Reminiscence Activates the Frontal Lobe and Ameliorates Negative Mood States in Cognitively Intact Older Adults

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Reminiscence is a non-pharmacological intervention that involves a narrative and reflective process of recalling past thoughts, feelings, and experiences. The positive effects of reminiscence intervention for cognitively intact older people have been reported ; however, the physiological mechanisms underlying the effect on the frontal lobe during and after the reminiscence are not well understood. We have demonstrated increased oxygenated hemoglobin concentrations in the right frontal lobe and decreased deoxygenated hemoglobin concentrations in both the frontal lobes during reminiscence in cognitively intact older participants using near-infrared spectroscopy. Furthermore, the mood state of older participants was evaluated using Profile of Mood States and increased subjective health perception scores and showed a significant improvement following reminiscence compared with pre-reminiscence. Reminiscence-based intervention activated the frontal lobe and provoked positive emotion in the mood state and health perception in cognitively intact older participants. These findings may improve treatment strategies of older adults for better quality of life. *Shinshu Med J 71 : 63—71, 2023*

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Key words : frontal lobe, mood states, near-infrared spectroscopy, older adults, reminiscence

I Introduction

In 2020, the older population (aged 65 years and over) was 36.19 million, constituting 28.8 % of the total population in Japan[1]. The normal aging process in this population causes functional decline in physical and cognitive abilities, which can introduce issues related to adaptation to old age, and may influence the independence of older people[2]. Therefore, it is important that the decline of cognitive functions is identified and treated.

Several approaches, including pharmacological and non-pharmacological strategies, can be used to treat or to prevent the decline of cognitive functions in older individuals[3][4]. Reminiscence therapy is usually used as a treatment for older patients because of its non-pharmacological nature. In this context, several studies reported that reminiscence therapy in older adults improved their adaptation to old age and cognitive status[5][6]. However, the physiological mechanisms underlying the effect on the frontal lobe of cognitively intact older adults during and after reminiscence are yet to be clarified.

Near-infrared spectroscopy (NIRS) is a non-invasive optical method for measuring concentration changes of oxygenated hemoglobin (oxy-Hb) and deoxygenated hemoglobin (deoxy-Hb) in cerebral blood flow. Measuring the absorbance of the infrared light intensity at different wavelengths to calculate the relative ratio of oxy-Hb to deoxy-Hb, using the modified Beer-Lambert law, is the principle of NIRS[7][8]. Neuronal activation causes an increase in oxy-Hb and a decrease in deoxy-Hb in the activated cortical area via neurovascular coupling[9][10]. NIRS activation studies usually include a combination of resting periods to assess baseline activities and brain activation periods[11]. To elucidate the physiological mechanisms underlying the effect of reminiscence on cognition in

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older adults, we assessed the frontal lobe activation of cognitively intact older participants during reminiscence using NIRS while simultaneously measuring their Profile of Mood States (POMS), heart rate variability (HRV), and subjective health perception scores before and after reminiscence.

Ⅱ Materials and Methods

A Participants

Twenty-one community-dwelling older adults with no diagnosis of dementia, psychiatric, or neurological diseases participated in this study. Their age range was 60-80 years (mean age ± standard deviation [SD] : 70.1 ± 4.7 years, 6 = male, 15 = female). All participants were healthy and right-handed.

B MMSE

The Mini-Mental State Examination (MMSE) was used to screen for cognitive impairment in participants. It assessed mental function in a number of areas, including orientation in time and place, alertness, attention, calculation, and memory. This test has minimum and maximum scores of 0 and 30, respectively.

C Reminiscence

We used a simple reminiscence as described by Webster et al. in 2010. The interviews with participants were unstructured, using open prompts such as "Please tell me about your good memories in childhood". Preliminary experiments were conducted to determine the optimal NIRS measurement times for baseline, recalling, and storytelling, which were 2 min each, taking into account the participants' ages and other factors. Therefore, reminiscence was conducted with a 2-min introduction (baseline period), a 2-min recalling period, and a 2-min verbal storytelling (storytelling period). The prompt for memory recalling was given just after the baseline period. The interviews were conducted by a trained nurse who had attended a workshop on reminiscence and was familiar with its implementation.

