Sawami et al., Neuropharm Open Access 2017, 3:1

Neurochemistry & Neuropharmacology

Research Article Open Access

Verification of Preventive Effect of Dual-Task and N-Back Task-Incorporated Music Therapy against Dementia

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Abstract

Introduction: Alzheimer's dementia (AD) is the most dominant (more than 60%) in the whole dementia and the incidence of AD for people at age 65 years or older becomes twice with an increase in age by 5 years, so the development of countermeasures against it is an urgent issue. For improving cognitive functions, the effectiveness of dual-task (a task for which two different things are performed at the same time) and that of n-back task (a task for which delayed recall of a thing performed at n times ago is carried out) have been verified. In addition, we have also verified that distress has negative effects on cognitive functions. Hence, we started dual-task- and n-back task-incorporated intervention geared toward elderly people living in Kashihara-city. In this method, music therapy was adopted for the distress reduction and the eustress enhancement. The purposes of this study are to verify the preventive effect against dementia by the dual-task- and n-back task-incorporated music therapy and to measure the effect of music therapy on the distress reduction. In this study, the intervention group and the control group were compared during the intervention for three months.

Methods: A screening test for mild cognitive impairment was carried out with Montreal Cognitive Assessment (MoCA test). Stress check was performed by collecting sublingual saliva and measuring α-amylase. Analysis was conducted with t-test corresponding to the comparison between the intervention group and the control group.

Results: The intervention group showed significant improvement of cognitive functions and a decrease in distress, compared to the control group.

Conclusion: The dual-task- and n-back task-incorporated music therapy improved cognitive functions and reduced distress. To verify this repeatedly to refine the technique and to accumulate effective programs are our future tasks.

Keywords: Cognitive function; Music therapy; Stress; Dual-task; n-back task

Introduction

According to the estimation by Ministry of Health, Labour and Welfare of Japan, the prevalence of dementia in the population of age 65 years or older in Japan in 2012 (approximately 30,740,000 people in total) is 15% (approximately 4,620,000 people) [1]. Among all kinds of dementia, Alzheimer's dementia (AD) is the most dominant (more than 60%) [2], the rate of which keeps increasing year by year [3]. The incidence of AD becomes twice with an increase in age by 5 years for elderly people at age 65 or older [4]. Hence, the development of countermeasures against AD is an urgent issue. However, in terms of medical treatment, the amyloid vaccine developed in 2000 was unable to prevent the depression of cognitive functions even after the removal of β-amyloid in the brain [5]. Therefore, in the present situation, presymptomatic preventive measures is the most important, but effective ways are still sought by efforts in local areas.

With such the background, we recruited participants of dementia prevention class by open recruitment geared toward elderly people living in Kashihara-city, and started preventive intervention against AD by adopting dual-task- and n-back task-incorporated music therapy. Evaluation was carried out using Montreal Cognitive Assessment (MoCA test) which is a screening scale of Mild Cognitive Impairment (MCI). Follow-up care for those who showed reduction in cognitive functions was performed in cooperation with Center for Dementia, Nara Medical University.

In the verification result indicating the effect of intervention, the effectiveness of n-back task had been verified, and the activation of frontal cortex and parietal cortex region had been indicated as the result of meta-analysis [6]. It had also been reported that dual-task can activate the brain more significantly, compared to single-task (a single task such as exercise only or learning only), and the activation of prefrontal cortex had been verified [7,8].

Judging from the previous studies described above, we expected a synergistic effect generated by the combination of n-back task and dual-task in this study. As for non-drug therapies to maintain cognitive functions, most of them are ways such as animal therapy and horticulture therapy to promote pleasant feelings which activate the brain's reward system (A10 nervous system) to become a motivation of keeping up something. In addition, in the study of comparing the effects of positive feelings and negative feelings based on the neutral state, it had been reported that positive feelings expand the ranges of carefulness, thought, and actions while negative feelings reduce the ranges of thought and actions [9]. We had verified the relationship between eustress/distress and cognitive functions [10,11]. Therefore, we adopted music therapy to reduce distress and enhance eustress in the intervention. The feature of intervention with music therapy is the rhythmical exercise that is known to activate serotonin [12,13]. It is also

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Received March 29, 2017; **Accepted** April 07, 2017; **Published** April 12, 2017

Citation: Sawami K, Nakagawa H, Katahata Y, Suishu C (2017) Verification of Preventive Effect of Dual-Task and N-Back Task-Incorporated Music Therapy against Dementia. Neurochem Neuropharm Open Access 3: 115.

known that serotonin is related to mental and physical balance and peace of mind as well as influences the memory in the hippocampus and the learning effect.

