in reducing depression, enhancing self-esteem, improving social interaction, and supporting cognitive function (Lee & Pan, 2025). Kim et al. (2020) demonstrated that a reminiscence-based color therapy program for older adults with mild cognitive impairment (MCI) had positive effects on both cognitive enhancement and emotional stability.

In recent years, increasing attention has been given to the use of synesthetic visual stimulation as a method for delivering reminiscence cues. Synesthesia refers to a neurological phenomenon in which stimulation of one sensory modality automatically and involuntarily triggers a perception in another sensory modality. This is often attributed to cross-activation between sensory pathways (Meier, 2021). Calderone et al. (2025), through a systematic literature review, emphasized that multisensory stimulation can be effective in cognitive rehabilitation for individuals with dementia.

Similarly, Jia and Tung (2024) found that thematic, art-based programs led to improvements in cognitive function and reductions in depressive symptoms in older adults. Another study by Jeong et al. (2022) reported that a memory training program for community-dwelling elderly not only improved memory but also positively influenced subjective health perception and reduced emotional distress (e.g., Hwabyeong).

The integration of synesthetic stimuli into reminiscence therapy holds particular significance, as it may enhance emotional engagement and memory recall. Typical forms of synesthetic visual cues include photographs, illustrations, posters, and short video clips from the past. These visual materials increase immersion in reminiscence activities and help elicit emotional responses, thereby contributing to cognitive activation (Yoo, 2015). When autobiographical memories and emotions are visually reactivated, multiple cognitive domains—such as attention, memory, language, and executive function—are stimulated simultaneously. This multimodal engagement may lead to deeper levels of cognitive processing compared to unimodal stimulation (Ha, 2024).

Recent neuroimaging studies also support this approach, showing that integrated sensory stimuli can activate core cognitive regions of the brain, including the hippocampus and prefrontal cortex. These findings provide empirical support for the effectiveness of reminiscence-based cognitive interventions.

2.3. The Concept of Empathy and Its Clinical Operationalization

Empathy is defined as the ability to understand and emotionally respond to the emotions, thoughts, and experiences of others. It is commonly conceptualized as comprising two core components: cognitive empathy and emotional empathy. Cognitive empathy refers to the capacity to recognize and interpret the emotional states of others, while emotional empathy involves affective resonance—the ability to emotionally respond to and share in another person's emotional experiences.

Although these two components share overlapping neural substrates, they rely on distinct cognitive processes: mentalization for cognitive empathy and emotional contagion for emotional empathy (Plieger et al., 2025). Lee and Pan (2025) reported that a synesthetic virtual reality-based reminiscence therapy significantly improved cognitive functions—particularly attention and executive function—in older adults. Similarly, Dolcos et al. (2025) conducted a comprehensive EEG-based review on how neurocognitive markers of cognitive and emotional empathy shift with aging during emotional processing.

In later life, social isolation and experiences of loss become more frequent, making empathic interactions critical for psychological stability and the maintenance of self-identity.

Table 1: Comparison of Previous Studies & Present Study

In reminiscence therapy, empathic responses are naturally elicited through emotional sharing and interactive engagement among participants. These empathic exchanges serve as important indicators for assessing the emotional effectiveness of the program. Prior studies have shown that reminiscence programs for older adults can foster emotional stability and a sense of ego-integrity by encouraging empathic engagement and emotional sharing (Nam, et al., 2011). In the present study, empathy is operationally defined as the frequency and intensity of verbal and non-verbal expressions elicited in response to others' reminiscence stimuli during each session. Specifically:

- Verbal responses were categorized as spontaneous sharing of personal experiences and the use of emotionally expressive language.
- Non-verbal responses included changes in facial expression, nodding, crying, and physical gestures.

These responses were recorded using session-end observation logs and semi-structured rating sheets completed by facilitators, providing a methodologically sound approach with both quantitative measurability and clinical validity. Accordingly, in this study, empathy is considered a qualitative indicator of emotional engagement and interpersonal responsiveness, and it is used as a supplementary index for evaluating both the immersiveness and emotional meaningfulness of the reminiscence program.

2.4. Review of Related Previous Studies

Numerous prior studies have reported that reminiscence therapy has positive effects on cognitive function and emotional stability in older adults. For instance, Mendrofa et al. (2025) developed a multisensory stimulation environment based on reminiscence therapy for individuals with dementia and demonstrated its effectiveness in enhancing quality of life through qualitative analysis. Similarly, Mao et al. (2024) conducted a systematic review showing that virtual reality-based reminiscence therapy had beneficial effects on both cognitive functions and emotional responses in older adults with cognitive decline.

Han and Kim (2024) found that music-based reminiscence interventions promoted memory recall and cognitive stimulation in both cognitively impaired and healthy older adults, while also contributing to emotional well-being. Go (2022) (2022) suggested that song-based reminiscence activities may induce positive emotions and stimulate both cognitive and emotional responses in individuals with mild neurocognitive disorder.

Category	Mendrofa et al., 2025	Mao et al., 2024	Pardini et al., 2025	Present Study
Intervention Stimuli	Multisensory stimulation environment	VR-based reminiscence stimuli	VR with integrated audiovisual and tactile stimuli	Reminiscence program using synesthetic visual cues
Level of Sensory Integration	Partial (mainly visual and auditory)	Primarily visual	Visual, auditory, and tactile integration	Full multisensory (visual, auditory, tactile, olfactory)
Participants	Older adults with dementia	Older adults with cognitive decline	Patients with Parkinson's disease and MCI	Long-term care residents with dementia
Evaluation Variables	Quality of life, emotional expression (qualitative)	Cognitive function, emotional response	Changes in cognitive function	Attention, language function, executive function, empathic expression
Analytical Approach	Primarily qualitative	Systematic literature review (qualitative summary)	Quantitative statistical analysis	Mixed-method: quantitative + qualitative analysis
Observation of Empathic Responses	Limited	Not included	Not included	Coded analysis of verbal/non-verbal empathic expressions
Research Design	Qualitative case study	Systematic review	Single-group experimental design	Quasi-experimental design (experimental vs. control group)

Pardini et al. (2025) reported that multisensory virtual reality reminiscence therapy—which integrated visual, auditory, and tactile stimuli—yielded significant improvements in cognitive function among patients with Parkinson's disease and mild cognitive impairment (MCI). Moreover, synesthetic stimuli were shown to activate multisensory integration regions in the brain (Fritz et al., 2025). Separately, Tok et al. (2025) demonstrated that forum theatre was an effective intervention for promoting attitude change toward the elderly.

Many of the existing studies on reminiscence therapy have focused primarily on single-sensory stimuli such as music, photographs, or videos, and often limited their analyses to quantitative outcomes related to cognitive function. In contrast, relatively few studies have conducted systematic analyses of empathic responses or emotional interactions that occur during reminiscence sessions using structured observational frameworks.

Accordingly, this study sought to address the limitations of traditional reminiscence therapy, which often relies on single-sensory stimuli, by applying a reminiscence program incorporating synesthetic visual cues. In addition to evaluating cognitive functions, the study also collected and analyzed observational data on emotional responses, particularly empathic expressions (both verbal and non-verbal). This approach offers a distinct contribution to the existing literature by providing foundational evidence for an

integrated analysis that considers both the cognitive and emotional effects of reminiscence therapy.

3. Research Materials and Methods

3.1. Research Design and Participants

This study was conducted as a small-scale pilot study designed to explore the preliminary effectiveness of a reminiscence program utilizing synesthetic visual cues. A mixed-method design with a quantitative emphasis was employed, involving pre- and post-intervention cognitive assessments with two groups: an experimental group (n=4) and a control group (n=4) of older adults. In addition, verbal and non-verbal empathic expressions observed during the sessions were qualitatively analyzed to complement the quantitative findings.