D NIRS measurements

Concentration changes of oxy-Hb and deoxy-Hb were measured using NIRO-300 (Hamamatsu Photonics KK, Hamamatsu, Japan). The emission and detection probes of NIRS were placed on the Fp1 and Fp2 positions in the 10/20 Electroencephalography system, which covered the left and right frontal lobe regions.

Four different wavelength (775, 810, 850, 910 nm) laser diodes were used as a light source. The distance between the emitter and detector probes was 3.5 cm. Oxy-Hb and deoxy-Hb concentrations measured by NIRS are relative values. We treated the values before reminiscence as baseline values. The oxy-Hb and deoxy-Hb concentrations measured every 1 s in each participant were averaged for 10 s in each of the baseline, recalling, and story-telling periods. Values measured during baseline, recalling, and storytelling were the average oxy-Hb and deoxy-Hb concentrations during 0-10 s before the start of recalling, 100-110 s after the start of recalling, and 70-80 s after the start of storytelling, respectively. The oxy- and deoxy-Hb values from recalling and storytelling were compared to those measured during baseline. Since the NIRS data had a large individual variability, we compared the averages of the 10 s when the NIRS data were most stable. These 10 s were 0-10 s before the start of recalling, 100-110 s after the start of recalling, and 70-80 s after the start of storytelling.

E POMS

The Profile of Mood States (POMS) was used to gauge the participants psychological responses. The POMS comprises 35 adjectives rated on a 0 (not at all) to 4 (extremely) scale that can be consolidated into the following seven effective dimensions : A-H (anger and hostility), C-B (confusion and bewilderment), D-D (depression and dejection), F-I (fatigue and inertia), T-A (tension and anxiety), V-A (vigor and activity), F (friendliness) and TMD (total mood disturbance). For the Japanese subjects, the Japanese edition of the POMS second edition (POMS 2) was used. In this study TMD was calculated by subtracting V-A from the sum of the scores for A-H, C-B, D-D, F-I, and T-A.

F Subjective health perception

Subjective health perception was measured by asking the participants the question "How do you

rate your health at the present time?" This question was answered using a 4-point Likert scale with the following options : 1 = very bad, 2 = bad, 3 = good, 4 = very good.

G HRV analysis

HRV is an indicator of autonomic nerve activity, measuring variations in the R-R interval per beat. An activator AC-301A (GMS, Japan) was used for continuous recording the R-R interval. Time series data were obtained for 1 min for power spectral analysis using Memcalc/Tarawa (GMS, Japan). The analysis was performed with a low frequency (LF) component of 0.04～0.15 Hz and a high frequency (HF) component of 0.15～0.40 Hz.

H Study procedures

Changes in the oxy-Hb and deoxy-Hb concentrations on NIRS and HRV were monitored in a quiet room. Participants sat on a chair, and the probes were attached. They were instructed to minimize head and body movements as much as possible during the measurements. The POMS and Likert scale of subjective health perception were completed before and after the reminiscence. The interval times between the evaluation of POMS, Likert scale of subjective health perception and reminiscence were 20 min each. Measurements of NIRS and HRV were started 2 min before reminiscence and ended 4 min after reminiscence. All procedures were performed by a trained nurse.

I Statistical analyses

We conducted a paired t test to compare the POMS scores, subjective health perception scores, and HRV data before and after the reminiscence. The average oxy-Hb and deoxy-Hb concentrations obtained from the NIRS data during the recalling and storytelling periods were compared with the concentrations during the baseline period using the paired Student's t test. The correlation analysis between the differences in POMS TMD scores and NIRS results before and after the reminiscence was evaluated using Pearson's correlation coefficient. P-values of < 0.05 were considered to indicate statistical significance. We used IBM SPSS26 software for statistical analysis. Data are presented as the mean ± 1 standard error.

J Ethical considerations

This study was approved by the institutional ethics committee of Shinshu University before the study (approval number 3762). All participants were well informed about the purpose and methods of the study, and written informed consent was obtained from each participant.

