RESEARCH ARTICLE

Examination on Brain Training Method: Effects of n-back task and dual-task [version 1; peer review: 1 not approved]

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Abstract

Background: Alzheimer's dementia (AD) is the most common dementia, accounting for more than 60% of all dementia cases. For adults aged >65 years, the incidence rate doubles for every 5 years of increased age; therefore, preserving cognitive function is a pressing issue. Thus, our team screens for AD in older adults with mild cognitive impairment, at 11 public halls in Kashihara City, Japan, and offers follow-up to those with cognitive difficulties. The purpose of this research was to measure the effects of two interventions, a dual-task (requiring the participant to perform two tasks at the same time) and an n-back task (test of memory retention, requiring the participant to identify the item occupying the nth-back position in a sequence of items). A comparison group performed a single learning task in place of the dual-task. Moreover, the majority of non-drug therapies for the maintenance of cognitive function help promote a positive mood, activating reward systems in the brain and motivating the individual to continue the task. Therefore, the correlation between cognitive function, and positive and negative mood was investigated.

Methods: Dual and n-back task (n = 304) and single-task (n = 78) groups were compared in a 6-month intervention. Salivary α -amylase concentration was measured, which reflects positive and negative mood, and correlations with cognitive function were analyzed.

Results: Cognitive function improved in both the dual-task and the single-task groups, and many cognitive domains had improved in the dual-task group. A correlation between salivary α -amylase and cognitive function was found, indicating that a greater positive mood was associated with greater cognitive function.

Conclusion: The results of this research show that functional decline can be improved by a cognitive intervention. Positive mood and cognitive function were correlated, suggesting that encouraging comfort in the participant can increase the effectiveness of the intervention.

Peer review discontinued

At the request of the author(s), this article is no longer under peer review. [What does this mean?](#)

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Any reports and responses or comments on the article can be found at the end of the article.	

Keywords

MCI, MoCA test, dual-task, n-back task, positive feeling

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Introduction

The Ministry of Health, Labour and Welfare estimates that 15% of the Japanese population aged >65 years have dementia, i.e., a total of approximately 4.62 million individuals (estimated in 2012)¹. Alzheimer's disease (AD) is the most common type of dementia and accounts for 60% or more of dementia cases; vascular dementia is the second most prevalent type of dementia, accounting for 15–20 % of cases². However, many individuals have a mixed dementia type, with lesions characteristic of both AD and vascular dementia³. AD has increased year-by-year⁴, and among adults >65 years of age, the incidence rate doubles with every 5 years of increased age⁵. This means that the construction of countermeasures is an urgent issue. For instance, although the amyloid vaccine was developed in 2000, it could not suppress the decline in cognitive function, even after amyloid β is removed from the brain⁶.

Since taking preventive measures before the onset of dementia is important, a worldwide project, the Alzheimer's Disease Neuroimaging Initiative (ADNI; <http://www.adni-info.org/>), has been implemented to establish a test that can indicate AD before onset, and therefore offer an opportunity for intervention to stop the progression of disease⁷. J-ADNI was also launched in Japan in 2007 (http://www.alz.org/research/funding/partnerships/WW-ADNI_japan.asp), though regional efforts in Japan are still at an early stage.

With this in mind, we started a brain training preventive intervention for AD in Kashihara City (Nara, Japan), at all 11 of the city's public halls. This initiative is a joint project between Nara Medical University and the dementia prevention project of the Kashihara City Council of Social Welfare, and screens individuals for Mild Cognitive Impairment (MCI), with follow-up for those meeting criteria for an MCI diagnosis. Screening is conducted twice a year, using the Montreal Cognitive Assessment (MoCA), a screening scale for MCI (<http://www.mocatest.org/>). Public health nurses conduct follow-up visits to participants with low scores. In addition, a brain training class is held once a month, and prevention interventions and cognitive function evaluations are continuously conducted.

