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Feasibility of Cognitive Training Using Virtual Reality in Patients with Cognitive Impairment

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Purpose
Cognitive training based on virtual reality (VR) leads to motivational and playful aspect of training in patients with mild cognitive impairment (MCI) and mild dementia. Enriched environment which refers a rich and stimulating environment has been reported positive effect on memory deficits in an Alzheimer disease mouse model. The aim of this study was to investigate the feasibility of cognitive training using fully immersive VR program on enriched environment to patients with MCI and mild dementia.

Methods
The VR hardware consisted of a commercialized head mount display (HTC Vive, HTC, Taiwan) and a custom-made Palm-Glove system developed for hand pose estimation and grip gesture recognition (Figure 1). We also developed the virtual harvest and cook games for memory, attention, and executive function training in enriched environment representing rural scenery (Figure 2.) Patients with MCI and mild dementia received 30 minutes usability test for cognitive training using VR. The baseline characteristics including age, sex, medical history, mini-mental state examination (MMSE), clinical dementia rating (CDR), and geriatric depression scale (GDS) were assessed. Response time and finger tapping were measured before and after usability test. After the end of test, usability was assessed self-report questionnaire with a 7 point Likert scale.

Results
Eleven patients with MCI and mild dementia were participated. The mean age was 72.64 ± 4.65 years (5 male) and the MMSE score was 26.91 ± 1.58 points (range 23-28). The CDR was 0.5 in 8 patients and 1 in 3 patients. Baseline the GDS score was 17.55 ± 6.30. Response time of dominant hand decrease after the single session of cognitive training using VR, but it was not statistically significant (612.18 ± 186.35ms to 546.82 ± 130.64ms, p =.248). There was no significant changes in finger tapping of right and left hand (p =.476 and p =.424, respectively). The average score of self-report questionnaire was 5.89 ± 1.04 on the 7 point Likert scale (Table 1).

Conclusion

A fully immersive VR cognitive training program may be feasible in patients with MCI and mild dementia based on patients' positive satisfaction and intent to further training. However, it was not enough to identify the function changes through the single session of the training. Additional clinical trials are needed to confirm the effect on cognitive function, mood, and physical outcomes.

Acknowledgment :This study was supported by Korea Radio Promotion Association.