The participants were long-term residents with dementia at an S nursing hospital located in City C, Gyeongsangnam-do, South Korea. As shown in Table 2, participants were selected based on the following criteria: evidence of cognitive decline but with the ability to engage in daily activities independently, and voluntary consent after being informed of the study's purpose and procedures. Initially, six participants were recruited for both the experimental and control groups. However, due to early discharge or temporary health issues (e.g., cold symptoms), the final

sample consisted of eight participants—four in the experimental group and four in the control group.

To complement the limitations of quantitative analysis, the study incorporated post-session affective observation methods, recording participants' non-verbal and verbal emotional reactions following each session. These included facial expressions, gestures, and emotionally expressive language, and were used as qualitative data to enhance the interpretative depth and support the reliability of statistical results. This approach aligns with the work of Subramaniam & Woods (2014), who emphasized the value of qualitative interpretation in reminiscence therapy interventions.

By adopting a small-scale experimental-control group pilot design, the study focused on observing empathic expressions and emotional responses throughout the intervention sessions. This mixed-method approach, integrating both quantitative and qualitative perspectives, is consistent with recent methodological frameworks proposed in related studies (Foo et al., 2024; Pollak et al., 2025).

Table 2: General Demographic Characteristics of Experimental and Control Group Older Adults (Female, N=8, as of January 2025)

Group	Age (Years)	Education Level	Length of Stay (Months)
Experimental 1	85	No formal Education	24
Experimental 2	89	Middle school Graduate	19
Experimental 3	66	Elementary school graduate	29
Experimental 4	62	Incomplete elementary school	12
Control 1	82	No formal education	29
Control 2	88	Middle school Graduate	17
Control 3	90	No formal Education	12
Control 4	86	No formal education	20

Note: All participants were female residents of a long-term care facility with varying levels of education and durations of institutionalization. The data were collected in January 2025.

All participants completed pre- and post-intervention cognitive assessments using the Korean version of the Cognitive Impairment Screening Test (CIST). Scoring was conducted by co-evaluators who had completed training provided by the principal investigator.

3.1.1. Intervention Content

The experimental group participated in a reminiscence program that utilized synesthetic visual stimuli designed by Ha (2024). The materials were centered around a thematic background image titled “The Most Precious and Cherished Version of Myself in This World,” specifically designed to visually evoke autobiographical memories in older adults. The program consisted of eight sessions (twice per week, 40–50 minutes per session), and each session included image-based reminiscence, visual and tactile stimulation activities, and the provision of multisensory materials, forming an integrated synesthetic approach.

In contrast, the control group engaged in a parallel eight-session program using “Nostalgic Play Coloring Book” by Hwang (2023). This commercially available material is based on visual stimuli only and includes themes such as maternal nostalgia, childhood memories, and intergenerational bonding. No synesthetic or multisensory elements were provided to the control group.

This intervention extends the approach of Kim et al. (2020), who used visual-based reminiscence color therapy, by incorporating not only visual but also tactile and auditory stimuli into a synesthetic reminiscence program. The design is also aligned with Jung et al. (2010), who implemented a multisensory stimulation program for dementia prevention, integrating various sensory modalities such as sight and touch into reminiscence activities.

3.1.2. Ethical Considerations

Given the nature of this intervention study involving individuals with dementia, the research was conducted with full cooperation from the long-term care hospital administration. Informed consent was obtained from all participants and their legal guardians prior to participation. All procedures were carried out in strict compliance with ethical guidelines and research ethics protocols.

3.2. Research Design

As shown in Table 3, this study employed a quasi-experimental design, specifically a non-equivalent control group pretest-posttest design. The independent variable was the reminiscence program incorporating synesthetic visual cues, and the dependent variable was the participants' cognitive function scores.

Table 3: Research Design for the Application of the Reminiscence Program

Group	Pretest	Intervention	Posttest
Experimental	O ₁ (Cognitive Function)	X (Reminiscence Program with Synesthetic Visual Cues)	O ₂ (Cognitive Function)
Control	O ₃ (Cognitive Function)	None	O ₄ (Cognitive Function)

Note:

X: Reminiscence program incorporating synesthetic visual cue stimuli

O₁, O₃: Pre-intervention cognitive function assessments

O₂, O₄: Post-intervention cognitive function assessments

A pretest was conducted to assess the baseline homogeneity of cognitive function between the two groups, and it confirmed that both groups were initially comparable. The intervention program was then applied only to the experimental group, followed by a posttest for both groups. The detailed structure of the research design is presented in the table below.

To test the hypotheses of this study, two groups—the experimental group and the control group—were selected based on similar levels of cognitive function, as determined by the results of the pre-intervention cognitive assessment. A homogeneity test was conducted to confirm that the two groups did not differ significantly in their baseline cognitive function. Following this, the experimental group received the reminiscence program incorporating synesthetic visual cues. Upon completion of all intervention sessions, post-intervention cognitive assessments were administered to both groups to evaluate the effectiveness of the intervention.

This study’s design was informed by the non-equivalent

control group pretest-posttest design used in the study by Hong et al. (2015), which confirmed the effectiveness of reminiscence therapy. Similarly, in line with Kim (2014), the current study adopted a non-equivalent control group design to objectively verify the impact of the intervention.

3.3. Research Instruments

3.3.1. Cognitive Impairment Screening Test (CIST)

To measure changes in cognitive function among older adults, this study employed the Cognitive Impairment Screening Test (CIST) as both the pre- and post-intervention assessment tool. The CIST was developed to address the limitations of the existing MMSE-DS (Mini-Mental State Examination for Dementia Screening) and is currently used as a standard dementia screening instrument at dementia care centers in South Korea. It is characterized by its ease of use and high discriminative validity for detecting cognitive decline (Ministry of Health and Welfare, 2025).

The CIST consists of 13 items, with a maximum score of 30 points, and evaluates multiple cognitive domains, including orientation, memory, attention, visuospatial ability, language, and executive function. Higher scores indicate better cognitive functioning. Based on diagnostic referral criteria provided by the Ministry of Health and Welfare (2025), results are classified into categories such as "normal" or "suspected cognitive impairment." The test takes approximately 10 minutes to complete and is administered in a one-on-one, face-to-face format. Normative standards are applied differentially based on chronological age and educational level.

Table 4: CIST Referral Cutoff Scores by Age & Education Level

Age Group*	Illiterate	No Formal Education / Literate ≤5 Years	(Elementary)6–8 Years	(Middle School) 9–11 Years	(High School) 12–15 Years	(College or Higher) ≥16 Years
50–59 yrs	–	–	22	24	26	27
60–69 yrs	–	16	21	23	25	26
70–79 yrs	13	14	19	22	22	25
80–89 yrs‡	10	11	16	18	28	22

Note:

Individuals scoring below the cutoff for their age and education level should be referred for diagnostic testing.

Age is based on chronological age (international age).

‡ For individuals aged 90 and above, the 80–89 age group standard is applied. Source: Ministry of Health and Welfare, National Institute of Dementia (2025). CIST Administration Manual.

The CIST may only be administered by individuals who have completed the required training provided by the

National Institute of Dementia, and it is implemented at dementia safety centers, public health clinics, or designated partner hospitals, following standardized procedures. The specific cognitive subdomains assessed in this study are

presented in Table 5.