The monthly brain training class aims to inform participants how to take precautions against risk factors for AD, and transform their lifestyle. Risk factors for AD that are targeted comprise of the following: high blood pressure, obesity, smoking, dyslipidemia, and lifestyle-related diseases, such as diabetes, and complications of these⁸. It is reported that the probability of developing AD in the future is 2 times as high in people with hypertension, 2.1 times in those who are obese (with a BMI of 30 or more), 1.8 times in those who smoke, 2.9 times in those with dyslipidemia (total cholesterol 250mg/dl or more), and 4.6 times in people with diabetes (HbA1c, 7% or higher)⁹. Furthermore, in the brains of people with AD, there is an increased quantity of oxidatively modified products¹⁰. Therefore, improving diet is an important part of disease prevention.

Aerobic exercise is also essential in preventing AD. For instance, it has been reported that participation in continuous aerobic exercise is linked to increases in brain derived neurotrophic factor (BDNF) and increases in the capacity of the hippocampus¹¹. In addition, brain training has shown some positive effects on the brain: the n-back task (a test of memory retention, requiring the participant to

identify the item occupying the nth-back position in a sequence of items) has been validated as an effective brain training task, and a meta-analysis indicates that this task is associated with activation of frontal and parietal cortex¹². Furthermore, it has been reported that, compared to a single-task (such as exercise or learning only), a dual-task (requiring the participant to perform two activities at the same time) generates more activation in the brain, in particular in the prefrontal cortex^{13,14}.

Drawing on the above-mentioned previous studies, in this study we considered that an intervention combining healthy-eating habit guidance, aerobic exercise, an n-back task and a dual-task might be effective. In addition, the majority of non-drug therapies, such as music therapy, for the maintenance of cognitive function promote feelings of comfort. These feelings of comfort activate reward systems in the brain, motivating the individual to continue the task in which they are engaged. For instance, in a study comparing the effects of negative and positive feeling, positive feeling increased an individual's repertoire of thinking, behavior and attention, whereas negative feeling reduced an individual's repertoire of thinking and behavior¹⁵. In addition, it is reported that improvement in self-efficacy is related to memory improvement¹⁶. Therefore, we thought it was important that the intervention assessed herein improved positive mood and feelings of comfort; therefore, we decided to use physical recreation in this intervention. The full intervention consisted of diet guidance, recreation, exercise, an n-back task, and a dual-task. The purpose of this study was to measure the effect of this intervention on improving cognitive function, and to clarify whether there is a correlation between cognitive function and positive mood.

Methods

Participants

A total of 382 adults of 65 years or older participated in the present study between June 2015 and June 2016, who volunteered for the intervention. We distributed public information to all houses in Kashihara city and invited participants. The participants were split into two groups: 304 people in a dual-task group, and 78 people in a single-task group.

The dual-task group focused on dietary guidance and recreation, combined with exercise, the n-back task and the dual-task. The single-task group performed learning tasks only.

We explained the contents of the intervention program and divided people who chose composite tasks combining dual-task and n-back task, and those who chose a single task of learning alone. Participants chose the program by themselves, so they were divided into unbalanced groups.

The exclusion requirement for intervention was people who could not move by themselves; however, all participants that volunteered were able to clear the requirement.

The intervention is once a month, the evaluation of cognitive function is before intervention and once every six months after intervention. Stress checks were carried out using salivary amylase before intervention.

Intervention

Intervention method. As an intervention method, the cognitive prevention class was held once a month and focused on diet guidance and recreation, combined with exercise, the n-back task, and the dual-task. Subjects received 12 interventions a year. Diet guidance was carried out using the following content:

1. Correlation between vascular age and cognitive function: Diet that prevents arteriosclerosis.
2. Reduced salt and reduced trans fatty acids.
3. Increased omega-3 fatty acid.
4. Diet to prevent saccharification.
5. Food containing antioxidants.

This has been continued for about 20 minutes.

For the exercise requirement, aerobic exercise was conducted under the guidance of an occupational therapist. The aerobic exercise undertaken was rhythmic gymnastics tailored to music, and was continued for about 20 minutes at a time.

