

Tomomi NAKAJIMA
Fujita Health University
e-mail:tomomi.nakajima@fujita-hu.ac.jp

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Evidence Building for Animal Therapy in the Elderly : Validation Through Frontal Lobe Function Assessment

Research Objectives

This study aimed to investigate the effects of Dog Assisted Activities (DAA) on the frontal lobes of healthy older adults at high risk for dementia.

Setting

Participants were recruited from healthy individuals aged 65 and older living in a local city in Japan. The experiment was conducted at the Japan Hearing Dog Association's training facility.

Participants

Participants were divided into two groups.

: Command Task group

21 participants (mean age 74.7 ± 5.2 years)
They performed tasks involving giving commands to the dogs.

: Communication Task group

20 participants (mean age 71.3 ± 4.0 years)
They interacted with the dogs by holding and petting them.

Interventions

Before the DAA, participants completed the Trail Making Test Part A (TMT-A Figure1), which assesses frontal lobe function. In the command-task group, seated participants instructed a dog to pick up a spoon and a newspaper from the floor. In the communication task group, seated participants held, petted, and talked to a small dog on their lap.

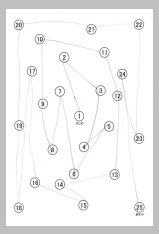


Figure- 1． TMT-A

Main Outcome Measure(s)

Oxygenated hemoglobin (oxy-Hb) concentrations were measured during all tasks using functional near-infrared spectroscopy (fNIRS).The Brodmann areas analyzed included the dorsolateral prefrontal cortex (BA9, BA46), inferior prefrontal cortex (BA47), and frontal pole (BA10). Paired t-tests were used to compare oxy-Hb differences between the command-task and TMT-A, as well as between the communication task and TMT-A.



Figure-2.
left:command-task
right: communication-task

fNIRS Analysis

The mean oxyhemoglobin (oxy-Hb) value during the 10-second period immediately preceding the onset of each task was used as the baseline (Figure 3). Each task was initiated with a verbal cue, after which most participants exhibited a brief pause of approximately 2 seconds before beginning the task. Therefore, task-related activation was defined as the mean oxy-Hb value over a 10-second window starting 2 seconds after task initiation.

Raw oxy-Hb data acquired via fNIRS during the tasks were normalized to z-scores using the following formula:

$$\text{z-score} = \frac{(\mu_1 - \mu_2)}{\sigma}$$

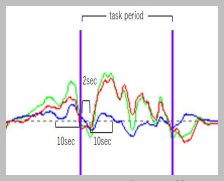


Figure-3. raw data cllected

where μ_1 represents the task value, μ_2 the baseline value, and σ the standard deviation of the baseline period.

Finally, differences in mean task-related activationbetween the TMT-A and command tasks were assessed using a paired t-test.

Results (Table .1)

Activation during the **command task** was **not significantly** different from TMT-A across all areas. However, during the **communication task**, activation was **significantly lower than TMT-A** in **right BA47** and **BA10**, as well as **left BA10**.

Discussion

■ **Effects of the Communication Task**

Partial improvement observed in specific cognitive functions
Potential contribution to improvements in cognitive functions

#Right BA9 : Activation levels comparable to TMT-A

- Indicated focused attention and interest in the dog
- Monitoring of episodic memory related to interaction with the dog
- Activity levels sufficient to support basic daily cognitive functioning

#Right BA10 : Activation levels comparable to TMT-A

- Improved attention control in older adults who exhibit excessive attentional switching(Rajah et al., 2011)

#Left BA9/BA46 : Activation levels comparable to TMT-A

- Involved in monitoring and manipulation of external information(Christoff et al., 2000)
- Also related to simulation of hypothetical events(Benoit et al., 2015)

#Other Channels(e.r.,right BA47 and BA10, left BA10)

: Significantly lower activation or smaller effect size compared to TMT-A.

- Overall effect considered limited

■ **Effects of the Command Task**

＊ Includes the effects of the Communication Task, with broader cognitive engagement.

#All examined channels showed activation levels comparable to TMT-A

- A broad range of cognitive functions necessary for daily life were activated

#Relevance to ADL in older adults

- Attention functions are crucial for basic ADL
- TMT-A performance is a significant predictor of ADL independence
- The Command Task may serve as an effective cognitive intervention to promote independence ADL

■ **Additional Hypothetical Effects of the Command Task**

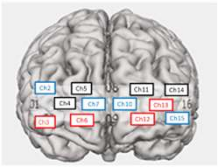
#Right BA46/BA47 : Improvement of apathy, mentalizing, emotional and motivational regulation, and mood adjustment in social situations(Yordanova et al., 2003)

#Right BA47/BA10 : Enhancement of prospective memory(Burgess et al., 2007)(Jones et al., 2021)

#Left BA10/BA47 : Improved understanding of emotional expression and enhanced empathy (Liakakis et al., 2011) (Decety et al., 2015)

●Attentional function plays a critical role in the performance of basic ADL in older adults. (Ramzaoui et al., 2018)
●TMT is widely regarded as a reliable measure of this cognitive domain. (Treviño et al., 2021)
●The ability to complete TMT-A is a significant predictor of functional independence in basic ADL among the elderly. (Cornelis et al., 2019) (Arentsen et al., 2022)

fNIRS data（z -score）



command-task Ch4, 5, 11, 14
: Brain Regions Showing Activity Comparable to TMT-A

Right Hemisphere

•Ch4 (BA10, MFG): Reduced activity in this region has been associated with apathy and diminished interest in external stimuli (Michel Benoît et al., 2004). The observed activation here suggests that participants exhibited interest in the dog stimulus.