Table 5: Cognitive Domains and Component Items of the Cognitive Impairment Screening Test (CIST)

Cognitive Domain	Subdomain	Description
Orientation	Time	Assesses awareness of the current date
	Place	Assesses awareness of the current location
Memory	Immediate Recall	Evaluates the ability to register key information
	Delayed Recall	Assesses storage and retrieval of verbal information
	Recognition	Evaluates the influence of cues on retrieving stored verbal information
Attention	Digit Span Forward	Assesses auditory attention and attentional span
	Digit Span Backward	Assesses auditory attention and working memory
Visuospatial Ability	Figure Copying	Assesses perception and construction based on visual stimuli
Language Function	Naming	Evaluates face recognition and naming ability
	Comprehension	Assesses understanding of spoken language
Executive Function	Visual Reasoning	Assesses reasoning using visual stimuli
	Verbal Reasoning	Assesses reasoning using verbal stimuli
	Fluency	Evaluates productivity and cognitive flexibility

Source: Ministry of Health and Welfare, National Institute of Dementia. CIST Administration Manual (2025)

3.3.2. Cognitive Stimulation Program Using Synesthetic Visual Cues

In this study, a cognitive stimulation program incorporating synesthetic visual cues was developed and implemented for older adults residing in a long-term care facility. For the experimental group, the program was adapted from the Memory Latte Sketchbook developed by Ha (2024) and modified to align with the objectives of this study. For the control group, a commercially available

coloring book titled Nostalgic Play Coloring Book by Hwang (2023) was used.

Both groups participated in a total of 8 sessions, held once a week for 40 minutes per session. Pre- and post-intervention assessments were conducted using the Cognitive Impairment Screening Test (CIST) to evaluate changes in cognitive function. The detailed structure of each session is presented in Table 6.

Table 6: Structure of the Reminiscence Program Using Synesthetic Visual Cues (Experimental Group)

Session	Theme	Activity Description	Expected Outcomes	Materials	Synesthetic Visual Cues (Five Senses)
Pre-test Cognitive screening (CIST)				Test sheet, clock, writing tools	-
1	Lullaby in Mother's Arms	<ul style="list-style-type: none"> Explore illustrations in workbook Multisensory activity: applying stickers (e.g., ribbon, dragonfly, butterfly) Coloring while reminiscing about being in mother's arms 	Emotional bonding, memory recall, orientation	Stickers (ribbon, dragonfly, etc.), lullaby audio	Auditory, visual, tactile
2	Healing Hands of Mom	<ul style="list-style-type: none"> Explore illustrations Multisensory activity: scratching back with massager, smelling handkerchief Coloring while recalling mother's hands 	Object recognition, language, executive function	Massager, handkerchief, stickers, song	Visual, tactile, auditory, olfactory

3	By the Stream	<ul style="list-style-type: none"> · Explore illustrations · Multisensory activity: catching toy fish with fishing rod · Coloring while recalling fishing in the stream 	Attention, memory, language, visuospatial, executive function	Toy fishing set, children's song	Visual, tactile, auditory, olfactory
4	Playing Jacks	<ul style="list-style-type: none"> · Explore illustrations · Multisensory activity: playing jacks, listening to traditional song · Coloring while recalling playing jacks with friends 	Memory recall, object recognition, orientation, language	Jacks toy, children's song	Visual, tactile, auditory
5	Bubble Blowing	<ul style="list-style-type: none"> · Explore illustrations · Multisensory activity: blowing toy horn · Coloring while recalling blowing bubbles and playing 	Attention, language, executive function	Horn toy	Visual, tactile, auditory, gustatory
6	Pretend Play 1	<ul style="list-style-type: none"> · Explore illustrations · Multisensory activity: playing pretend games, listening to songs · Coloring while recalling childhood pretend play 	Memory recall, object recognition, attention, language, visuospatial, executive function	Toy kitchen set, songs	Visual, tactile, auditory, olfactory
7	Pretend Play 2	<ul style="list-style-type: none"> · Explore illustrations · Multisensory activity: role-playing (e.g., mother-father), listening to traditional songs · Coloring while recalling role-play 	Same as above	Toy kitchen set, traditional/folk songs	Visual, tactile, auditory, olfactory
8	Korean Folk Music Play	<ul style="list-style-type: none"> · Explore illustrations · Multisensory activity: playing janggu and sogo drums · Coloring while recalling village festival and folk performances 	Object recognition, flexibility, fluency, perception, language, executive function	Janggu, sogo drums	Visual, tactile, auditory, olfactory
Post-test Cognitive screening (CIST)				Test sheet, clock, writing tools	–

3.3.3. Operational Definition and Observation Criteria for Empathy

In addition to cognitive function, this study also observed and analyzed participants' emotional responses, specifically their empathic reactions, as part of the outcome measures. Empathy was operationally defined as follows. In this study, the criteria for observing empathic responses were based on the verbal and non-verbal components of empathy as proposed by Kim and Kim (2017), including their operational definitions.

Empathy was defined as the frequency and intensity of both verbal responses (e.g., spontaneous sharing of personal experiences, emotional expressions) and non-verbal responses (e.g., changes in facial expression, gestures) displayed by participants in reaction to others' emotional reminiscence cues during each session. These responses were recorded through observation logs and semi-structured ratings by the program facilitators.

According to Zaki's (2014) theory of empathy, empathy goes beyond passive emotional resonance and involves conscious, motivated cognitive and behavioral responses, which are observable through both verbal and non-verbal behaviors. The empathic response data collected in this

study were used as qualitative indicators to supplement the interpretation of quantitative findings and served as auxiliary analytical data to assess participants' levels of emotional engagement.

3.3.4. Data Processing and Statistical Analysis

To analyze the effects of synesthetic visual cues on cognitive function in older adults residing in long-term care facilities, this study utilized the SPSS Statistics 29.0 software.

First, an independent samples t-test was conducted to verify the baseline homogeneity between the experimental and control groups based on the pre-intervention cognitive assessment scores. Following the completion of the program, another independent samples t-test was performed to analyze differences in cognitive function outcomes between the two groups, based on the post-intervention test results. The same analysis was applied to the cognitive subdomains—attention, language function, and executive function.

In cases where the sample size was small and the assumption of normality was not met for some variables, the Mann–Whitney U test, a non-parametric statistical method,

was also employed to enhance the reliability of the results.

This approach follows that of Cha (2016), who also applied the Mann–Whitney U test in studies involving small samples and non-normal distributions. Similarly, as demonstrated in Gil et al. (2022), this study used a non-parametric method suitable for quasi-experimental designs with small samples to ensure statistical validity.

This dual approach was adopted to compensate for the small sample size and the non-normal distribution of the data, thereby improving the statistical rigor of the findings. For each variable, the mean (M) and standard deviation

3.3.5. Data Processing and Statistical Software

To analyze the effects of synesthetic visual cues on the cognitive function of older adults in a long-term care facility, this study utilized SPSS version 29.0. First, an independent samples t-test was conducted to verify the homogeneity of cognitive function between the experimental and control groups based on the pre-test scores.

Following the completion of the intervention program,

post-test results were analyzed using independent samples t-tests to compare cognitive changes between groups. This analysis was also applied to the subdomains of cognitive function—attention, language, and executive function.

In cases where the sample size was small or the assumption of normality was not met for certain variables, the non-parametric Mann–Whitney U test was additionally employed to enhance the reliability of the results. Consistent with Cha (2016), this study used the Mann–Whitney U test as a supplementary method for small samples and non-normally distributed data. As in the quasi-experimental study by Gil et al. (2022), the Mann–Whitney U test was selected to ensure statistical validity under small sample conditions.

This approach was deemed appropriate to account for both the small sample size and the non-normal distribution of some data, thereby increasing the overall statistical validity of the findings. For each variable, means (M) and standard deviations (SD) were calculated, and the level of statistical significance was set at $\alpha = .05$.