Ⅲ Results

The participants' MMSE scores were between 27 and 30 (One with 27, five with 28, four with 29, and 11 with 30). Most participants had no cognitive impairments.

Fig. 1A shows the grand average oxy-Hb concentration in the left and right frontal lobes of all participants during the period from probe attachment to completion of reminiscence (recalling and storytelling). In this study, reminiscence was composed of the recalling and storytelling periods. This figure indicates that oxy-Hb increased during the period of recalling and storytelling in both frontal lobes.

Fig. 1B shows the grand average deoxy-Hb concentration in the left and right frontal lobes of all participants during the period from probe attachment to completion of reminiscence. The deoxy-Hb concentration decreased during the period of recalling and storytelling in both frontal lobes.

The oxy-Hb concentrations in the right frontal lobe during recalling (0.69 ± 0.39 μmol/L) and storytelling (1.18 ± 0.50 μmol/L) were significantly higher than those measured at baseline (-0.31 ± 0.22 μmol/L) ($p < 0.01$ and $p < 0.01$, respectively) **(Fig. 2)**.

The deoxy-Hb concentrations in the right frontal lobe during recalling (-0.61 ± 0.16 μmol/L) were not significantly different from those measured at baseline (-0.41 ± 0.13 μmol/L) ($p = 0.07$) ; however, those during the storytelling period (-0.89 ± 0.18 μmol/L) were significantly lower than those at baseline ($p < 0.01$) **(Fig. 3)**.

The oxy-Hb concentrations in the left frontal lobe during recalling (0.17 ± 0.34 μmol/L) and storytelling (0.72 ± 0.52 μmol/L) were not significantly different from those at baseline (-0.34 ± 0.38 μmol/L) ($p = 0.09$ and $p = 0.13$, respectively) **(Fig. 2)**.