Based on the background described above, the purposes of this study are to measure the effect of improving cognition functions by this intervention program and to clarify whether distress can be reduced and eustress can be enhanced by the music therapy, a rhythmical exercise.

Methods

Subject

Elderly people who applied for the open recruitment in Kashihara City.

Period

April 2016 to September 2016.

Intervention method

The music therapy with the combination of n-back task and dual-task was implemented once a month during the intervention for three months. n-Back task is a task of delayed recall where 1-back task, 2-back task, and 3-back task meaning recalling a task one time ago, two times ago, and three times ago, respectively, were sequentially done with an increase in the number n (see Figure 1).

Dual-task is a task where two different things such as step and calculation are performed at the same time (see Figure 2).

Before implementing the intervention, we registered to Japan Bureau for Popularization of Cognisize which carries out the activities to popularize dual-task-utilizing exercise methods.

Evaluation method

Measurement was conducted with the following screening test and measuring equipment.

MCI screening

was implemented with Montreal Cognitive Assessment (MoCA test) which is a screening test for MCI. Intervention and control groups were compared before and after. The full score of the test is 30. Higher scores indicate higher cognitive functions. The cutoff score is 26. This test was implemented after we obtained permission to use it from Dr. Ziad Nasreddine who developed the original edition and Dr. Toshiyuki Suzuki at Tokyo Metropolitan Institute of Gerontology who translated

Delayed recall of choreograph performed one time ago, two times ago, and three times ago.

Figure 1: An example of n-back task.

The rhythm is changed between duple time and triple time during the step of both feet. As for hands, motions in duple time and triple time are performed with one hand and the other hand, respectively.

Figure 2: An example of dual-task.

it to make the Japanese edition.

For the eustress/distress measurement, α-amylase was measured by collecting sublingual saliva. The mechanism is reflected by sympathetic activity, as shown in Figure 3, and the concentration of it increases by distress and decreases by eustress.

The standard value of α-amylase in sublingual saliva is as shown in Table 1, which is obtained by Nipro, the manufacturer of α-amylase measuring equipment.

Analysis method

To compare the scores of MoCA test and the concentrations of α-amylase in sublingual saliva before and after the intervention, the corresponding t-test was carried out. Pearson correlation coefficient was used for the relationship among each of test items.

Ethical consideration

This study was approved by Research Ethics Committee of Nara Medical University before the implementation. Subjects were explained verbally and in a written form about study purposes and methods, free-will participation and the right to refuse, privacy protection, data management methods, and release of the results. They participated in this study by signing in the letter of consent.

Results

For the intervention group (78 participants), data obtained from 57 participants (73.1%) who participated in the whole sessions were analyzed. For the control group (72 participants), data obtained from 48 participants (66.7%) who participated in the first session and the third session (three months later) were analyzed. The average age of the subjects was 73.1 ± 7.6 years old. Eight male subjects and 97 female subjects were included. As for the cognitive functions, the average scores of each item of MoCA test and the results of the corresponding t-test were shown in Table 2.

The total score of MoCA test before the intervention was 24.65 on average, which was lower than the cutoff value (26). After the completion of the intervention, it increased to 26.42 and reached the cutoff value ($p<0.01$).

For the items of cognitive functions after the intervention, significant function improvement was observed for the intervention group in "Repetition", "Short-term memory recall", "Attention", "Concentration", and "Other" ($p<0.05$).

Next, as for the results of measuring stress (α-amylase), the control group did not show any significant change, while the intervention group showed a significant decrease in negative stress from 47.88 (before the intervention) to 40.51 (after the intervention) on average ($p<0.01$). In addition, there was a negative correlation between the result of MoCA test and salivary α-amylase, and subjects with higher cognitive functions had lower negative stress as shown in Figure 4 (Pearson correlation coefficient, $r=-0.397$).

