A Kinect-based Interactive Game to Improve the Cognitive Inhibition of the Elderly

(Demonstration)

Siyuan Liu[1], Zhiqi Shen[1], Han Yu[1], Han Lin[1], Zhengjin Guo[1], Zhengxiang Pan[1],
Chunyan Miao[1], Cyril Leung[1,2]
[1]Joint NTU-UBC Research Centre of Excellence in Active Living for the Elderly
Nanyang Technological University, 50 Nanyang Avenue, Singapore 639798
[2]Department of Electrical and Computer Engineering, The University of British Columbia, Canada
{syliu, zqshen, han.yu, linhan,zjguo, panz0012, ascymiao}@ntu.edu.sg, cleung@ece.ubc.ca

ABSTRACT

Cognitive abilities, including cognitive inhibition, degenerate with the aging process. In this demonstration, we present a Kinect-based interactive game which aims to improve the cognitive inhibition ability of the elderly. The game is designed in the table tennis theme, and the adoption of Kinect makes it convenient for the elderly to use. The players' in-game behaviour data are recorded for the health advisor agent to conduct personalization, analysis, and decision making. A pilot study has been conducted to investigate the relationship between the players' cognitive inhibition abilities and their in-game performance. The study results suggest that the in-game performance can reflect a player's cognitive inhibition ability, and indicate that the game can be used to improve the cognitive inhibition ability of the elderly in the future.

Keywords

Game, Cognitive Inhibition, Elderly, Table Tennis, Kinect

1. INTRODUCTION

It is well-known that human cognitive abilities decline with age [3]. These cognitive skills include *cognitive inhibition* which refers to the ability to tune out the stimuli that are irrelevant to the current mental state [8]. It is a key mechanism in emotion and behavior regulations [9]. Cognitive inhibition deficits can lead to various conditions such as depression [5].

Older adults can maintain and improve their cognitive inhibition abilities through consistent physical exercise [1]. In recent years, interactive games have been found to be helpful in improving general cognitive wellness [14, 15], and rehabilitation for stroke [4] and Parkinson's Disease [2, 6, 7] which require sustained physical exercise. In this demonstration, we present a Kinect-based interactive game – *PingPingPongPong* to improve the cognitive inhibition ability of the elderly. The game is incorporated with the traditional Go/No-go tests which require the player to perform an action given certain stimuli [10]. It is implemented in the theme of playing table tennis which the elderly users are generally familiar with. The adoption of Kinect makes it convenient for the elderly to play the game. Driven by each individual player's in-game behaviour trajectory data, a health advisor agent in the game provides feedbacks to the player to recommend suitable exercises for him to train his cognitive inhibition, and determine whether his current condition needs to be brought to the attention of medical professionals. The agents are designed and implemented with our Goal Net Design tools [13]

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2. THE DEMONSTRATION

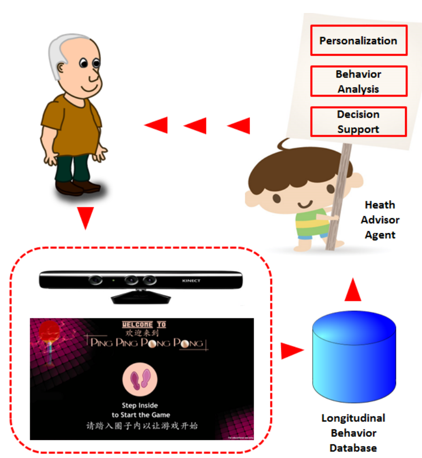
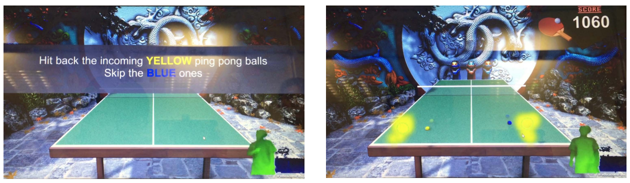


Figure 1: The conceptual framework of the PingPingPongPong game

The game has been infused with familiarity design considerations to improve the adoption by local senior citizens in Singapore [11]. As shown in Figure 1, the player can begin the game through interacting with Kinect with his gestures. After the user logins to the game, his historical playing data will be analysed by the health advisor agent for personalization to calibrate the game difficulty to suit the player's physical and cognitive conditions. The player in-game behavior data will be captured and stored in the longitudinal behavior database to form his personal playing trajectory. After the player completes the game, the agent conducts behavior analysis and makes suggestions to the player according to the analysis results. The data stored in the database will be further used for long-term behavior analysis.