Table 7: Research Hypotheses and Corresponding Statistical Analyses

No.	Hypothesis	Statistical Method	Notes
Hypothesis 1	The experimental group participating in the reminiscence program with synesthetic visual cues will show significantly higher post-intervention cognitive scores compared to the control group.	Mann–Whitney U test	- Comparison of total post-test cognitive scores - Non-parametric test used due to possible violation of normality assumption
H1-1	Attention scores will show a significant improvement.	Mann–Whitney U test	- Comparison of post-test scores for cognitive subdomains
H1-2	Language function scores will show a significant improvement.	Mann–Whitney U test	- Comparison of post-test scores for cognitive subdomains
H1-3	Executive function scores will show a significant improvement.	Mann–Whitney U test	- Comparison of post-test scores for cognitive subdomains
Hypothesis 2	The experimental group will demonstrate a significantly higher frequency of verbal and non-verbal empathic responses during sessions compared to the control group.	Mann–Whitney U test or Independent t-test	- If empathy scores are quantified using rating scales, t-test may be used as a supplementary analysis - Requires observational logs and evaluation criteria

Prior to statistical analysis, the normality of distribution for each variable was assessed. The Shapiro–Wilk test was used to verify the normality assumption for each variable.

As a result, the attention variable met the assumption of normality. However, the language function and executive function variables did not satisfy the normality assumption, and thus the non-parametric Mann–Whitney U test was applied for those variables.

Cognitive Subdomain Variables

Variable	Shapiro–Wilk p-value	Normality
Attention	0.144	Normality assumed
Language Function	0.029	Normality not Assumed
Executive Function	0.017	Normality not assumed

Note: A p-value less than 0.05 indicates a violation of the normality assumption.

Table 8: Shapiro–Wilk Test Results for Normality of

4. Research Results and Discussion

4.1. Homogeneity Test Between Groups

A pretest was conducted to verify the homogeneity of cognitive function between the experimental group and the control group, prior to the application of the reminiscence program incorporating synesthetic visual cues. The results are presented in Table 9.

Table 9: Homogeneity Test Results for Pre-Intervention Cognitive Function Between Experimental and Control Groups

Cognitive Subdomain	Group	N	Mean	SD	t	p
Orientation	Experimental	4	2.50	1.73	0.926	0.390
	Control	4	1.50	1.29		
Memory	Experimental	4	1.25	1.26	-0.485	0.645
	Control	4	2.50	5.00		
Attention	Experimental	4	1.50	0.58	0.655	0.537
	Control	4	1.25	0.50		
Visuospatial Ability	Experimental	4	1.00	1.15	1.192	0.298
	Control	4	0.25	0.50		
Language Function	Experimental	4	3.00	0.82	0.655	0.537
	Control	4	2.50	1.29		
Executive Function	Experimental	4	0.75	0.96	-0.926	0.390
	Control	4	1.25	0.50		

Note: Independent samples t-tests were used to assess pre-intervention homogeneity between groups across all cognitive subdomains. No statistically significant differences were found ($p > .05$).

The mean scores for orientation were similar between the experimental group ($M = 2.50$) and the control group ($M = 1.50$), with no significant difference ($t = 0.926, p > .05$). For memory, the experimental group ($M = 1.25$) and the control group ($M = 2.50$) also showed similar means, with no significant difference ($t = -0.485, p > .05$). In attention, both groups had comparable mean scores (experimental group $M = 1.50$, control group $M = 1.25$), and the difference was not statistically significant ($t = 0.655, p > .05$).

Regarding visuospatial ability, the experimental group ($M = 1.00$) and the control group ($M = 0.25$) showed no significant difference ($t = 1.192, p > .05$). In language function, the mean scores were close (experimental group $M = 3.00$, control group $M = 2.50$), with no statistically significant difference ($t = 0.655, p > .05$). For executive function, the experimental group ($M = 0.75$) and the control group ($M = 1.25$) also showed no significant difference ($t =$

$-0.926, p > .05$).

In conclusion, no statistically significant differences were found between the experimental and control groups in any of the cognitive domains, indicating that the two groups were homogeneous at baseline.

4.2. Effects of Synesthetic Visual Cues on Cognitive Function

4.2.1. Independent Samples t-Test Analysis

4.2.1.1. Changes in Orientation

We examine the effect of synesthetic visual cues on orientation in older adults residing in long-term care facilities, an independent samples t-test was conducted on the post-test scores of the experimental and control groups.

As shown in Table 10, the experimental group ($M = 3.75, SD = 0.96$) had a slightly higher mean score than the control group ($M = 2.75, SD = 1.71$); however, this difference was not statistically significant ($t = 1.022, p = .346$).

This result suggests that the provision of synesthetic visual cues did not have a statistically significant effect on improving orientation.

Table 10: Comparison of Post-Test Orientation Scores Between Experimental and Control Groups

Cognitive Subdomain	Group	N	Mean	SD	t	p
Orientation	Experimental	4	3.75	0.96	1.022	.346
	Control	4	2.75	1.71		

Note: Independent samples t-test. No statistically significant difference was observed ($p > .05$).

4.2.1.2. Changes in Memory

To examine the effect of synesthetic visual cues on memory in older adults residing in long-term care facilities, a comparison was made between the post-test memory scores of the experimental and control groups.

As shown in Table 11, the results of the independent samples t-test revealed no statistically significant difference between the experimental group ($M = 7.00, SD = 2.71$) and the control group ($M = 4.00, SD = 4.90$), ($t = 1.072, p = .325$).

This suggests that the provision of synesthetic visual cues did not produce a statistically significant improvement in memory.

Table 11: Comparison of Post-Test Memory Scores Between

Experimental and Control Groups

Cognitive Subdomain	Group	N	Mean	SD	t	p
Memory	Experimental	4	7.00	2.71	1.072	.325
	Control	4	4.00	4.90		

Note: Independent samples t-test. No statistically significant difference was found ($p > .05$).

4.2.1.3. Changes in Attention

To analyze the effect of synesthetic visual cues on attention among older adults in long-term care facilities, a comparison of post-test attention scores between the experimental and control groups was conducted.

As shown in Table 12, the experimental group ($M = 2.75$, $SD = 0.50$) scored significantly higher than the control group ($M = 1.50$, $SD = 0.58$), and the difference was statistically significant ($t = 3.273$, $p < .05$).

Table 12: Comparison of Post-Test Attention Scores Between Experimental and Control Groups

Cognitive Subdomain	Group	N	Mean	SD	t	p
Attention	Experimental	4	2.75	0.50	3.273*	.017
	Control	4	1.50	0.58		

The attention score of the experimental group improved from a pre-test mean of $M = 1.50$ to $M = 2.75$ in the post-test, whereas the control group showed only a slight increase from $M = 1.25$ to $M = 1.50$. These results suggest that the reminiscence program using synesthetic visual cues had a significant positive effect on improving attention in older adults.

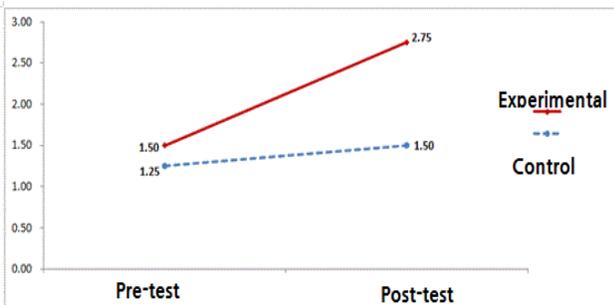


Figure 1: Comparison of Pre- and Post-Test Attention Scores Between Experimental and Control Groups

As shown in Figure 1, the experimental group showed a 1.25-point increase in attention scores from the pre-test ($M = 1.50$) to the post-test ($M = 2.75$). In contrast, the control group exhibited only a minimal change, with scores increasing from $M = 1.25$ to $M = 1.50$.

The comparison of post-test results between the two groups

revealed a statistically significant difference ($t = 3.273$, $p < .05$), indicating that the provision of synesthetic visual cues had a positive effect on improving attention in older adults.

