A Possible Effect of the PICMOR Intervention Program on Regional Brain Volume in Older Adults

Hikaru Sugimoto & Mihoko Otake-Matsuura

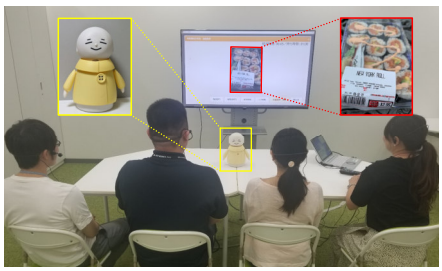
RIKEN Center for Advanced Intelligence Project

Introduction

Background

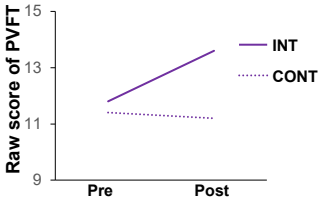
- Interest in the development of methods to prevent or delay dementia is growing rapidly[1]. Given evidence of a relationship between cognitive function and social interaction[2], interventions that include social activities could be candidates for such methods.
- However, evidence regarding the effects of social activity-based interventions on cognitive functions is still scarce[3].
- Towards addressing this gap, we have developed an intervention program named **Photo-Integrated Conversation Moderated by Robots (PICMOR)**[4].

PICMOR

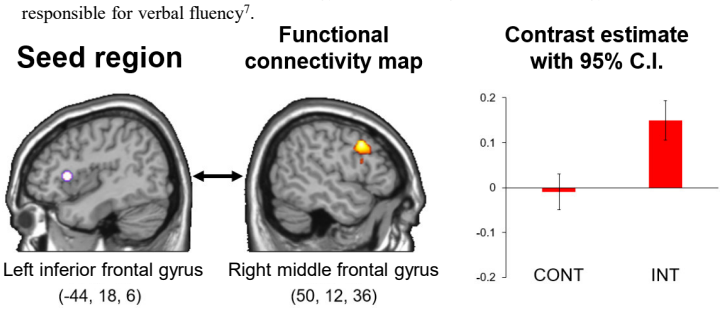


- The PICMOR offers a moderated group conversation context with robot-based facilitation.
- Specifically, a robot encourages participants to talk about their daily life, using photos they have prepared beforehand, and to answer questions asked by other people about the topic.
- Alternatively, they are required to listen carefully to others and ask them questions.
- This program is partly characterized by **enforced output**, where the system and robot have been designed to directly and strongly encourage participants to continue talking about various topics for a certain length of time.

Our previous findings



- To examine the effect of PICMOR on cognitive functions in older adults, we previously conducted a randomized controlled trial (RCT)[4].
- Participants in **the intervention group (INT)** took part in the PICMOR once a week for 12 weeks, while participants in **the control group (CONT)** joined in a control program, in which they were asked to make a group conversation without photos or robotic supports.
- We found a significantly larger increase in the score obtained in **the phonemic verbal fluency task (PVFT)**, which is included in the Japanese version of Montreal Cognitive Assessment (MoCA-J)[5], in INT than in CONT through the intervention period.
- The verbal fluency task is often used to measure verbal ability and executive control ability[6].
- Our previous RCT study employed the standard PVFT, in which participants were required to produce as many words as possible beginning with a specific letter (/ka/ in Japanese)[5].
- The number of correct unique words generated in one minute was used as a measure of performance.
- Given the difference in training demands between the two groups (i.e., enforced output), it would be reasonable to assume that **the verbal ability to produce language within a limited time** was enhanced in INT compared with CONT through the intervention period, and therefore, differences in the brain networks responsible for verbal fluency emerged between the two groups.
- Indeed, we found significantly higher resting-state functional connectivity in INT than in CONT between the left inferior frontal gyrus seed and right middle frontal gyrus, which are responsible for verbal fluency[7].



Purpose

- To provide candidates for brain regions that could reflect the beneficial intervention effects of PICMOR on brain structures for future research, we additionally conducted a **voxel-based morphometric analysis** for the structural MRI data that were obtained after the intervention and examined a possible difference in brain structures between the two groups.

Methods

Participants

- Sixty five healthy community-dwelling older adults, who participated in our previous RCT study (32 in INT and 33 in CONT)[4], were recruited in the present study.
- A total of 61 participants, including **31 in INT** and **30 in CONT** took part in MRI scanning.
- All participants were right-handed and native Japanese-speaking individuals.
- They gave informed consent for the protocol, which was approved by the IRB of RIKEN.

	INT (N = 31)	CONT (N = 30)	Group difference
Age (mean ± SD)	72.84 ± 3.45	72.03 ± 2.72	$t(59) = 1.01$, $p = 0.32$
Gender (males : females)	16 : 15	13 : 17	$\chi^2(1) = 0.15$, $p = 0.70$
Educational level (≥ 13 years : < 13 years)	20 : 11	17 : 13	$\chi^2(1) = 0.13$, $p = 0.71$
Amount of talking time in group conversations during the intervention period (sec) (mean ± SD)	5000.52 ± 800.63	7627.19 ± 3377.06	$t(59) = 4.21$, $p < 0.01$
PVFT score at the pre-intervention (mean ± SD)	12.03 ± 3.61	11.13 ± 4.07	$t(59) = 0.91$, $p = 0.36$
PVFT score at the post-intervention (mean ± SD)	13.71 ± 3.55	11.07 ± 2.95	$t(59) = 3.16$, $p < 0.01$