The n-back task is a delayed recall task, in which subjects answer tasks a certain number of times. Subjects started this experiment from a set of back tasks and kept adding an extra set of back task each time for 40 minutes. Gradually, the difficulty of the tasks increased.

For a set of back tasks, subjects first memorized ten random words by reading them aloud. Subjects were not allowed to write them down. After that, subjects performed a dual task game and then wrote down what they remembered from those ten words. For the second set of back tasks, subjects memorized a new set of ten words and then played two dual task games. After playing two games, they tried to write down as many words as possible from those new ten words that they had memorized. For the third set of back tasks, they again memorized a new set of ten words, played an additional dual task game and did the same thing. They continued this process for 40 minutes and increased the difficulty of the n-back task.

Upon conducting the dual-task (<http://www.ncgg.go.jp/cgss/depart-ment/cre/cognicise.html>), we have registered at Japan Cognisize Spread Secretariat, which spreads exercise method by dual-task (<http://www.ncgg.go.jp/topics/20150512.html>), and conducted it. The dual-task requires the participant to perform two activities at the same time, such as arithmetic calculations while stepping.

As a comparison to the dual-task, a single learning task was conducted. In this method, we conducted a lecture style learning task for 90 minutes with a 10 minute break in the middle.

Evaluation methods

MCI screening. MCI screening was used for comparison before intervention and after 6 months and was conducted using the Montreal Cognitive Assessment (MoCA: http://www.mocatest.org/pdf_files/instructions/MoCA-Instructions-English_2010.pdf).

This is a 30-point scale; a higher score indicates higher cognitive function. The cut-off value for MCI is 26 points. We obtained a license to use the scale from Dr. Ziad Nasreddine, the developer of the original version.

Measurement of positive and negative mood. Positive and negative mood was measured by collecting sublingual saliva and measuring salivary α -amylase concentration (NIPRO; catalog number, 34549000). This was measured before intervention. Salivary α -amylase reflects sympathetic nervous activity. It rises following a negative stimulus, and reduces following a positive one¹⁷. The reference values of salivary α -amylase by NIPRO, the manufacturer of the measurement device, is as follows:

- 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 or more: There is a high amount of negative stress.

Analytical methods

To compare MoCA scores before and after the intervention, paired t-test were conducted. Correlations of MoCA scores with age and salivary α -amylase were computed using Pearson product-moment correlation coefficients. SPSS 21.0 for Windows was used for analysis.

Ethical considerations

This study was approved by the Ethics Committee of the Nara Medical University (approval number: 741). For the benefit of the participants, we explained in speech and writing: (i) the purpose and method of the study; (ii) the freedom and veto each individual had over participation; (iii) the measures taken to protect privacy; (iv) the approach to data management; (v) and our intentions regarding publication of the results. Written informed consent was required for participation.

Clinical trial registration

This study has been retrospectively registered in the clinical trial registration database: University Hospital Medical Information Network (UMIN), registration date: December 31, 2016; registration number: R000028956. (https://upload.umin.ac.jp/cgi-open-bin/ctr/ctr_view.cgi?recptno=R000028956).

Results

The intervention had a 100% completion rate. The average age of the subjects was 72.3 ($\pm$ 6.6) years old. The group consisted of 129 men and 253 women. The MoCA scores for each age category (50s, 60s, 70s, and 80s) are shown in **Figure 1**. This was measured before intervention. The correlation coefficients between age and each cognitive function at the beginning of the intervention are also shown in **Figure 1**. These are classified by MoCA Assessment items.

As shown in **Figure 1**, the cognitive function with the strongest negative correlation with age at the start of the intervention was the short-term memory recall task; the MoCA score rapidly decreased

Figure 1. The relationship between MoCA scores and age Pearson moment correlation coefficient, $n = 382$.

in participants in their 70s and 80s compared to participants in their 50s and 60s ($r = -0.56$). Other tests whose results were negatively correlated with age were the trail making task and the clock-task (together indicating visuospatial cognitive ability, $r = -0.38, -0.49$), verbal fluency (memory retrieval ability, $r = -0.46$), attention, concentration and working memory (ability to concentrate and attention and memory, $r = 0.53$), repetition task (memory, $r = -0.49$), abstract thinking ($r = -0.31$), and orientation ($r = -0.34$). Cognitive functions that were maintained with increasing age were visuoconstructional skills (cube: graphic replication) and naming (animal name recall).