•Ch5 (BA9, dlPFC): This region is implicated in the retrieval, evaluation, and monitoring of episodic memory (Matthew D. et al., 2007), and is also involved in decision-related and monitoring processes across multiple cognitive domains (Hayama et al., 2009).

Left Hemisphere

•Ch11 (BA9) & Ch14 (BA46), dlPFC: These areas are responsible for monitoring and manipulating information derived from external stimuli (Christoff et al., 2000). The activation patterns suggest participants were focused on sensory input from the dog.

Table 1. fNIRS data

「TMT-A」＊「communication-task」paired-samples t-test

right-side	oxy-Hb mean (mM*mm) TMT-A	communication-task	defference in mean 「TMT-A」-「communication-task」	Cohen's d	t	v	p-Value	broadmann area
Ch 2	**4.62 ±4.03**	**2.24 ±4.12**	**2.38 ± 3.49**	**0.60**	**3.12**	**20**	**0.005 ****	**BA46**
Ch 3	**8.17 ±7.44**	**2.82 ±4.34**	**5.35 ± 7.39**	**0.90**	**3.32**	**20**	**0.003 ****	**BA47**
Ch 4	1.39 ±6.94	0.18 ±5.48	1.21 ± 7.53	0.20	0.74	20	0.469	BA10
Ch 5	4.79 ±8.80	3.20 ±7.349	1.59 ± 9.45	0.20	0.77	20	0.450	BA 9
Ch 6	**7.77 ±6.15**	**3.03 ±3.85**	**4.75 ± 7.31**	**0.95**	**2.98**	**20**	**0.008 ****	**BA10**
Ch 7	**2.77 ±4.75**	**-0.43 ±4.03**	**3.20 ± 4.10**	**0.74**	**3.58**	**20**	**0.002 ****	**BA10**
left-side								
Ch 10	**4.34 ±8.21**	**-0.22 ±4.55**	**4.56 ± 7.20**	**0.70**	**2.90**	**20**	**0.009 ****	**BA10**
Ch 11	7.00 ±7.83	3.58 ±3.71	3.42 ± 9.00	0.57	1.74	20	0.097	BA 9
Ch 12	**6.86 ±7.48**	**2.47 ±2.50**	**4.39 ± 7.14**	**0.81**	**2.82**	**20**	**0.011 ***	**BA10**
Ch 13	**5.70 ±5.55**	**1.46 ±3.61**	**4.24 ± 6.84**	**0.93**	**2.84**	**20**	**0.010 ***	**BA10**
Ch 14	6.86 ±6.31	4.37 ±4.26	2.49 ± 5.87	0.47	1.95	20	0.066	BA46
Ch 15	**8.82 ±9.19**	**3.63 ±8.44**	**5.19 ± 7.90**	**0.60**	**3.01**	**20**	**0.007 ****	**BA47**

「TMT-A」＊「command-task」paired-samples t-test

right-side	oxy-Hb mean (mM*mm) TMT-A	command-task	defference in mean 「TMT-A」-「command-task」	Cohen's d	t	v	p-Value	broadmann
Ch 2	4.36 ±6.98	2.20 ±4.48	2.15 ±6.08	0.38	1.58	19	0.13	BA46
Ch 3	6.53 ±8.52	4.85 ±5.95	1.68 ±10.30	0.23	0.73	19	0.48	BA47
Ch 4	2.83 ±5.59	2.41 ±3.82	0.42 ±6.22	0.09	0.30	19	0.77	BA10
Ch 5	3.37 ±6.38	2.63 ±4.728	0.74 ±7.63	0.14	0.43	19	0.67	BA 9
Ch 6	7.23 ±9.98	3.42 ±6.10	3.82 ±10.65	0.47	1.60	19	0.13	BA10
Ch 7	2.51 ±4.63	2.65 ±4.51	-0.14 ±5.27	0.03	0.12	19	0.91	BA10
left-side								
Ch 10	3.39 ±5.16	2.49 ±5.01	0.90 ±6.34	0.18	0.64	19	0.53	BA10
Ch 11	3.74 ±5.31	2.70 ±4.22	1.04 ±5.75	0.22	0.81	19	0.43	BA 9
Ch 12	5.72 ±9.44	3.74 ±5.18	1.98 ±9.80	0.27	0.90	19	0.38	BA10
Ch 13	2.56 ±4.95	2.49 ±2.88	0.07 ±5.89	0.02	0.05	19	0.96	BA10
Ch 14	5.61 ±6.55	4.30 ±3.33	1.31 ±6.64	0.26	0.88	19	0.39	BA46
Ch 15	6.89 ±8.40	5.03 ±5.04	1.86 ±8.84	0.28	0.94	19	0.36	BA47