

ORAL PAPER PRESENTATION 3: PHYSICAL AND MENTAL HEALTH

Cognitive behavioral assistive technology (CBAT) as AI for super aged society

M. Otake-Matsuura, M. S. Abe, T. Sekiguchi, S. Tokunaga, H. Sugimoto, T. M. Rutkowski, K. W. Miura

Purpose AI nurturing or complementing human intelligence is becoming more important than ever. The goal of the Cognitive Behavioral Assistive Technology (CBAT), advocated by the author since 2017, is to develop technology assisting cognition and behavior of human with and without disabilities. For the first step, we focus on technology which promotes cognitive health for preventing cognitive decline and dementia among older adults by social activities, since a systematic review found that social activity intervention may help maintain cognitive function among healthy older adults (Kelly et al., 2017), there are no global recommendations for social activity interventions related to cognitive health because evidence of the impact of such intervention is limited (World Health Organization, 2019). One major reason was the lack of technology for generating quantitatively and qualitatively consistent social activities necessary for cognitive intervention. **Method** In order to realize cognitive intervention via social activities, we develop novel technologies which promote intensive conversations among older adults, and demonstrate their effects on older adults' cognitive and brain functions. We also develop technologies to predict cognitive functions from different modalities of behavioral and/or physiological data, aiming to monitor cognitive functions in everyday life. **Results and Discussion** The five main results were obtained as follows: 1) Photo-Integrated Conversation Moderated by Robots (PICMOR), a group conversation intervention program and its supporting systems, was developed to build resilience against cognitive decline and dementia. A randomized controlled trial (RCT) of PICMOR demonstrated for the first time the positive effects of a robotic social activity intervention on cognitive function in healthy older adults (Otake-Matsuura et al. 2021). 2) A voxel-based morphometric analysis was applied to the structural MRI data. In the analysis, the regional brain volume was compared between the intervention group and the control group. Candidate brain regions were identified successfully that reflect the beneficial effect of conversation-based interventions on cognitive function (Sugimoto and Otake-Matsuura 2022). 3) We recorded large-scale data of one million words from group conversations among healthy elderly people through an RCT and analyzed the relationship between spoken language and cognitive functions in terms of scaling laws, namely, Heaps' law (Abe and Otake-Matsuura 2020). The results suggest that we can predict the cognitive function of the speaker through analyzing transcribed conversation data. 4) A Dialogue-Based System with Photo and Storytelling for Older Adults (DBS-PS), a dialogue-based robot system, was developed for cognitive training at home (Tokunaga et al. 2021). The system was successfully utilized by older adults during the pandemic. 5) Behavioral responses were analyzed in a facial emotion implicit-short-term-memory learning and evaluation experiment. Various shallow and deep learning machine learning models were applied, resulting in median accuracies just under a 90% benchmark for automatic discrimination of normal cognition versus a mild cognitive impairment (MCI) (Rutkowski et al. 2020). The results show that the application of machine learning (ML) to data collected through simple behavioral examination is effective for MCI and dementia onset diagnostics. The developed technologies are exemplars of CBAT as AI for super aged society.

References

- Kelly, M. E., Duff, H., Kelly, S., McHugh Power, J. E., Brennan, S., Lawlor, B. A., et al. (2017). The impact of social activities, social networks, social support and social relationships on the cognitive functioning of healthy older adults: a systematic review. *Systematic Review* 6 (1), 259. <https://doi.org/10.1186/s13643-017-0632-2>
- World Health Organization (2019). Risk reduction of cognitive decline and dementia—WHO Guidelines. Available at: https://www.who.int/mental_health/neurology/dementia/guidelines_risk_reduction/en/
- Otake-Matsuura, M., Tokunaga, S., Watanabe, K., Abe, M. S., Sekiguchi, T., Sugimoto, H., Kishimoto, T., Kudo, T. (2021). Cognitive Intervention through Photo-Integrated Conversation Moderated by Robots (PICMOR) Program: A Randomized Controlled Trial. *Frontiers in Robotics and AI*, 8:633076. <https://doi.org/10.3389/frobt.2021.633076>
- Sugimoto, H., Otake-Matsuura, M. (2022). A pilot voxel-based morphometry study of older adults after the PICMOR intervention program. *BMC Geriatrics*, 22, 63. <https://doi.org/10.1186/s12877-021-02669-x>
- Abe, M. S., Otake-Matsuura, M. (2021). Scaling laws in natural conversations among elderly people. *PLoS ONE* 16(2): e0246884. <https://doi.org/10.1371/journal.pone.0246884>
- Tokunaga, S., Tamura, K., Otake-Matsuura, M. (2021). A Dialogue-Based System with Photo and Storytelling for Older Adults: Toward Daily Cognitive Training. *Frontiers Robotics AI* 8: 644964. <https://doi.org/10.3389/frobt.2021.644964>
- Rutkowski, T. M., Abe, M. S., Koculak, M., Otake-Matsuura, M. (2020). Classifying Mild Cognitive Impairment from Behavioral Responses in Emotional Arousal and Valence Evaluation Task - AI Approach for Early Dementia Biomarker in Aging Societies -. In: *42nd Annual International Conference of the IEEE Engineering in Medicine and Biology Society (EMBC)*. IEEE Engineering in Medicine and Biology Society. Montreal, Canada: IEEE Press. p. 5537-5543. <https://doi.org/10.1109/EMBC44109.2020.9175805>

Keywords: cognitive intervention, machine learning, dementia, conversation, dialogue

Address: Center for Advanced Intelligence Project, RIKEN, Japan

Email: mihoko.otake@riken.jp

Acknowledgement This work was supported by JSPS KAKENHI Grant Numbers JP18KT0035, JP19H01138, JP20H05022, JP20H05574, JP22H04872, JP22H00544 and the Japan Science and Technology Agency Grant Numbers JPMJCR20G1, JPMJST2168, and JPMJPF2101.