With an intervention once a month, an evaluation can be seen before and six months after the intervention in Table 1. This is a comparison of the results of all ages. The average of the total scores before the intervention was >26 points in both the dual-task group and the single-task group; this met the cut-off value for MCI (26 points). After the intervention, there was significant improvement in both the dual-task group and single-task group, and the average value on the MoCA was above the cutoff value for MCI ($p < 0.01$).

Comparing the results of the dual-task group and the single-task group, only the dual-task group showed a significant improvement in the trail making and the cube drawing tests (visual-spatial

cognitive abilities), and in abstract thinking, speaking in order, speaking in reverse, sustained attention, and calculation (ability to concentrate & attention & memory) ($p < 0.01$). There were significant improvements in both the dual-task and single-task groups in the verbal fluency, the repetition task (memory), delayed recall task (memory playback capability), and in the overall score on the MoCA (the presence or absence of MCI) ($p < 0.05$).

Regarding collection of salivary amylase, was taken at a briefing session before the intervention. At that time, the subjects, after receiving the MoCA test, remained in the venue and collected saliva. As it takes time to collect individual saliva and measure alpha amylase, only subjects with time remained in the venue. In addition, there were subjects who were unable to measure α -amylase (measurement error) subject to influence of hypertensive internal medicine and others. For this reason, the number of subjects that were able to collect the salivary α -amylase, is 280 people. In the measurement of salivary α -amylase, the minimum value was 2 KU/L and the maximum value was 216 KU/L (mean, 49.7 ± 47.0). The correlation of salivary α -amylase and MoCA total score was negative ($r = -0.31$).

Therefore, there was a trend for MoCA scores to be lower in individuals experiencing greater stress (Figure 2).

Table 1. Comparisons of the dual-task and single-task groups before and after the intervention. Corresponding paired t-test, n=382 (dual task, n= 304; single task, n= 78). These are the average scores of all participants in all age groups (mean).

MoCA test component	Description of the test component (maximum score)	Before/after comparison			
		Dual-task	p-value	Single-task	p-value
Trail Making	Subject alternates between connecting numbers and connecting letters, in the ascending order "1→A→2→B..." (1)	0.51 0.86	0.000	0.69 0.64	0.045
Visuoconstructional skills	The participant is asked to accurately replicate a drawing of a cube. (1)	0.97 1.00	0.001	0.97 1.00	0.159
Verbal fluency	The participant is asked to list as many words as possible that begin with a designated letter of alphabet (1)	0.43 0.68	0.000	0.60 0.73	0.001
Repetition	The participant is read a sentence and asked to repeat it back exactly. (2)	0.85 1.52	0.000	0.99 1.59	0.000
Abstract thinking	The participant is required to describe what characteristic 2 words have in common (2)	1.48 1.81	0.000	1.86 1.94	0.083
Naming	The participant is shown pictures of animals and asked to correctly name them. (3)	2.82 2.93	0.000	3.00 3.00	1.000
Visuoconstructional skills	The participant is asked to draw a clock in a specified period of time. (3)	2.39 2.74	0.000	2.85 2.97	0.001
Short-term memory recall	The participant must recall a list of 5 words (5)	2.49 3.75	0.000	2.99 3.49	0.000
Attention, concentration, other	Repeat, reciprocal number, target detection, subtraction task. (6)	4.93 5.69	0.000	5.55 5.54	0.658
Orientation	The participant is asked to give precisely the current date as well as their present location (6)	5.46 5.56	0.000	5.83 5.92	0.019
TOTAL SCORE	The total possible score is 30 points. A score of 26 or above is considered normal.	22.33 26.54	0.000	25.33 26.82	0.000

Figure 2. Correlation between salivary α -amylase and MoCA total score. N=280.