Discussion

The preventive intervention for AD implemented by each local government is still in the process of trial and error, and thus the development of effective techniques is an urgent issue. It is notable in this assault that the combination of music therapy with the brain-training tasks resulted in the improvement of cognitive functions and even the stress reduction.

In terms of cognitive functions, "Repetition", "Short-term memory recall", "Attention", "Concentration", and "Other" significantly improved. The total score exceeded the cutoff value after the intervention. For this, since the function of the frontal cortex centered around the prefrontal cortex is essential for the execution of two different tasks at the same time for dual-task incorporated in the intervention, [14] the frontal cortex seems to be trained by the intervention. In fact, in the verification results with brain waves and near-infrared spectroscopy, it has been reported that the frontal cortex is activated during the execution of dual-task [15,16] Judging from the fact that the functional deterioration in the prefrontal region by aging occurs earlier, compared to functions supported by other brain regions [17] attempts of activating the frontal cortex including the prefrontal

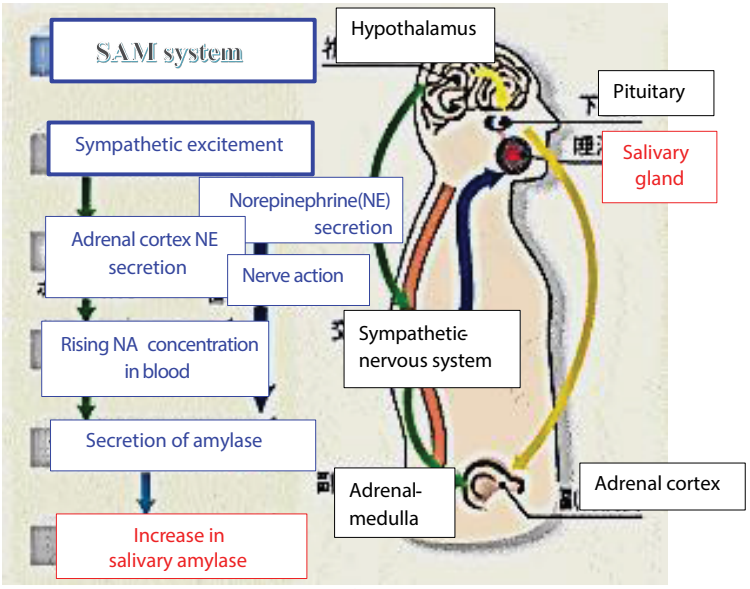

Figure 3: Mechanism of amylase secretion into saliva.

0-30 KU/L	There is no negative stress.
31-45 KU/L	There is slight negative stress.
46-60 KU/L	There is negative stress.
61 KU/L	There is a high amount of negative stress.

Table 1: The reference values of salivary α- amylase.

MoCA test component	Description of the test component (maximum score)	Mean score of control group		Mean score of intervention group	
		Before	After	Before	After
Trail Making	Subject alternates between connecting numbers and connecting letters, in the ascending order"1→A→2→B..." (1)	0.90	0.85	0.77	0.89
Visuoconstructional skills	The participant is asked to accurately replicate a drawing of a cube. (1)	0.85	0.77	0.80	0.84
Verbal fluency	The participant is asked to list as many words as possible that begin with a designated letter of alphabet (1)	0.48	0.46	0.55	0.54
Repetition	The participant is read a sentence and asked to repeat it back exactly. (2)	0.75	0.81	0.77	1.12**
Abstract thinking	The participant is required to describe what characteristic 2 words have in common (2)	1.63	1.67	1.68	1.70
Naming	The participant is shown pictures of animals and asked to correctly name them (3)	2.92	2.92	2.95	2.96
Visuoconstructional skills	The partipcant is asked to draw a clock in a specified period of time. (3)	2.67	2.67	2.70	2.74
Short-term memory recall	The participant must recall a list of 5 words(5)	3.44	3.58	3.44	4.23**
Attention, concentration, other	Repeat, reciprocal number, target detection, subtraction task. (6)	5.46	5.50	5.12	5.51**
Orientation	The participant is asked to give precisely the current date as well as their present location (6)	5.71	5.73	5.86	5.88
TOTAL SCORE	The total possible score is 30 points. A score of 26 or above is considered normal.	24.81	24.96	24.65	26.42**
Salivary α-amylase	Salivary α- amylase reflects sympathetic nervous activity. It rises following a negative stimulus, and reduces following a positive one.	46.33	43.58	47.88	40.51**

Corresponding paired t-test, n=105 (intervention group, n=57; Control group, n=48); ** Significant at 1% level.

