

## BRIDGES BETWEEN NEURONIMAGING AND SOCIETY

**R. Kawashima**

*Department of Functional Brain Imaging, IDAC, Tohoku University, Sendai, Japan*

The relationship between mental exercise and mental aging is a controversial issue. People generally believe the so-called mental-exercise hypothesis, that is, the age-related decline in cognitive function is less pronounced for people who are mentally active, and there is insufficient scientific evidence supporting this hypothesis. Recently, cognitive training has generally received increasing interest as a solution to such an age-related cognitive decline. Although the general public's interest in cognitive or brain training is increasing, scientists doubt the effect of cognitive training, particularly the generalizing or transfer effect of such training. Previous randomized controlled trial studies showed convincing beneficial effects of cognitive training on directly targeted cognitive functions. Nevertheless, it remains unclear whether cognitive training has a positive transfer effect on other cognitive functions necessary for improving performance in real-life tasks and independent living. With regard to changes of cognitive functions during aging, it is important to note that although cognitive functions related to semantic knowledge do not decline during aging, cognitive functions requires the function of the prefrontal cortex, particularly the executive function decline linearly during aging.

Previously, we introduced a new cognitive intervention program for senile dementia, the concept of which is derived from the knowledge of both brain science and clinical studies, named learning therapy. Learning therapy has been developed to stimulate the cognitive functions of the dorsolateral prefrontal cortex, as well as those of the temporal and parietal association cortices. We prepared two tasks in arithmetic and Japanese language, which were systematized basic problems in arithmetic and reading, respectively, for daily training. Because results of brain imaging studies indicate that reading sentences or words aloud and simple arithmetic operations activate the three association cortices, including the dorsolateral prefrontal cortex, of the bilateral hemispheres of humans, and because both reading aloud and solving arithmetic problems require working memory, this prefrontal stimulation may lead to the positive transfer effect on other cognitive functions. In addition, both reading aloud and solving arithmetic problems can be very simple and easy, so that even people with senile dementia can understand, perform, and continue the tasks prepared. As results, a comparison between the randomly assigned intervention and control groups revealed that not only frontal functions but also functions associated with communication and independence improved in the intervention group. Our findings suggest that a daily cognitive intervention by reading and solving arithmetic problems improves non-targeted cognitive functions.

We, then, applied a similar daily cognitive training to the study of community-dwelling seniors to determine the effects of training on cognitive functions, particularly on the function of the prefrontal cortex, by a single-blind randomized controlled trial. In this study, neuropsychological measures were determined prior to and six months after the intervention (post-test) by mini-mental state examination (MMSE), frontal assessment battery at bed side (FAB), and digit-symbol substitution test (DST) of WAIS-R. The speed of processing (as measured by DST) and executive function (as measured by FAB) that are not directly tied to the intervention showed a statistically significant improvement in the post-test compared with the pre-test, such improvement was maintained up to six months of follow-up tests in only the experimental group.

Our intervention program is based on a daily training system. There is no doubt that the brain has a lifelong capacity for plasticity, and results of many clinical studies of humans and experimental studies of animals support the idea that a continuous stimulation of the brain causes changes in the brain. Therefore, it is reasonable to induce changes in the brain networks using such a type of daily intervention program.

The results of our previous investigations indicate that the transfer effect of cognitive intervention by reading and solving arithmetic problems on non-targeted cognitive functions was demonstrated in this study, and are convincing evidence that cognitive training has the beneficial effects of maintaining and improving cognitive functions.

Recently, our intervention system has been integrated into video games, such as Nintendo DS brain training series. We measured brain activity during playing those video games by near infra-red spectroscopy (NIRs), and confirmed significant activation of the bilateral dorsolateral prefrontal cortex, by Industry-University cooperative researches. The beneficial effects on cognitive functions using those video games have been tested by several other investigators. Examples of those results will be introduced during my presentation.

We have been trying to create bridges between brain imaging research and society by Industry-University cooperative researches. All the products and systems relating to our daily life are perceived as stimuli by the senses, such as vision, hearing, touch, etc., and recognized as meaningful and connected to our actions or ideas. We believe we can evaluate the impact of the use of their products and systems on the human brain through scientific instrumentation centering on functional brain imaging and through psychological experiments, and study how to apply the findings to development of new products. By making our functional brain imaging technologies easily available to companies, we aim at creating a society in which companies are aware of the impact their products and systems have on the brain, and disclose information to consumers so that they can enhance the safety of their products and systems as well as increase their added value. We believe the scientific evaluation of such impact on the brain, particularly in the case of teaching or play materials and software for children, is indispensable, and we provide necessary information so that our proposed "human brain engineering" serves as a standard.

### References

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