Dataset 1. MoCA scores and age.

<http://dx.doi.org/10.5256/f1000research.10584.d150825>

Sheet 1 is the data before age and MoCA test intervention and after intervention. Sheet 2 is the data before and after the intervention divided into the dual-task group and the single-task group.

Dataset 2. MoCA and salivary amylase

<http://dx.doi.org/10.5256/f1000research.10584.d150826>

This is the data showing the score of the MoCA test before the intervention and the measured value of salivary α -amylase.

Discussion

Prophylactic interventions of AD, which were carried out in each municipality, are still at the stage of trial and error (<http://www.mhlw.go.jp/file/06-Seisakujouhou-12300000-Roukenkyoku/0000136616.pdf>). As shown in this study, dementia preventive measures in Japan, there is a disparity of each municipality. A preventive program for dementia has not been established yet. It can be noted that general cognitive function, which decreased along with age, can be dissociated from specific cognitive functions, some of which were relatively maintained with increasing age. The specific cognitive function that had the strongest negative correlation with age was the delayed recall task, which requires the individual to memorize five nouns and to recall them after about five minutes. The brain's ability to memorize new things, maintain them, and reproduce them rapidly decreased in proportion to age. Performance on the trail making and clock-drawing tasks (both measuring visuospatial cognitive ability) also rapidly decreased with age. Visuospatial cognition refers to the brain's ability to process visual information. When this ability declines, people tend to get lost¹⁸. There were also correlations between age and word recall (thinking ability), speaking in order, speaking in reverse, sustained attention and calculation (ability to concentrate & attention & memory), and the repetition task (memory). Decreased performance in the word recall task indicates that an individual may have trouble recalling words during a conversation. Decreasing ability to concentrate affects safety and the continuity of actions; when attention is impaired, people struggle to maintain attention on stimuli, so their actions become distracted¹⁹. Memory was assessed in this study through tasks requiring the participants to speak in order, to speak in reverse, and to listen to and reproduce sentences. A decline in memory due to aging (age-associated memory impairment) is caused by a decline in the function of cranial nerve²⁰ and a failure in the network of the brain²¹. Disruption to the cognitive functions considered above adversely affects daily life and lowers safety. Therefore, reducing the risks associated with cognitive decline is an important issue. By contrast, some cognitive functions were maintained even with increasing age, as indicated by performance on the tasks requiring shape replication, animal name recall. These tasks require the reproduction of familiar forms, learned from a young age, and are not tasks in which the participant memorizes new things. Abstract thinking is also a common task of the

situations that require common knowledge. In tasks based on familiar stimuli, cognitive function is maintained with increasing age. Due to this, familiar experiences are easier to retrieve²².

Comparing scores before and after the intervention, the cognitive tasks that improved significantly in the course of the intervention were the trail making and clock drawing tests (visual-spatial cognitive ability), abstract thinking, speaking in order, speaking in reverse, sustained attention and calculation (ability to concentrate & attention & memory), the repetition task (memory), the delayed recall task (memory playback capability). All these cognitive functions decrease with age, but here showed an improvement throughout the intervention; importantly, these functions are associated with the ability of an older person to keep safe and secure in their everyday life.

On comparing the results of the dual-task group and the single-task group, a greater number of cognitive functions showed significant improvement in the dual-task group. Comparing the results after intervention, visuospatial cognition, abstract thinking, concentration, attention, and memory, only those within the dual-task group showed significant improvement. To run two tasks at the same time, the frontal lobe, and in particular the most anterior region, the prefrontal cortex, is essential²³. Based on this understanding, the dual-task is considered to train the frontal lobe, and this view has been supported by neuroscience studies that show frontal activation during the dual-task^{24,25}. The prefrontal cortex ages earlier than other brain regions²⁶, meaning that cognitive training for the elderly needs to be considered a priority on maintaining the function on the prefrontal cortex. Interestingly, it has been found that the number of neural stem cells, which are needed for the regeneration of nerve cells, is maintained, even with increasing age^{27,28}. Thus, it is reasonable to expect that cognitive training can maintain cognitive function by drawing on these neural stem cells.