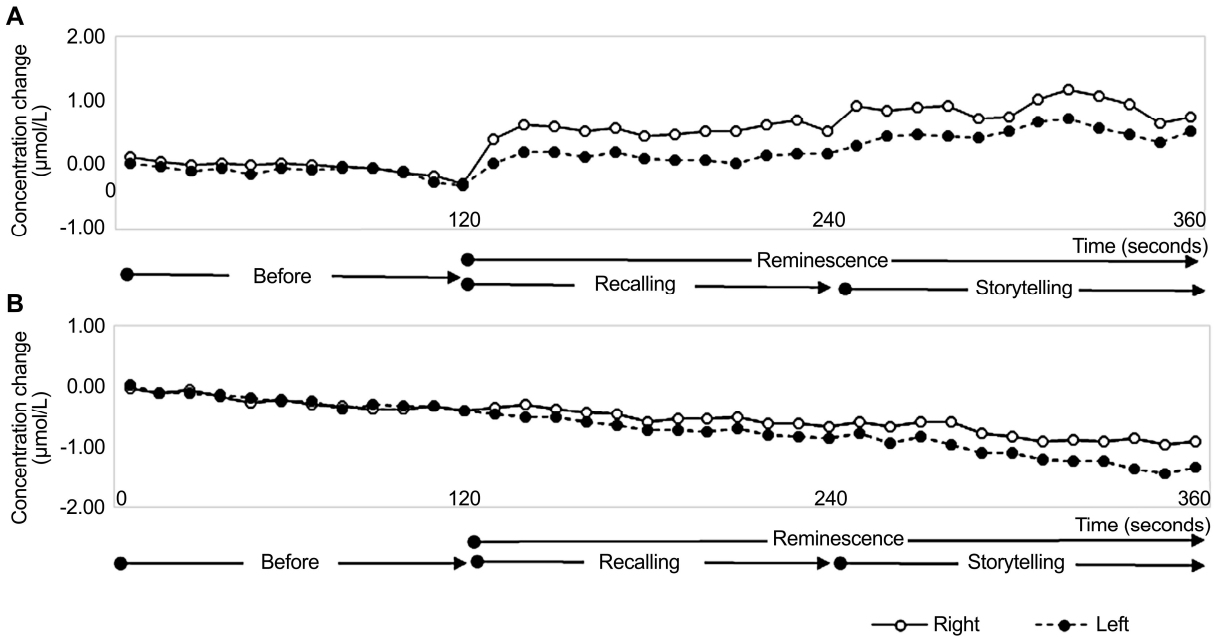

Fig. 1 Grand average concentrations of oxygenated hemoglobin (A) and deoxygenated hemoglobin (B) during baseline (0–120 s) and reminiscence (120–360 s) measured using near-infrared spectroscopy for all participants. Reminiscence comprises recalling periods (120–240 s) and storytelling periods (240–360 s). The data show the relative concentrations (μmol/L) every 10 s. The solid circle shows the concentrations of the right frontal lobe, and the open circle shows the concentrations of the left frontal lobe.

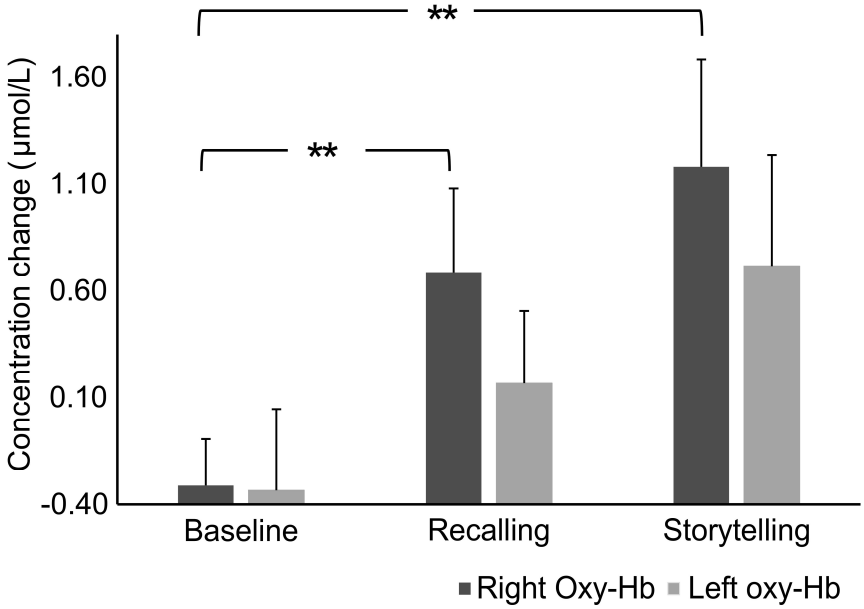

Fig. 2 Mean relative values of oxygenated hemoglobin (oxy-Hb) for the right frontal lobe (black bar) and left frontal lobe (shaded bar) before reminiscence (baseline) and during reminiscence (recalling and storytelling) in all participants. Oxy-Hb values of the right frontal lobe during recalling and storytelling were significantly higher than those at baseline (**$p<0.01$). The vertical bars are standard errors.

The deoxy-Hb concentrations in the left frontal lobes during recalling (−0.84 ± 0.18 μmol/L) and storytelling (−1.23 ± 0.21 μmol/L) were significantly lower than those at baseline (−0.41 ± 0.19 μmol/L) ($p<0.001$ and $p<0.001$, respectively) **(Fig. 3)**. We found no difference in the results of NIRS data between male