4.2.1.4. Changes in Visuospatial Function

As shown in Table 13, the post-test mean score for visuospatial function was $M = 1.00$ ($SD = 1.15$) in the experimental group and $M = 0.00$ ($SD = 0.00$) in the control group. The results of the independent samples t-test indicated no statistically significant difference between the groups ($t = 1.732$, $p = .134$).

This suggests that the effect of synesthetic visual stimulation on improving visuospatial function was limited.

Table 13: Comparison of Post-Test Visuospatial Function Scores Between Experimental and Control Groups

Cognitive Subdomain	Group	N	Mean	SD	t	p
Visuospatial Function	Experimental	4	1.00	1.15	1.732	.134
	Control	4	0.00	0.00		

4.2.1.5. Changes in Language Function

As shown in Table 14, the post-test mean score for language function was $M = 3.75$ ($SD = 0.50$) in the experimental group and $M = 2.75$ ($SD = 0.50$) in the control group. Results from the independent samples t-test indicated a statistically significant difference between the two groups ($t = 2.828$, $p = .030$).

Table 14: Post-Test Language Function Scores of Experimental and Control Groups

Cognitive Subdomain	Group	N	Mean	SD	t	p
Language Function	Experimental	4	3.75	0.50	2.828*	.030
	Control	4	2.75	0.50		

* $p < .05$

This suggests that the provision of synesthetic visual cues had a positive effect on improving language function among older adults in long-term care facilities.

As shown in Figure 2, the experimental group showed an increase in language function scores from the pre-test ($M = 3.00$) to the post-test ($M = 3.75$). In contrast, the control group showed only a minimal change, from $M = 2.50$ at pre-test to $M = 2.75$ at post-test. The independent samples t-test for the post-test scores revealed a statistically significant difference between the groups ($t = 2.828$, $p < .05$).

This suggests that the provision of synesthetic visual cues had a positive effect on improving language function in older adults.

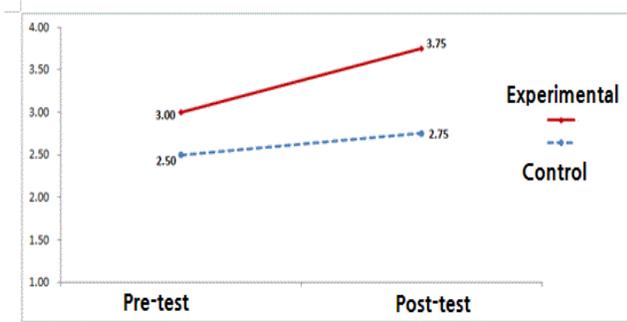


Figure 2: Comparison of Pre- and Post-Test Language Function Scores Between the Experimental and Control Groups

4.2.1.6. Changes in Executive Function

To examine the effect of synesthetic visual cues on executive function among nursing home residents, the post-intervention executive function scores of the experimental and control groups were compared. The results are presented in Table 15.

Table 15: Comparison of Post-Test Executive Function Scores Between Experimental and Control Groups

Subdomain	Group	N	Mean	Standard Deviation	t	p
Executive Function	Experimental Group	4	3.75	1.50	2.800*	.031
	Control Group	4	1.50	0.58		

The experimental group showed an increase in executive function scores from M = 0.75 (pre-test) to M = 3.75 (post-test), a gain of 3.00 points. In contrast, the control group showed minimal change, from M = 1.25 (pre-test) to M = 1.50 (post-test). The comparison of post-test scores revealed a statistically significant difference between the two groups (t = 2.800, p < .05).

These findings suggest that the provision of synesthetic visual cues had a positive effect on improving executive function in older adults residing in nursing homes. Meanwhile, as shown in Figure 3, the experimental group recorded an average score of 0.75 on the pre-test of executive function, which significantly increased to 3.75 on the post-test. In contrast, the control group showed relatively little change, with a pre-test score of 1.25 and a post-test score of 1.50.

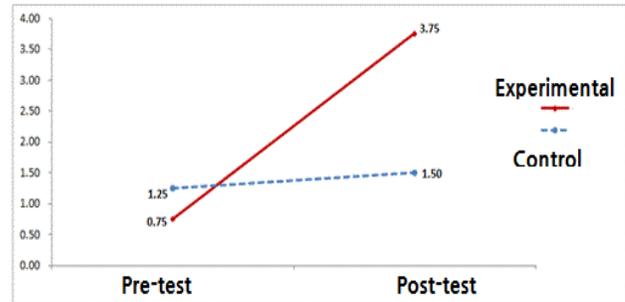


Figure 3: Changes in Executive Function Between the Experimental and Control Groups

An independent samples t-test comparing the post-test scores between the two groups revealed a statistically significant difference (t = 2.800, p < .05), suggesting that the reminiscence program using synesthetic visual cues had a positive effect on improving executive function in older adults.

4.2.2. Mann–Whitney U Test Analysis

4.2.2.1. Concept of Mann–Whitney U Test Analysis

In this study, since both the experimental and control groups consisted of only 4 participants each, relying solely on the independent samples t-test, which assumes normal distribution, might not sufficiently explain differences between the groups. Therefore, to obtain more reliable comparisons even with a small sample size, the non-parametric Mann–Whitney U test was also performed.

The Mann–Whitney U test is a statistical method used to compare differences in median values between two independent groups without assuming a normal distribution. It is especially suitable when the sample size is fewer than 30 and is widely used as an alternative to parametric tests.

This test works by combining all observations from both groups, assigning ranks to all values in the combined dataset, and then calculating the sum of ranks for each group. In other words, the Mann–Whitney U test compares the distributions or central tendencies of two independent samples using their rank sums. The rank sum of the experimental group is typically denoted as R₁, and that of the control group as R₂. The U-values for each group are then calculated based on these rank sums.

Among the two U-values obtained, the smaller one is used as the final test statistic. This value is then used to determine whether the observed difference between groups is statistically significant or likely due to chance. Unlike the t-test, the Mann–Whitney U test does not require the assumption of normality, making it more robust in cases of

small sample sizes or non-symmetric data distributions.

The test statistics are typically computed using the following formula: Let n_1 and n_2 be the sizes of the two groups, and let R_1 and R_2 be the rank sums of each group, respectively. Then, the U-values for each group are calculated as follows:

$$U_1 = n_1 n_2 + \frac{n_1(n_1 + 1)}{2} - R_1$$

$$U_2 = n_1 n_2 + \frac{n_2(n_2 + 1)}{2} - R_2$$

In the above formula, R_1 is the rank sum of Group 1 (experimental group), and R_2 is the rank sum of Group 2 (control group).

4.2.2.2. Mann–Whitney U Test Results

To more precisely analyze the effects of synesthetic visual cues on the cognitive subdomains of elderly residents in care facilities, the non-parametric Mann–Whitney U test was conducted, as shown in Table 16.

The test results revealed that in the attention domain, the experimental group had a mean rank of 6.88, while the control group had 2.13. The test statistic was $U = 15.0$, $p = .047$, indicating a statistically significant difference. This suggests that the synesthetic visual stimulus was effective in enhancing attention among older adults. In the language function domain, the mean ranks for the experimental and control groups were 6.75 and 2.25, respectively. The result was $U = 14.5$, $p = .058$. While this does not reach the conventional level of statistical significance ($p < .05$), a meaningful trend was observed. Given the small sample size, this finding may still be considered noteworthy.