The n-back task, first introduced by Wayne Kirchner in 1958²⁹, measures the capacity of an individual's working memory. It has been demonstrated that the n-back task not only measures working memory, but also can improve it when structured in a brain training intervention. Improvements in fluid intelligence³⁰, and increased density of dopamine³¹ have been demonstrated. A synergistic effect in combination with dual-task can be expected.

In addition, the present intervention improved positive mood, presumably activating the brain's reward system. An increase in positive feelings is reported to have effects on body and mind, such as increasing satisfaction and success³², improving immune function³³, increasing confidence towards others and fostering closer relationships³⁴, positively affecting physical and mental health³⁵, and speeding up recovery from disease³⁶. Thus, by targeting an improved positive mood, other positive effects might be expected. In the present study, a correlation was found between salivary α -amylase, which reflects mood, and cognitive function; when negative stress was high, the MoCA was low. Our research group, in a study in the last year, demonstrated a correlation between

the ability to cope with stress (Sense of Coherence SOC) and cognitive functions³⁷, and the current study supports this finding.

Conclusion

An intervention, combining exercise, an n-back task, and a dual-task, improved performance in a greater number of areas of cognitive function, compared with a similar intervention in which a single learning task was substituted for the dual-task. The cognitive functions that decreased most with increasing age were delayed recall, visuospatial cognition, thinking, concentration, attention, and memory. The cognitive tasks that had no correlation with age, and were maintained even with age, were graphic replication, animal name recall, abstract thinking, and orientation – all of which require the reproduction of familiar forms or names. The results of this study show that it is possible to improve cognition by a structured intervention. In addition, a correlation between cognitive function and positive mood has been demonstrated by the present study. It would be interesting to investigate whether improvement in positive feeling directly improves the effectiveness of brain training.

Data availability

Dataset 1. MoCA scores and age. Sheet 1 is the data before age and MoCA test intervention and after intervention. Sheet 2 is the data before and after the intervention divided into the dual-task group and the single-task group. doi, [10.5256/f1000research.10584.d150825](https://doi.org/10.5256/f1000research.10584.d150825)³⁸

Dataset 2. MoCA and salivary amylase. This is the data showing the score of the MoCA test before the intervention and the measured value of salivary α -amylase. doi, [10.5256/f1000research.10584.d150826](https://doi.org/10.5256/f1000research.10584.d150826)³⁹

Author contributions

KS, YK, and CS conceived the study. All authors implemented this intervention, carried out the data collection and reported the results of the functional evaluation to the participants.

KS directed the project and drafted the manuscript. All authors were involved in the revision of the draft manuscript and have agreed to the final content.

Competing interests

This study was a collaborative project led by the Kashihara City Council of Social Welfare. No competing interests were disclosed.

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Supplementary material

Supplementary File 1: CONSORT checklist.

[Click here to access the data.](#)

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At the request of the author(s), this article is no longer under peer review. What does this mean?

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Examination on brain training method: Effects of n-back task and dual task

Summary of overview: Although the authors have a large sample and an innovative approach providing their participants with several interventions in a monthly session, the groups are poorly defined and do not adhere to the literature on dual-task (see meta-analysis or reviews on the topic, for example: Verhaeghen *et al.*, 2003¹, Fraser & Bherer, 2013²). Dual task is a combination of two tasks and when these two tasks are examined alone these are the single tasks. In the study described, I believe that the authors are comparing a combined intervention group (including dual-task, n-back, education, etc.) and an active control group (that listened to lectures), but the manuscript does not present it this way. The rationale for examining the individual components of the MoCA between the groups and correlating salivary samples is also not clear to the reader from the overview provided. There is a possible self-selection bias and confound that the "dual task group" has lower MoCA scores at baseline. There is no indication of whether or not the individual components of the combined intervention group (dual task group) improved...Did those that completed dual task training, n-back training get better on those tasks? The paper needs to be completely revised properly labelling the two groups and identifying the MoCA and the salivary measures as the primary outcome measures of interest in this study.