Methods

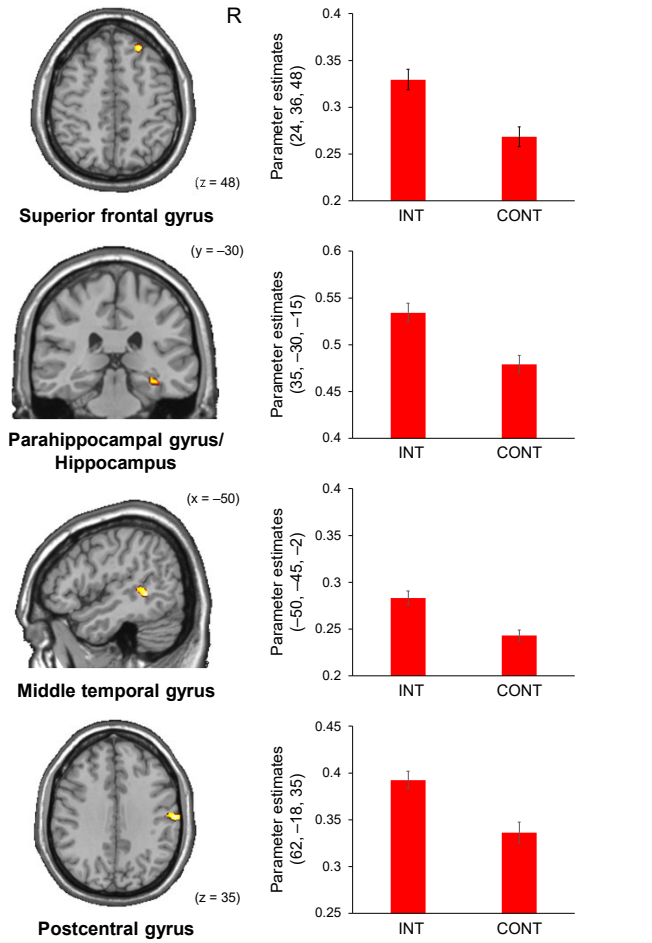
Data acquisition

- All MRI data were acquired with a Philips Achieva 3.0 MRI scanner. The data were collected only after the intervention.
- Anatomical structures were scanned by a high-resolution T1-weighted [repetition time = 6.41 ms, echo time = 3.00 ms, field of view = 24.0 cm × 24.0 cm, matrix size = 256 × 256, slice thickness/gap = 1.2/0 mm, 170 sagittal slices].

Data analysis

- **Preprocessing:**
  The data were analyzed by SPM12. First, the images were segmented into intracranial parts and non-brain structures[8]. Second, the registration process was implemented by the DARTEL toolbox[9]. Third, we spatially normalized individual images into the MNI space with a resolution of 1.5 × 1.5 × 1.5 mm^3 voxels. Fourth, normalized images were modulated. Finally, these images were smoothed with a Gaussian kernel of 8 mm FWHM.
- **Group analysis:**
  A binarized mask image was made from the preprocessed images by a masking toolbox. Employing this mask image as an explicit mask, we conducted a **two-sample *t*-test** to identify group differences in regional brain volumes. The model included participants' age, gender, and education level as nuisance covariates. Total intracranial volumes (TIV) were also entered into the model for global calculation.
- **Statistics:**
  In the present study, 1,000-iteration Monte-Carlo simulations were employed to determine a sufficient voxel contiguity threshold[10], assuming a type I error voxel-level threshold of $p = 0.001$ and a cluster extent threshold of $p < 0.05$. Results indicated a cluster extent of 69 contiguous resampled voxels was sufficient to correct for multiple comparisons. Based on the simulations, clusters with at least 69 voxels were reported in this study.

Regions showing greater volume in INT than in CONT



The superior frontal gyrus, parahippocampal gyrus/hippocampus, middle temporal gyrus, and postcentral gyrus showed significantly greater volume in INT than in CONT.

Conclusion

- **This pilot study provided the candidates for brain regions that could reflect the beneficial effects of PICMOR on brain structures, including the lateral prefrontal cortex that plays an important role in executive functions.**
- **Further investigation will be needed to confirm this possible effect by collecting and comparing MRI data from the pre- and post-intervention periods in future studies.**

References

1. WHO guidelines, 2019.
2. Kelly et al., *Syst Rev*, 6: 259, 2017.
3. Livingston et al., *Lancet*, 390: 2673-2734, 2017.
4. Otake-Matsuura et al., *MedRxiv*, 2019.
5. Fujiwara et al., *Geriatr Gerontol Int*, 10: 225-232, 2010.
6. Shao et al., *Front Psychol*, 5: 772, 2014.
7. Sugimoto et al., *Research Square*, 2020.
8. Ashburner & Friston, *Neuroimage*, 26: 839-851, 2005.
9. Ashburner, *Neuroimage*, 38: 95-113, 2007.
10. Slotnick, *Cogn Neurosci*, 8: 150-157, 2017.

Hikaru SUGIMOTO, PhD.

RIKEN Center for Advanced Intelligence Project, Nihonbashi 1-chome Mitsui Building,15th floor, 1-4-1 Nihonbashi, Chuo-ku, Tokyo 103-0027, Japan

E-mail: hikaru.sugimoto@riken.jp

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