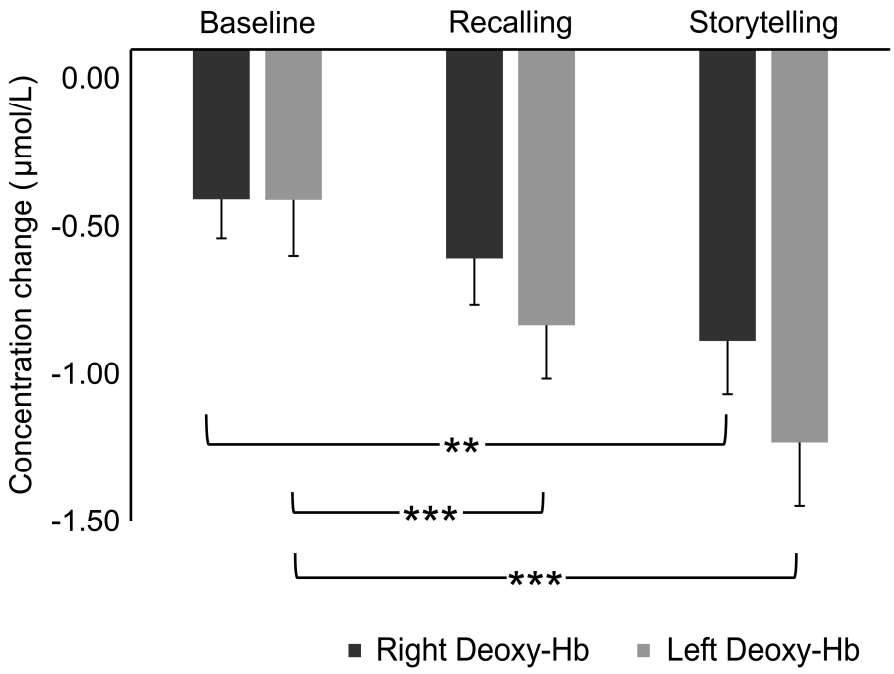

Fig. 3 Mean relative values of deoxygenated hemoglobin (deoxy-Hb) for the right frontal lobe (black bar) and left frontal lobe (shaded bar) before reminiscence (baseline) and during reminiscence (recalling and storytelling) in all participants. Deoxy-Hb values of the right frontal lobe during storytelling were significantly lower than those at baseline (**$p<0.01$). Deoxy-Hb values of the left frontal lobe during recalling and storytelling were significantly lower than those at baseline (***$p<0.001$). The vertical bars are standard errors.

Table 1 Comparison of the Profile of Mood States second edition scores for before and after reminiscence (n = 21)

7 Factors & Total Mood Disturbance	Before	After	p-value
Anger - Hostility	1.7 ± 0.4	0.3 ± 0.1	***
Confusion - Bewilderment	2.4 ± 0.6	1.1 ± 0.4	*
Depression - Dejection	2.4 ± 0.6	0.9 ± 0.3	***
Fatigue - Inertia	1.2 ± 0.3	0.6 ± 0.3	n.s.
Tension - Anxiety	4.0 ± 0.7	1.6 ± 0.3	***
Vigor - Activity	13.3 ± 0.8	14.3 ± 0.9	n.s.
Friendliness	14.1 ± 0.7	15.6 ± 0.7	*
Total Mood Disturbance	-1.6 ± 2.2	-9.9 ± 1.4	***

The data are presented as means ± standard errors of the 7-factor scores and TMD score measured by the POMS 2. P values were calculated using a paired t test.
***: $p<0.001$, *: $p<0.05$, n.s.: not significant.

and female participants (data not shown).

The average POMS 2 scores for the participants before and after the reminiscence are summarized in **Table 1**. Scores reflecting a negative mood state were significantly lower after reminiscence than before reminiscence (A-H : $p<0.001$, C-B : $p<0.05$, D-D : $p<0.001$, T-A : $p<0.001$, TMD : $p<0.001$). The F score reflects a positive mood state and was significantly higher after reminiscence than before reminiscence (F : $p<0.05$). We found no correlation between the differences in POMS TMD scores and NIRS results before and after the reminiscence (data not shown).

Subjective health perception of the participants was measured by the Likert scale score. As shown in **Fig. 4**, the mean subjective health score after reminiscence (3.38 ± 0.13) was higher than that before reminiscence