Title: Examination on brain training method: Effects of n-back task and dual task

This title does not reflect the contents of the paper

Abstract:

Background: Rationale for mood measures not clearly stated. Perhaps: The majority of non-drug interventions (this way there is a link with the 2 interventions (dual task + n-back studied))

Methods: 6 month intervention? Was this conducted in groups? How many times per week?

Results: Many cognitive domains improved – What cognitive domains were measured? In methods, should state that participants had neuropsychological testing (if this is the measure of cognitive domains).

Correlations with cognitive function and salivary α -amylase: Which cognitive functions? N-back performance, dual task performance or single task? The statement of these results is too vague.

Conclusions: First sentence...perhaps functional decline can be reduced with cognitive intervention? Second sentence: "Positive mood and cognitive function were correlated, suggesting that encouraging comfort in the participant can increase the effectiveness of the intervention." I do not understand how this conclusion stems from the correlation between salivary α -amylase and cognitive function.

Introduction: "In addition, a brain training class is held once a month, and prevention interventions and cognitive function evaluations are continuously conducted." This sentence from the introduction sounds like methodology...perhaps stated differently: In these public halls brain training classes were offered once a month and prevention interventions.... Also, how is brain training and prevention interventions different here? And what is meant by continuously conducted? Is this every week, every day?
Brain training – is risk prevention class? The description that follows brain training suggests that it is an educational class not a training class.

To my knowledge, the n-back task has not been validated as an effective brain training task – Can you provide a reference for this statement? There has been specific demonstration n-back training on fluid intelligence (Jaeggi and colleagues)...but broadly stating that it is valid and effective based on these results is not accurate.

Rationale for all the different "interventions" is not clear. In the one session of brain training, all participants got aerobic training, n-back, dual task, lifestyle education for brain health, recreation?

Methods: The distinction between what has been labeled dual task group and single task group is not clear. I believe these groups have not been appropriately labeled. Especially since the dual task group is doing more than a dual task. This is a combined intervention group that is exposed to many different interventions including dual task but is not a dual-task specific intervention group. And single task, typically this means that the person would only complete one component of the dual task - so if the task is walking and talking, then participants would only walk alone and talk alone but never perform the two tasks together.

The participants chose the groups themselves? This creates a selection bias – how do you control for this?

Description of the n-back task unclear. Did they have to remember one item back, two items back? See Jaeggi *et al.*, 2003³ for visual description of one type of n-back task...Was this an auditory n-back task?

For the dual-task, the example provided is stepping with arithmetic – were there other combinations of tasks? This is not clear from the description. Typically dual task performance is compared to single task performance on the component tasks (i.e., if stepping and arithmetic as dual task then this would be compared to performance on arithmetic alone (no stepping) or stepping alone (no arithmetic).

The use of a completely different task: lecture style learning task is not an appropriate comparison for the dual task performance. Also what is a lecture style learning task? Are participants presented a lecture on some topic?

Was anything measured in these trained tasks? Reaction times? Accuracy? Steps taken?

Results:

All participants are pooled for the correlational results? Initially you mentioned having 2 groups (dual task and single task).

The MoCA is typically a global cognitive function score on 30...I have never seen this broken down by each item...it is not a neuropsychological battery – it is a global score. Can you provide rationale for this type of analysis? Was there a significant correlation between age and the global score on 30?

In Table 1. Based on the global score the combined intervention group (or dual task group) had lower overall MoCA scores than the Single task group at baseline. But the change from pre to post in the global score on 30, seems larger in the dual task group (up by 4.21 points) versus single (up by only 1.49 points).

Discussion: Not reviewed because other sections need major clarification.

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Is the work clearly and accurately presented and does it cite the current literature?

No

Is the study design appropriate and is the work technically sound?

No

Are sufficient details of methods and analysis provided to allow replication by others?

No

If applicable, is the statistical analysis and its interpretation appropriate?

Partly

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?

No

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Dual-task, Aging, Cognitive Function, Physical Function, Neuroimaging

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.

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