Table 2: Comparison before and after the intervention and control groups.

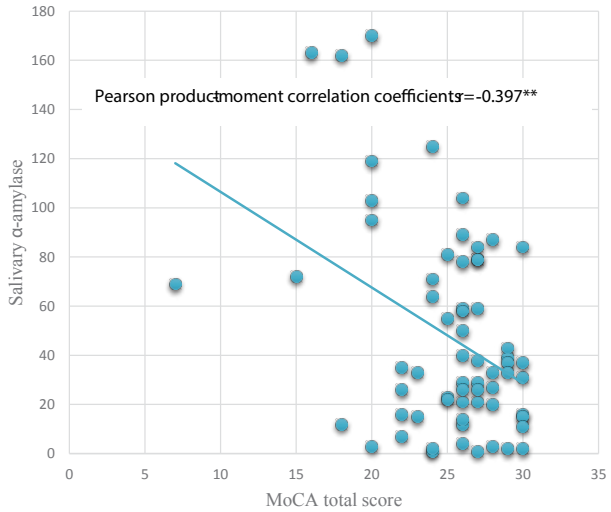

Figure 4: Correlation between cognitive function (MoCa test) and stress (α-amylase).

region from the early stage is extremely needed in the cognitive function-training for elderly people.

As for n-back task, it is a method of measuring the temporary memory ability, introduced by Wayne Kirchner in 1958. It turned out to be not only usable for checking the temporary memory ability but also even effective in improving it, and so has used as a technique of the brain training [18]. So far, it has been clarified that n-back task improves fluid intelligence [19] and increases dopamine density [20] and thus the combination with dual-task can be expected to have a synergistic effect. Since it was verified in this study, we recommend the combination of dual-task and n-back task.

Furthermore, the intervention in this study activates the brain's reward system by improving positive feelings, and so utilizes music therapy. Such the increase in experiencing positive feelings has been reported to result in mental and physical effects such as enhancing a sense of satisfaction for activities and consequently increasing the chance for success [21] improving immune functions [22] enhancing a sense of trust of others and improving the relationship with them [23] giving

positive effects on mental and physical health [24] and accelerating the recovery from illnesses [25].

After the intervention with music therapy in this study, a significant reduction of negative stress was observed. Chronic stresses induce aging of cells [26] and become a factor of deterioration of mental and physical functions, called Functional Somatic Syndrome [27]. Hence, the stress management in older age is extremely important.

The reason of particularly utilizing music therapy in this study was to carry out the rhythmical exercise with music. In Japan, dance with music has been adopted as a required subject in elementary schools and junior high schools since 2012 [28]. This rhythmical exercise can be expected to be substantially effective in improving both mental and physical health, because it does not only activate serotonin to improve one's feelings but also improve physical functions such as the strength of one's legs [29].

More importantly, a negative correlation between cognitive functions and negative stresses was revealed, and it was shown that the reduction of negative stresses is essential to maintain and improve cognitive functions. Since in this study the significant decrease in negative stress was shown by exercising with rhythmical music, we would like to widely recommend this technique.

Repeated verification to refine the intervention method for further cognitive function-improvement and stress reduction and accumulation of effective programs are our future tasks.

Conclusion

The intervention with the combination of n-back task and dual-task utilizing music therapy improved cognitive functions and reduced negative stresses. In addition, a correlation was manifested between negative stress-reflecting salivary α-amylase and cognitive functions, and thus the reduction of negative stress is essential to maintain and improve cognitive functions. Hence, the development of programs enabling the improvement of cognitive functions and the reduction of negative stress at the same time is significantly important, and attempting further development of programs is our future task.

Acknowledgement

We deeply thank participants for their cooperation and all the people involved in this study for their precious time and support.

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