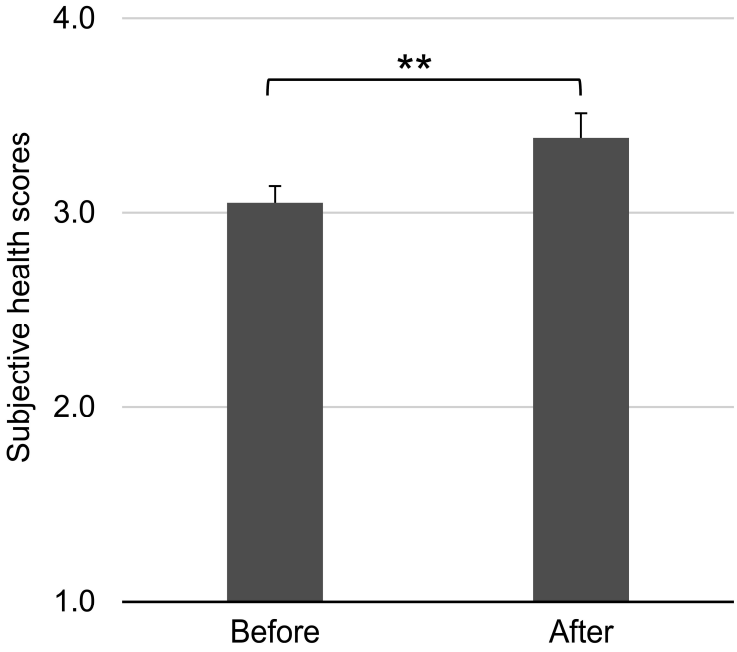

Fig. 4 Changes of the subjective health scores before and after reminiscence in all participants. P values were calculated using paired t tests (**p<0.01). The vertical bars are standard errors.

Table 2 Comparison of heart rate variability before and after reminiscence (n=21)

	Baseline	Recalling	Storytelling	p-value
HF (ms^2)	68.60 ± 16.77	71.39 ± 16.56	75.95 ± 18.60	n.s.
LF/HF	4.54 ± 1.04	4.62 ± 0.90	5.59 ± 0.98	n.s.

Data are presented as means ± standard errors.
Data analysis was performed using a paired t-test, comparing baseline and recalling and baseline and storytelling. n.s. : not significant, LF : low frequency, HF : high frequency

(3.05±0.08) (p<0.01).

HRV assesses the activity of the autonomic nervous system. The LF component reflects the sympathetic and parasympathetic nervous system activities, whereas the HF component reflects the parasympathetic nervous system activity. LF/HF indicates sympathetic nervous system activity. HF and LF/HF were not significantly different during reminiscence (recalling and storytelling) compared with before reminiscence **(Table 2)**.

Ⅳ Discussion

Reminiscence is a non-pharmacological intervention. It is a narrative and reflective process of recalling past thoughts, feelings, and experiences to enhance happiness[12)13)]. Reminiscence is recognized as reminiscence therapy, which has been conducted by professional practitioners such as psychologists, nursing staff, and social workers in clinical settings and palliative care[6)14)].

The positive effects of reminiscence therapy for patients with dementia, Alzheimer's disease, and life-limiting diseases have been demonstrated in several studies, in terms of reducing depressive symptoms, promoting cognitive functions, and improving a patient's well-being. Following their meta-analysis, Park et al[15)]. concluded that reminiscence therapy for people with dementia had a moderate effect on depression and could be used to decrease depression as an alternative to antipsychotic drugs.

Recently, Tam et al.[5)] showed the effectiveness of reminiscence-based intervention on improving psychological well-being in cognitively intact older adults using a systematic review and meta-analysis. Their results demonstrated that a significant reduction of depressive symptoms, improvement in life satisfaction, enhancement of self-esteem, and improvement in happiness were achieved through rem-

iniscence-based intervention in cognitively intact older adults. In most cases, the effectiveness of reminiscence-based intervention was evaluated using outcome assessment tests, such as the Mini-Mental State Examination, Life Satisfaction Index A, and Geriatric Depression Scale 30[5)15)-17)]. We were unable to find a study that evaluated the effectiveness of reminiscence-based intervention using the physiological index of the brain.

In this study, we have demonstrated increased oxy-Hb concentrations in the right frontal lobe and decreased deoxy-Hb concentrations in both the frontal lobes during reminiscence compared with baseline values in older participants, using NIRS. Although the oxy-Hb concentrations in the left frontal lobe during reminiscence were not different from the baseline concentrations, these results suggested that frontal lobe activation was observed during reminiscence in cognitively intact older adults.