Table 16: Mann–Whitney U-Test Results for Post-Test Scores Between Experimental and Control Groups

Cognitive Subdomain	Group	N	Mean Rank	Rank Sum (R)	U	p-value
Attention	Experimental	4	6.88	27.5	15.0	.047*
	Control	4	2.13	8.5		
Language Function	Experimental	4	6.75	27.0	14.5	.058
	Control	4	2.25	9.0		
Executive Function	Experimental	4	7.00	28.0	16.0	.025*
	Control	4	2.00	8.0		

* $p < .05$

Lastly, in the domain of executive function, the experimental group had a mean rank of 7.00, while the control group had a mean rank of 2.00. The Mann–Whitney U test yielded $U = 16.0$, $p = .025$, indicating a statistically significant difference. This suggests that reminiscence

activities using synesthetic visual cues had a positive impact on improving executive function among older adults in long-term care facilities. These findings imply that reminiscence programs incorporating synesthetic stimuli are particularly effective in enhancing attention and executive function, with a possible positive influence on language function as well. This has clinical significance, as both attention and executive function are closely linked to independence and self-management abilities in daily life.

Despite the limitations of a small sample size, the study strengthens its methodological rigor by applying the Mann–Whitney U test to ensure statistical validity. Therefore, the results serve as supplementary evidence supporting the effectiveness of synesthetic visual cue-based cognitive stimulation in enhancing cognitive function, particularly in attention and executive domains, among institutionalized elderly individuals.

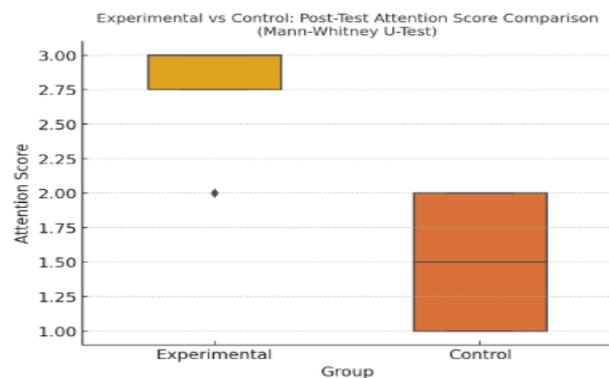


Figure 4: Comparison of Post-Test Attention Scores Between the Experimental and Control Groups

Figure 4 visually compares the post-test attention score distributions of the experimental and control groups. As shown in the boxplot, the scores in the experimental group are mostly concentrated between 2.75 and 3.0, with a median of 3.0. In contrast, the control group scores are distributed between 1.0 and 2.0, with a median around 1.5. The Mann–Whitney U test revealed a statistically significant difference between the two groups ($p = .047$), and this visualization clearly and intuitively illustrates that result. This supports the interpretation that the synesthetic visual cue program had a tangible effect on improving attention in older adults residing in care facilities.

Individual scores for each group are indicated with black dots (strip plot), showing that all participants in the experimental group scored within a relatively higher range. Notably, all experimental group participants scored 2 points or higher, whereas control group scores remained at 1 or 2 points. This visually demonstrates that attention levels in the

experimental group were distinctly higher than those in the control group at post-test.

4.3. Comparison of Session Reactions Between the Experimental and Control Groups

4.3.1. Comparison of Reactions in Sessions 1–2

Objective: Building rapport; facilitating memory and orientation

In the experimental group in Figure 5-1 participants were provided with visual cues to help them engage with the background image. Multisensory activities included touching and attaching stickers such as hair ribbons, dragonflies, and butterflies to enhance sensory engagement. While coloring, participants were encouraged to think of a mother and baby. One participant remarked that while attaching the multisensory stickers, it felt as though they could hear a mother’s lullaby, birds chirping, and insects buzzing—demonstrating a high level of sensory immersion and recall.

In contrast, the control group in Figure 5-2 proceeded without any visual cues or sensory stimuli. One participant, typically quiet and passive, occasionally expressed dissatisfaction and lacked engagement. They showed difficulty maintaining concentration during the session and frequently mentioned feeling unwell, such as complaining of stomach pain.

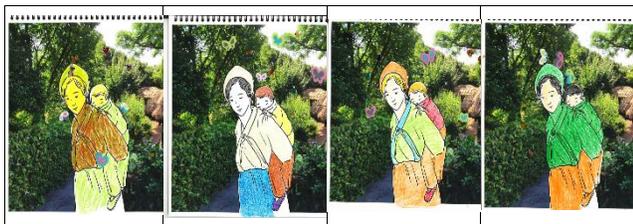


Figure 5-1: Experimental Group

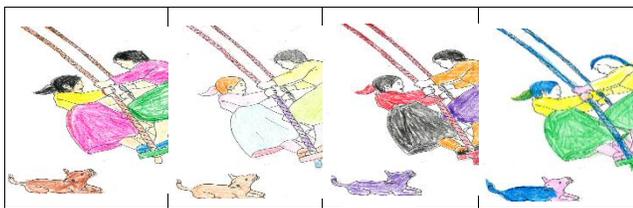


Figure 5-2: Control Group

4.3.2. Comparison of Reactions in Sessions 3–4

Objective: To enhance attention, memory, language ability, visuospatial function, and executive function.

In Figure 5-3, the participants engaged in multisensory stimulation by recalling stories about playing in the stream and catching fish. Visual cues were provided through

background images in the workbook to evoke reminiscence. One participant responded by saying they missed the old days. For sensory stimulation, participants excitedly used toy fishing tools to "catch fish" and colored while recalling memories of splashing water and catching fish with friends.

In Figure 5-4, The session was conducted without any visual cues or multisensory stimulation, which may have contributed to a lack of attention. The activity proceeded in a very quiet atmosphere with little energy. The participant colored in silence, without speaking or engaging in active response.



Figure 5-3: Experimental Group



Figure 5-4: Control Group

4.3.3. Comparison of Reactions in Sessions 5–6

Objective: To facilitate memory recall, object recognition, attention, language ability, visuospatial function, and executive function.

In Figure 5-5, visual cues were provided through the background images, which naturally led to sharing stories from childhood as participants explored the scenes using a multisensory approach. Using sensory toys, participants cut, touched, and recalled the smell of various colorful toy fruits and vegetables. This session showed highly positive responses with lively activities, improved attention, and focus, accompanied by a wealth of shared stories and engagement.

In Figure 5-6, the session was conducted without any visual cues. The participant held colored pencils in both hands and carefully filled in the pictures. When coloring the rubber band play scene, they thoughtfully considered color choices and took time in selecting hues. However, due to the lack of sensory stimulation, there were no verbal responses or storytelling observed during the session.

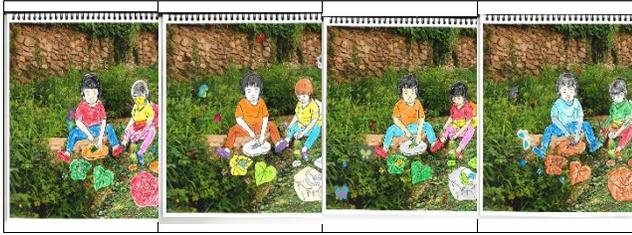


Figure 5-5: Experimental Group

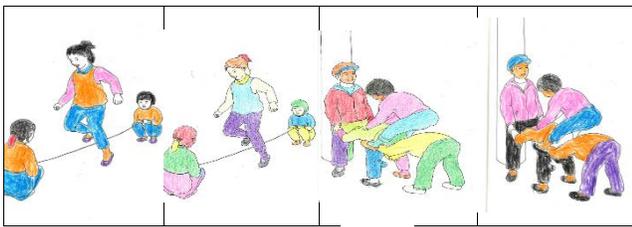


Figure 5-6: Control Group

4.3.4. Comparison of Reactions in Sessions 7–8

Objective: To enhance object recognition, cognitive flexibility, perception, language ability, and executive function.

In Figure 5-7, participants began by talking about the activities they had done so far and explored the background images while discussing traditional Korean farm music (Nongak) and bountiful harvests. For multisensory stimulation, they used a janggu (drum) and sogo (small hand drum), took turns singing along with the janggu rhythm, and engaged in vibrant, energetic play. They played the janggu with enthusiasm, colored cone hats vividly, and used the same color for people's clothing to express unity—suggesting cognitive and emotional engagement with the activity.

