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Investigating the Effects of Olfactory VR Content on Cognitive Function in Elderly People

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Abstract

Smell is a fundamental human sense, and its use is expected to enhance cognitive functions. In addition, virtual reality technology allows humans to experience virtual worlds and is expected to be applied to rehabilitation in spaces where movement might be limited, such as elderly care facilities and hospitals. We are conducting research on the use of olfactory VR game content to enhance cognitive function in elderly people and undertaking a study of the effects. Early indications suggest that while there may be some ceiling effects, improved scores for attention and mind rotation tasks are detected, indicating that olfactory VR content has the potential to enhance cognitive function in elderly people. Based on these results we can determine the appropriate contents of the cognitive test to evaluate the olfactory game.

CCS Concepts

• ***Human-centered computing*** → *Interaction design;* • ***Applied computing*** → *Life and medical sciences;*

1. Introduction

It is known that olfactory abnormalities can occur as an early symptom of cognitive impairment [DMML*00]. The olfactory stimulation has been suggested to have positive effects in brain function [VDBK*24]. For the purpose of this research olfactory stimulation is used for cognitive rehabilitation for the elderly. This also has the potential to be applied more widely to day-to-day sensory training to improve smell cognition and detect loss of olfactory function.

A device that is connected to a computer and presents selected odors is called an olfactory display, and can be used to create interactive olfactory game contents. A combination of virtual reality experience with odor presentation using an olfactory display is called olfactory VR.

We are investigating the effects of olfactory VR to enhance cognitive function in elderly people by developing specific content for this purpose, which we are now testing to understand the effects.

2. The Olfactory VR Content

2.1. Devices

For the olfactory VR content we used 4 devices: a computer, a head-mounted display for VR, a controller, and an olfactory display machine housing the odor samples. The players experienced the content sitting on swivel chairs.

2.2. Olfactory Game Contents

The olfactory VR game content requires memorizing specific odors through sensory information and the selection of matching odors encountered as the game proceeds.

No linguistic or visual information is presented in the content to identify the odor when it is introduced at the start of each game sequence (naming a smell is not easy without visual or verbal cues [Cai79]). This requires the player to memorize only the sensory information they receive from the act of smelling odors.

The olfactory game proceeds as follows:

1. Presentation of the reference odor to be memorized
2. Searching for the odor source in the virtual landscape while keeping in mind the odor being sought.
3. Matching the memorized odor with a choice of 3 contrasting odors presented at the conclusion to each game sequence.

2.3. Odors

At the start of each game sequence the odor to be memorized is randomly selected from among the three odors, and is also randomly assigned to the cloud used in the odor comparison.

The 2 odor sets include:

1. Banana, Orange, Basil
2. Soap, Lavender, Peppermint

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3. The Experiment

3.1. Materials and Methods

The players included 10 healthy elderly ethnic Japanese people (63-77 years old, mean 71.7 years old, SD = 4.3, 4 males) assigned by the Silver Human Resource Center.

The experiment proceeded as follows:

1. Completion of the consent form.
2. Cognitive test (pre-game).
3. Playing the olfactory VR game.
4. Cognitive test (post-game).

One cognitive test was assigned to each subject from the MMSE-J [SKS*18], MOCA-J [FSY*10], and custom tasks. For the 10 participants, 3 were assigned MMSE-J, 3 MOCA-J, and 4 custom tasks. (One of the three who were assigned MMSE-J terminated the olfactory VR content halfway due to equipment failure.)

The custom task consists of six items:

1. Memory tasks.
2. Calculation tasks
3. Attention and decision tasks.
4. Language ability tasks.
5. Hiragana rotation task (from MEDE).
6. Matrix reasoning (from WAIS-IV).

3.2. Results

There was no difference in the test scores pre- and post- game experience of the olfactory VR content for MMSE-J, MOCA-J, and custom tasks, except for the hiragana rot-tion. A ceiling effect, where most participants achieved similarly high scores, was observed even for the custom tasks that were devised.

In the hiragana rotation task, three out of four participants improved their scores pre- and post- experience of the olfactory game VR content (Figure 1).

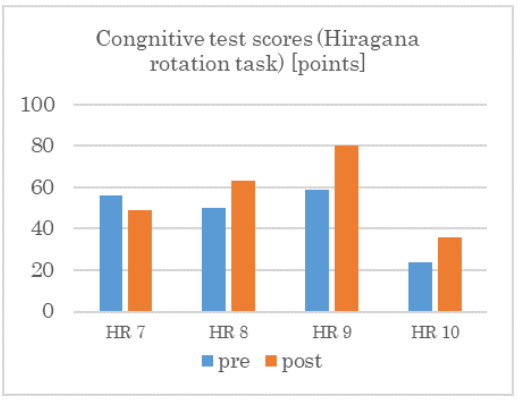

Figure 1: *Cognitive test scores (Hiragana rotation task). Hiragana rotation is a time-limited task with no upper limit in score. 3 of the 4 subjects showed improvement in their scores.*

3.3. Discussion

Ceiling effects were observed for most of the cognitive tasks as the players were healthy active elderly people whose cognitive abilities have not significantly declined. The hiragana rotation task has no upper limit to the score, yet increase in scores were still observed. The hiragana rotation task is originally an attention task, but it is thought that the improvement in mental rotation has contributed to the score improvement. This preliminary experimental result suggests that there are positive effects on attention and mental rotation through experiencing olfactory VR content for elderly people, and no negative effects on other cognitive functions.

Based on the results of this experiment, it is possible to avoid ceiling effects by using the MMSE-J and MOCA-J as a screening tool, increasing the difficulty level of custom tasks by increasing the number of cards in the spatial memory task, and employing tasks with no upper limit on scores, such as the hiragana rotation task.

3.4. Conclusion

To investigate the effects of olfactory VR on the cognitive function of elderly people, we conducted a preliminary experiment that tests its effectiveness. The results of the experiment suggest an improvement in attention and mental rotation.

The next main experiment will recruit more participants, as many as 30 with within-subject design. By using MMSE-J and MOCA-J as screening and by making a modification to prevent ceiling effects, such as increasing difficulty in custom memory tasks, it will be possible to investigate wider effects of olfactory VR on the cognitive function of elderly people.

4. Acknowledgement

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