Oxy-Hb concentrations in the right frontal lobe significantly increased during reminiscence, while there was no significant difference in oxy-Hb concentrations in the left frontal lobe. The right frontal lobe appears to be more activated than the left frontal lobe. However, deoxy-Hb concentrations significantly decreased in the bilateral frontal lobes during reminiscence. The increase in oxy-Hb concentration in the left frontal lobe during the reminiscence was not significant, but had a p-value of 0.09. Therefore, we think that there is no laterality in the activation of the frontal lobes during reminiscence.

The POMS is one of the most popular mood state measures. The standard English version comprises 65 items rated on a 5-point response format[18)]. The POMS is available for use in older adults, and the questionnaire has been translated into many languages[19)]. In this study, we used the Japanese version of the POMS 2, and asked "How do you feel right now" to assess the acute effect of reminiscence. The results of the POMS in this study showed that the older participants had an improved mood status following reminiscence compared with before reminiscence.

The complex interaction of mood with cortical oxygenation in the frontal lobe has been suggested by several studies. Aoki et al[20)]. and Sato et al[21)]. reported a negative correlation between negative POMS mood scores and oxy-Hb concentrations in the prefrontal cortex during the verbal working memory task in healthy adults, measured using optical topography and NIRS. Miyata et al. examined the effect of three nights of sleep restriction on frontal lobe oxygenation and mood using NIRS and the POMS. They reported that three nights of < 4 h sleep significantly suppressed cortical oxygenation in the frontal lobe during a word frequency task. The POMS vigor scores after nights of insufficient sleep were lower than those after nights of sufficient sleep. The fatigue and TMD scores of the POMS after nights of insufficient sleep were higher than those after nights of sufficient sleep[22)]. They suggested that a decrease in cortical oxygenation in the frontal lobe due to sleep deprivation might lead to mood disturbance.

Sato et al.[21)] reported that participants with higher POMS TMD scores before the verbal working memory task showed less PFC activity during the task. However, we were not able to show a direct correlation between mood improvement and frontal lobe activation in the present study. Our present data analyzed the association between the difference in POMS TMD scores and the NIRS results before and after the reminiscence, while Sato et al. analyzed the association between POMS TMD scores before verbal working memory and NIRS results.

Previous studies suggested that positive emotions are beneficial for health and that negative emotions are detrimental to it[23)24)]. Considering that activation of the frontal lobes correlates with emotional experiences, the increase in subjective health perception scores after reminiscence may be related to activation of the frontal lobes of older participants in our study.

The important aspect of reminiscence is not only to recall pleasant memories from the past but also to talk about them in words to the listener. In the present study, the average oxy-Hb levels continued to increase and deoxy-Hb levels continued to decrease between the time of recalling and storytelling. This

may indicate the importance of verbalizing the recalled pleasant memories in reminiscence.

In conclusion, reminiscence in cognitively intact older adults activated the frontal lobes and ameliorated negative mood states, but did not affect autonomic nervous system activities.

Limitations

NIRS data are suitable for measurement in structured interviews, but may not be suitable for measurement during semi-structured interviews such as those prompting reminiscence. This may be the reason for the variability of the NIRS data. Furthermore, extracranial hemodynamic changes such as skin blood flow influence the forehead NIRS data. We need to take this phenomenon into account when interpreting the data. In this study, the exclusion of neurological diseases was based on self-report only. Considering that the cerebral blood flow has a significant impact on NIRS data, a more precise method (such as MRI) to determine the exclusion of neurological diseases may be needed. Lastly, we were unable to ask participants for information regarding current medicines in the context of personal information protection.

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Conflicts of Interest

The authors declare no conflict of interest.