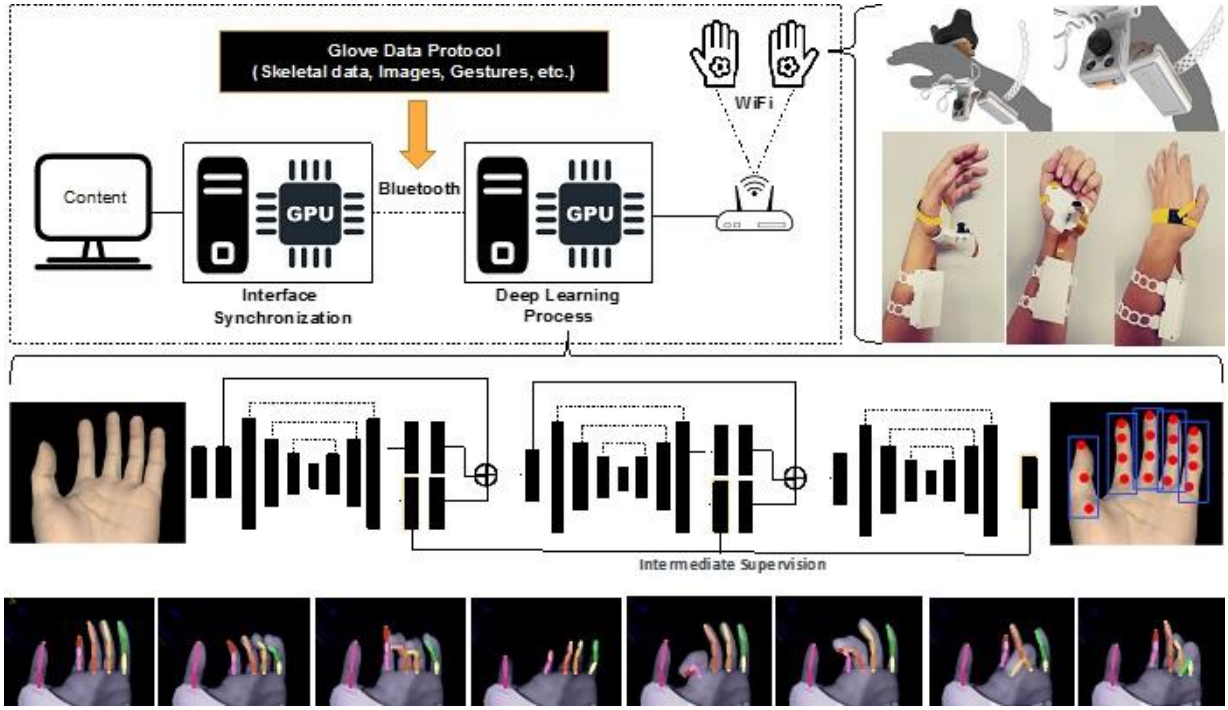

Figure 1. Overall flowchart and result images of hand pose estimation. The Palm-Glove system consists of two glove device, which are camera-based hand image input devices, a deep learning process module for estimating the hand pose, and an interface synchronization module for the interoperation and synchronization between the contents and interface. The two glove devices transmit hand images to the deep learning process module through multiple Wi-Fi communications to analyze the hand skeleton and gesture, and the results are delivered to the interface synchronization module through Bluetooth. For the recognition of a grip, the positional correlations between the joints values of each finger and the thumb-to-finger tap gesture are considered.

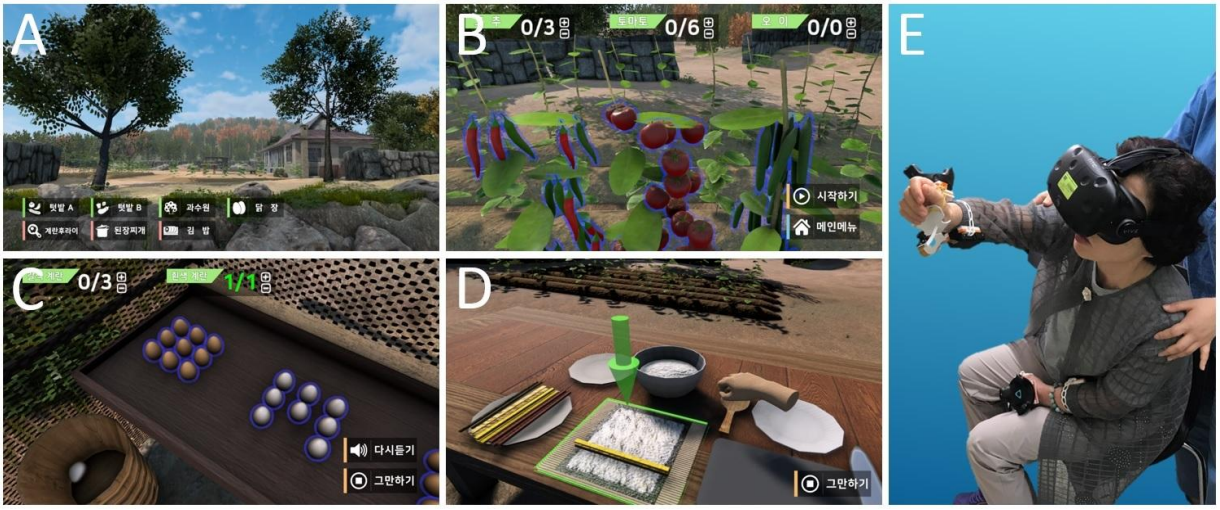

Figure 2. The cognitive training using virtual reality (VR) in enriched environment consists of two programs; the harvest and cook. The harvest program includes 4 different backgrounds which are the farm 1 (chili peppers, tomatoes, and cucumbers), farm 2 (strawberries, green sweet peppers, and eggplants), orchard (apples, mandarins, and pears) and hen house (brown and white eggs). The artificial voice informs the patient about the type and number of crops and eggs to harvest. In the cook program, instructor could choose one of recipes among fried eggs, Kimbap, and Soybean paste stew. A patient is instructed how to cook through the voice and arrows sequentially. (A) Primary screen shows a usual Korean farm village and country house where could perform harvest and cook. (B) In the vegetable garden Ⅰ, the crops to be harvested are highlighted. (C) Several brown and white eggs are in hen house. (D) Patient's virtual hands make a Kimbap in order. (E) A patient experiences the virtual reality training with the head mount display and Palm-Glove.

Table 1. Survey after experience of cognitive training using virtual reality

No.	Items	M ± SD
1	Interest	5.82 ± 1.33
2	Mood	6.18 ± 1.40
3	Motivation	5.36 ± 1.57
4	Difficulty	5.45 ± 1.51
5	Discomfort	6.91 ± 0.30
6	Anxiety	6.27 ± 1.62
7	Overall satisfaction	5.64 ± 1.43
8	Intent to continue training	5.82 ± 1.83
9	Expectations for virtual reality training	5.54 ± 1.44
	Average	5.89 ± 1.04

The 7 point Likert scale, the higher the score, the more positive it is.