In Figure 5-8, the session was conducted without any synesthetic visual or sensory cues. The participant colored meticulously and showed signs of immersion while coloring fireflies in green. In the control group, some participants consistently began by coloring the heads in each illustration. Some worked so slowly that it was difficult to proceed to the next step within the session timeframe.

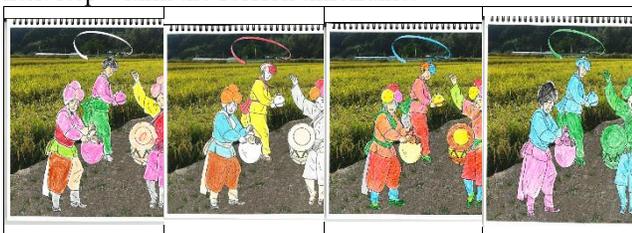


Figure 5-7: Experimental Group

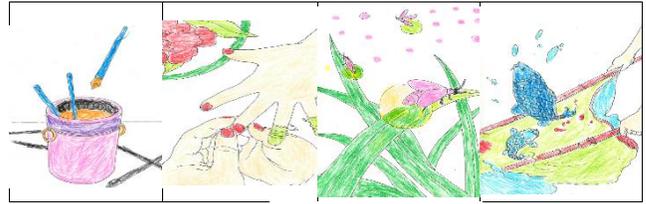


Figure 5-8: Experimental Group

In each session, the experimental group was provided with synesthetic visual cues that stimulated the five senses. Similar to the findings of Lee & Pan (2025), the synesthetic visual stimuli in this study also elicited positive cognitive responses in the elderly, particularly in attention and memory recall.

Multisensory activities—such as touching and sticking stickers of ribbons, dragonflies, and butterflies—were used to create vivid and engaging experiences. One participant mentioned that it felt like they could hear a mother's lullaby, birds chirping, and insects buzzing. During the sessions on streamside play, the participants recalled catching fish and splashing in the water. They were provided with visual cues from background images and used fishing toys as part of the sensory stimulation, actively reminiscing about their childhood experiences while coloring.

In later sessions, they explored colorful toy fruits and vegetables—cutting, touching, and smelling them—leading to heightened concentration, attentiveness, and storytelling, resulting in highly engaging activities. During the traditional music-themed session, participants played with janggu (traditional Korean drums) and sogo (hand drums), sang songs, and engaged in rhythmic movement, which created a dynamic and joyful environment.

In contrast, the control group proceeded without synesthetic visual cues. Attendance was inconsistent, and sessions were conducted in a quiet, subdued atmosphere. As Calderone et al. (2025) reported, reminiscence-based multisensory stimulation is an effective non-pharmacological intervention for cognitive rehabilitation in elderly individuals with dementia. This aligns closely with the multisensory reminiscence approach used in this study.

In the experimental group, synesthetic experiences triggered cross-modal responses—where visual perception evoked stimulation in other sensory modalities. According to Lee (2020), such perceptual activities can enhance visual imagery. Visual cues like photos and illustrations helped participants transition smoothly between familiar and new environments, encouraging behavioral self-regulation. Kim (2002) emphasized that visual cue-based learning is especially effective because it enhances perceptual recognition among various stimuli.

Similarly, Kim et al. (2020) found that color-centered reminiscence activities improved language and attention in older adults with mild cognitive impairment. Taken together, the provision of a synesthetic visual cue-based cognitive stimulation program to nursing home residents appears to have had a positive effect on cognitive functions—particularly attention, language ability, and executive function. These findings are consistent with the study by Lee and Park (2019), which also confirmed the cognitive benefits of multisensory reminiscence activities.

Mendrofa et al. (2025) developed a "multisensory space" that integrates reminiscence therapy and sensory stimulation, reporting improvements in emotional responses and quality of life for dementia patients—an approach that parallels the synesthetic strategy used in this study.

4.4. Results of Hypothesis Testing: Empathic Responses and Cognitive Function in the Experimental and Control Groups

4.4.1. Hypothesis 1

“The experimental group participating in the reminiscence program incorporating synesthetic visual cues will show a statistically significant improvement in post-intervention cognitive function scores compared to the control group receiving general reminiscence stimuli.”

To analyze the impact of the reminiscence program incorporating synesthetic visual stimuli on cognitive function in older adults, a comparison was made between the post-test cognitive function scores of the experimental and control groups.

As shown in Table 17, the non-parametric test (Mann–Whitney U-test) revealed that the experimental group scored significantly higher than the control group in post-intervention cognitive function, thereby supporting Hypothesis 1 ($U = 15.0, p = .047$).

Table 17: Mann–Whitney U-Test Results of Post-Test Cognitive Function Between the Experimental and Control Groups

Cognitive Function Subdomain	Group	N	Mean Rank	Rank Sum (R)	U	p-value
Attention	Experimental	4	6.88	27.5	15.0	.047*
	Control	4	2.13	8.5		
Language Function	Experimental	4	6.75	27.0	14.5	.058
	Control	4	2.25	9.0		

Executive Function	Experimental	4	7.00	28.0	16.0	.025*
	Control	4	2.00	8.0		

$p < .05$

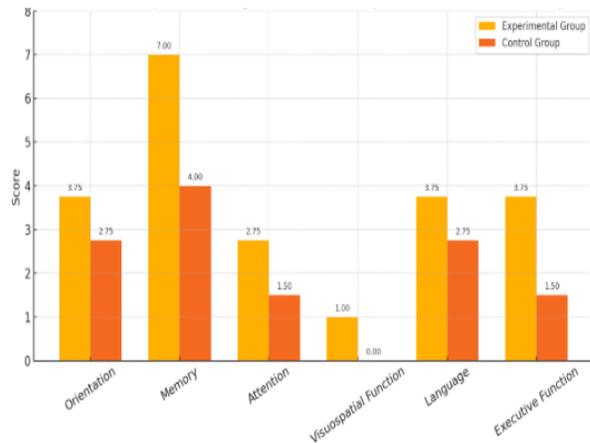


Figure 6: Comparison of Post-Test Cognitive Function Scores Between the Experimental and Control Groups

4.4.4.1. H1-1. Attention scores will improve significantly.

The experimental group showed a statistically significant improvement in post-test attention scores compared to the control group ($U = 15.0, p = .047$). This suggests that the multisensory stimulation was effective in enhancing attention.

4.4.4.2. H1-2. Language function scores will improve significantly.

The experimental group demonstrated higher average scores in language function than the control group, with a statistically marginal significance ($U = 14.5, p = .058$). This indicates that the intervention may have had a partial effect on improving language function.

4.4.4.3. H1-3. Executive function scores will improve significantly.

In terms of executive function, the experimental group also showed a statistically significant improvement compared to the control group ($U = 16.0, p = .025$), indicating that the multisensory visual cues were effective in enhancing executive function.

These results suggest that the reminiscence program incorporating multisensory visual cues can have a positive impact on various cognitive domains in older adults, beyond the effects of traditional reminiscence activities alone. In particular, the significant improvements observed in attention and executive function are closely related to daily living independence, thus providing empirical support for the clinical effectiveness of this approach.

4.4.2. Hypothesis 2 (The experimental group that participated in the reminiscence program with multisensory visual cues will exhibit more verbal and non-verbal expressions of empathy (e.g., facial expressions, gestures, emotional language) during the sessions than the control group.)

As outlined in Hypothesis 2, the impact of multisensory visual cue provision on verbal and non-verbal empathic responses was observed. The experimental group showed more active emotional expressions and non-verbal reactions (such as facial expressions and gestures) during the sessions, as confirmed through qualitative observation and session activity logs.