References

1) Statistics Bureau, Ministry of Internal Affairs and Communications Japan : Statistical Handbook of Japan 2021. Statistics Bureau, Ministry of Internal Affairs and Communications Japan, Tokyo, 2021
2) Cabeza R, Albert M, Belleville S, et al : Cognitive neuroscience of healthy aging : Maintenance, reserve, and compensation. Nat Rev Neurosci 19 : 701–710, 2018
3) Barnes JN : Exercise, cognitive function, and aging. Adv Physiol Educ 39 : 55–62, 2015
4) Austad SN, Wood MA, Villeda SA, Voss JL, Sahay A, Albert M : Innovative approaches in cognitive aging. Neurobiol Aging 83 : 150–154, 2019
5) Tam W, Poon SN, Mahendran R, Kua EH, Wu XV : The effectiveness of reminiscence-based intervention on improving psychological well-being in cognitively intact older adults : a systematic review and meta-analysis. Int J Nurs Stud 114 : 103847, 2021
6) Syed Elias SM, Neville C, Scott T : The effectiveness of group reminiscence therapy for loneliness, anxiety, and depression in older adults in long-term care : a systematic review. Geriatr Nurs 36 : 372–380, 2015
7) Jöbsis FF : Noninvasive, infrared monitoring of cerebral and myocardial oxygen sufficiency and circulatory parameters. Science 198 : 1264–1267, 1977
8) Scholkmann F, Klerser S, Metz AJ, et al : A review on continuous wave functional near-infrared spectroscopy and imaging instrumentation and methodology. Neuroimage 85 : 6–27, 2014
9) Hebden JC, Delpy DT : Diagnostic imaging with light. Br J Radiol 70 : S206–S214, 1997
10) Chen W-L, Wagner J, Heugel N, et al : Functional near-infrared spectroscopy and its clinical application in the field of neuroscience : advances and future directions. Front Neurosci 14 : 724, 2020
11) Udina C, Avtzi S, Durduran T, et al : Functional near-infrared spectroscopy to study cerebral hemodynamics in older adults during cognitive and motor tasks : a review. Front Aging Neurosci 11 : 367, 2020
12) Butler RN : The life-review : an interpretation of reminiscence in the aged. Psychiatry 26 : 65–76, 1963
13) Webster JD, Bohlmeijer ET, Websterhof GJ : Mapping the future of reminiscence : a conceptual guide for research and practice. Res Aging 32 : 527–564, 2010
14) Woods B, Spector A, Johns C, Orrell M, Davies S : Reminiscence therapy for dementia. Cochrane database syst rev,

2, CD001120. doi : 10.1002/14651858. CD001120.pub2, 2005

15) Park K, Lee S, Yang J, Song T, Son Hong G-R : A systematic review and meta-analysis on the effect of reminiscence therapy for people with dementia. Int Psychogeriatr 31 : 1581-1597, 2019

16) Cuevas PEG, Davidson PM, Mejilla JL, Rodney TW : Reminiscence therapy for older adults with Alzheimer's disease : a literature review. Int J Ment Health Nurs 29 : 364-371, 2020

17) Siverová J, Buźgová R : The effect of reminiscence therapy on quality of life, attitudes to ageing, and depressive symptoms in institutionalized elderly adults with cognitive impairment : a quasi-experimental study. Int J Ment Health Nurs 27 : 1430-1439, 2018

18) McNair DM, Lorr M, Droppleman LF : Revised manual for Profile of Mood States. San Diego, CA : Educational and Industrial Testing Service 1992

19) Payne ME, Porter Starr KN, Orenduff M, et al : Quality of life and mental health in older adults with obesity and frailty : associations with a weight loss intervention. J Nutr Health Aging 22 : 1259-1265, 2018

20) Aoki R, Sato H, Katura T, et al : Relationship of negative mood with prefrontal cortex activity during working memory tasks : an optical topography study. Neurosci Res 70 : 189-196, 2011

21) Sato H, Dresler T, Haeussinger FB, Fallgatter AJ, Ehlis A-C : Replication of correlation between natural mood states and working memory-related prefrontal activity measured by near-infrared spectroscopy in a German sample. Front Hum Neurosci 8 : 37, 2014

22) Miyata S, Noda A, Iwamoto K, et al : Impaired cortical oxygenation is related to mood disturbance resulting from three nights of sleep restriction. Sleep Biol Rhythms 13 : 387-394, 2015

23) Cohen S, Pressman SD : Positive affect and health. Curr Dir Psychol Sci 15 : 122-125, 2006

24) Kitayama S, Park J : Emotion and biological health : the socio-cultural moderation. Curr Opin Psychol 17 : 99-105, 2017

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