The game is currently designed with 3 tasks, and each includes several sessions (i.e., a session refers to one or multiple table tennis ball(s) being dealt to the player for him to hit it/them back). Figure 2 shows an example session in Task 3.



(a) Instructions (b) Session example

Figure 2: Example game scenarios

Task 1 is a single colored task. In each session, there is one colored ball coming out and the player needs to hit the ball in a given color back. For example, the player is asked to only hit the yellow balls back, and should perform nothing when seeing a red ball being dealt to him. The color of the ball in each session is randomized. In this case, color is the stimulus as in the traditional Go/No-go tests. Tasks 2 and 3 are both tasks with two colors. In each session of Task 2, a white ball and a coloured ball are being dealt simultaneously to a player. The player needs to hit the colored ball back. In each session of Task 3, two colored balls are being dealt simultaneously. The color combination of the two balls will not change throughout all sessions. The player needs to hit the ball with a given color back. For example, as shown in Figure 2(a), the instructions ask the player to hit the yellow balls, and skip the blue balls.

The player's in-game behavior data are recorded in the database. Key feature data captured include the spatial locations of key points in a player's skeleton (e.g., hand, elbow, shoulder, hip) at all sampling time steps, the time the balls are dealt, and the session results (i.e., whether the player hits the ball that he should hit). These data are passed to the health advisor agent for real-time analysis and decision making as well as personalization and long-term analysis.

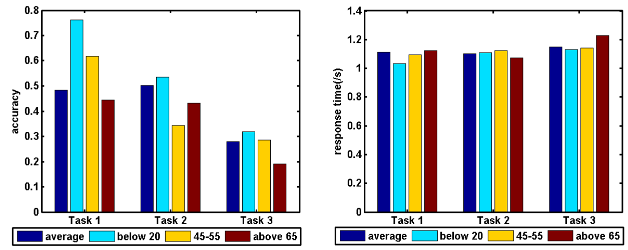
3. PRELIMINARY RESULTS

We conducted a pilot study to investigate the effectiveness of the game in assessing the players' cognitive inhibition abilities. We invited 3 groups of players in the age group of "above 65", "45-55", and "below 20" in the study. Each group includes 50 subjects who completed all the three tasks. We use the following two commonly adopted metrics [12] in the traditional Go/No-go tests to evaluate the players' cognitive inhibition abilities: accuracy (a) and response time (r). They are calculated as follows:

$$a = \frac{N_h}{N}, \tag{1}$$

$$r = \frac{1}{N}\sum_{i=1}^{N}(P_i - C_i), \tag{2}$$

where N is the number of balls being dealt, and N_h is the number of balls hit accurately by the player. C_i is the time that a ball is dealt, and P_i is the time that the player starts movement after he sees the ball. A player with a higher cognitive ability should have a higher accuracy and a lower response time. The average results for the 3 groups of subjects are shown in Figure 3.



(a) Accuracy (b) Response time

Figure 3: Pilot study results

It can be seen from the results that in Task 1, the accuracy decreases with the increases in players' age. There are some interesting points to note in the results of Task 2. The accuracy for the group of "above 65" is remarkably better than the accuracy of the group of "45-55". The observation may be due to the elderly's difficulty in seeing the white balls. Therefore, they directly hit the coloured balls. The explanation can be further supported by the results of Task 3, where the accuracy for the group of "above 65" is lower than the accuracy for the group of "45-55" as the two balls are both coloured, and the elderly need to take time to differentiate them and hit the correct balls back. The response time for the three tasks present an opposite trend to the accuracy results across the three groups, suggesting that the elderly may need more time to take actions (except for Task 2).

In summary, the pilot study results suggest that the performance of the players in playing the game is correlated with player cognitive inhibition ability (i.e., the older players tend to have lower cognitive inhibition ability, and present lower accuracy and longer response time in playing the game). This implies that the designed game can be used to assess and further improve the cognitive ability of the elderly.

4. CONCLUSIONS

In this demonstration, we proposed a Kinect-based interactive game which targets to improve the cognitive inhibition ability of the elderly. Three tasks are currently designed and implemented. A pilot study has been conducted to investigate the effectiveness of the designed game in assessing the cognitive inhibition ability of the players. The results show that the player behavior reflected in the game is correlated with his cognitive inhibition ability. In subsequent research, we will study the long-term effectiveness of the game in improving the cognitive inhibition ability of the elderly.

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