These findings suggest that multisensory stimulation may facilitate emotional engagement and empathetic communication in older adults. However, future studies should incorporate more quantitative measurement tools to objectively assess and quantify empathic responses.

4.5. Discussion: Comparison of Session Responses Between Experimental and Control Groups

In terms of attention improvement, the experimental group showed an increase of 1.25 points from pre-test ($M = 1.50$) to post-test ($M = 2.75$), while the control group exhibited only a slight change from pre-test ($M = 1.25$) to post-test ($M = 1.50$). The difference between the two groups in the post-test was statistically significant ($t = 3.273, p < .05$).

For language function, the experimental group's score increased by 0.75 points from pre-test ($M = 3.00$) to post-test ($M = 3.75$), whereas the control group showed a minimal increase from $M = 2.50$ to $M = 2.75$. This difference was also statistically significant ($t = 2.828, p < .05$). Regarding executive function, the experimental group improved from $M = 0.75$ (pre-test) to $M = 3.75$ (post-test), a 3.00-point increase, while the control group showed little change from $M = 1.25$ to $M = 1.50$. The difference was statistically significant ($t = 2.800, p < .05$).

In session-by-session comparisons, the experimental group demonstrated significant responses in areas of attention, language function, and executive function. In particular, the multisensory stimulation activities were found to be effective for enhancing verbal abilities (e.g., naming, comprehension), executive functions (e.g., visual and verbal reasoning), and cognitive flexibility (e.g., fluency).

Furthermore, the experimental group exhibited more frequent verbal and non-verbal empathic expressions (e.g., facial expressions, gestures, emotional language) than the

control group throughout the sessions. This supports Hypothesis 2. However, since these empathic responses were assessed through observation, future research should employ quantitative measurement tools to more objectively assess empathy.

Reminiscence activities go beyond stimulating memory—they can help maintain a sense of identity, promote ego integrity, enhance social interaction, facilitate emotional expression, and support emotional stability (Lim, 2016; Lee & Jang, 2019). Han and Kim (2024) reported that reminiscence therapy has positive effects not only on cognitive function but also on verbal emotional expression. Similarly, in this study, as in Lee's (2022), multisensory stimulation led to improvements in attention and emotional vitality. Emotional responses during sessions were shown to positively affect cognition and emotional well-being (Khatib et al., 2025).

Particularly, visual cues support non-verbal communication and can serve as an expressive tool for older adults with cognitive decline. Multisensory stimulation can enhance immersion and concentration, contributing to improved cognitive function (Kim, 2002; Lee, 2020). Pardini et al. (2025) also reported that audiovisual-based multisensory reminiscence significantly impacts self-expression and executive function in individuals with cognitive decline.

In summary, the reminiscence program based on multisensory visual cues significantly improved attention, language, and executive function. These findings suggest that this approach may serve as an effective non-pharmacological intervention for maintaining and enhancing cognitive function in older adults in long-term care facilities. Therefore, continued and structured application of this program is recommended.

Although this study was conducted with a small sample size ($n = 4$ for each group), qualitative analysis—including emotional expression during sessions and session-by-session response logs—was used to complement the validity of the quantitative results. This qualitative approach supports the statistical findings, showing that the experimental group exhibited more active emotional and cognitive responses.

While the study employed a pre-post comparison and included a control group, the total sample size ($N = 8$) limits the statistical power. Caution is required when interpreting the results. To enhance generalizability, future research should adopt multi-center approaches and expand the sample size.

5. Conclusions and Recommendations

5.1. Conclusion

In his study aimed to analyze the effects of a reminiscence program utilizing multisensory visual cues on the cognitive function of older adults in a long-term care facility. The experimental group was provided with the Memory Latte Sketchbook (Ha, 2024) and engaging multisensory activities, while the control group used only a commercially available nostalgic coloring book (Hwang, 2023).

The participants included eight older adults (4 in the experimental group and 4 in the control group) from a nursing hospital in City C, who were mobile and willing to participate. Cognitive function was measured using the Cognitive Impairment Screening Test (CIST) before and after the intervention. The visual cue-based cognitive stimulation program was conducted once a week for 40 minutes per session, over a total of 8 sessions.

Data analysis was performed using SPSS 29.0. To verify group homogeneity, independent samples t-tests were conducted based on pre-test data, calculating the mean and standard deviation for each group. Then, post-test results were analyzed using the Mann-Whitney U test to determine the effects of the reminiscence-based multisensory visual cue intervention on cognitive function. The results revealed statistically significant improvements in several subdomains of cognitive function for the experimental group:

- Attention: Improved from a pre-test mean ($M = 1.50$) to a post-test mean ($M = 2.75$), showing a statistically significant increase ($t = 3.273, p < .05$). This suggests that multisensory stimuli facilitated focused attention through visual prompts. These results are consistent with previous studies (e.g., Kim, 2015), which demonstrated the efficacy of multisensory stimulation in enhancing cognitive attention in older adults. Specifically, attention may have been naturally reinforced through tasks involving visual reasoning, color discrimination, and pattern recognition.

- Language Function: Increased from $M = 3.00$ (pre) to $M = 3.75$ (post), with a statistically significant effect ($t = 2.828, p < .05$). This improvement is likely due to repeated stimulation through spoken language and emotional verbal expressions during reminiscence. Word recall connected to emotionally meaningful stimuli (e.g., old photos, symbolic objects) appeared to activate the language domain. These findings align with Lee Sun-joo's (2019) research on the language-enhancing effects of reminiscence therapy.

- Executive Function: Improved significantly from $M = 0.75$ (pre) to $M = 3.75$ (post) ($t = 2.800, p < .05$). In contrast, orientation ($t = 1.022, p > .05$), memory ($t = 1.072, p > .05$), and visuospatial function ($t = 1.732, p > .05$) showed no statistically significant changes. The gains in executive function may have been driven by structured activities requiring visual reasoning and problem-solving, such as inferring or combining scenarios from the sketchbook.

These findings are consistent with Cha (2021), who emphasized the cognitive rehabilitation potential of executive function activities. The program also supports experimental evidence suggesting that multisensory stimulation evokes past memories and emotional responses, making it a useful non-pharmacological cognitive intervention (Olorunda & McCrindle, 2023).

As an exploratory pilot study, the research holds significance in demonstrating the potential effects of multisensory interventions on specific cognitive subdomains. Particularly, notable improvements were observed in attention, language expression, and executive function, suggesting that a reminiscence program incorporating multisensory visual cues can serve as an effective non-drug intervention for older adults in care facilities. Future studies should verify the long-term effects and generalizability of the program using larger sample sizes and longitudinal designs.

5.2. Recommendations

Based on the findings of this study, the following directions for future research are proposed.

First, there is a need to increase the sample size and expand the number of sessions. This study was conducted as a short-term program with only eight participants (four in each group) over eight sessions, which limits the generalizability of the results. Future research should include a larger sample and a longer-term program to more precisely verify the effectiveness of the intervention.

Second, the diversity of research participants should be improved. Participants in this study were limited to older adults aged 62 to 90 residing in a nursing hospital, which narrows the scope of the sample and limits the representativeness of the findings. Future studies should include older adults from a wider range of age groups and living environments to enhance generalizability.

Third, follow-up testing is needed to verify the sustainability of the program's effects. This study assessed effectiveness only through pre- and post-tests, so it was not

possible to evaluate whether the cognitive improvements were sustained over time. Future studies should incorporate follow-up testing after a set period to assess the long-term durability of cognitive function improvements.

Additionally, this study demonstrated that a reminiscence-based cognitive program utilizing multisensory visual cues had significant positive effects on attention, language function, and executive function in older adults residing in care facilities. These results suggest the potential for this program to serve as an effective non-pharmacological cognitive intervention.

Future studies should take a more systematic and expanded approach to verify the program's effectiveness in a more objective and comprehensive manner.

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