Enhancing eye-hand coordination in older adults: A nature-inspired drone training approach

K. Chaitika, Z.-L. Wu, H.-F. Chieh, C.-J. Lin, K.-N. An, F.-C. Su

Purpose Aging society has become an unavoidable issue globally. Therefore, healthy aging emerges as an effective long-term solution that can help older adults maintain their abilities to perform daily activities, particularly requiring good eye-hand coordination (EHC). While various innovative EHC training tools have been developed, most are computerized, either in a two-dimensional platform involving tapping a rapidly appearing object on the screen or a three-dimensional platform simulating immersive experiences in a virtual reality headset. From the authors' perspective, the existing EHC training tools still lack essential information for users, such as depth perception and realism, which might enhance their training. In this study, we designed and developed a nature-inspired system for EHC training using a palm-size drone as a medium for users to practice their EHC skills. Participants engaged with the drone as if catching insects like a fly or butterfly. The drone featured a ball-shaped object hanging beneath it for participants to catch as it flew away. At this preliminary stage, we conducted a one-time experiment to investigate the phenomena when older adults interact with our proposed system in various challenging conditions, which would benefit our future training study. We set three simple drone leaving directions (forward, rightward, and upward) to observe participants' responses to a rapidly moving object in different directions. Additionally, we varied the drone's leaving speeds (0.8 m/s and 1.0 m/s) to challenge participants and validate the impact of direction on their performance. Since participants were unaware of the drone's fly-out direction and speed beforehand, this would challenge their cognitive-motor coordination and EHC throughout the experiment. We believe that this training system can assist older adults in developing their EHC skills, upper limb movement, and balance control abilities. **Method** Eight healthy individuals, comprising five females and three males with an age range of 71.75±4.17 years, were recruited for this study. Data were recorded using a motion capture system to track the subjects' hand and drone movements. The study received approval from the National Cheng Kung University Hospital Institutional Review Board. The drone used in this study was a Crazyflie 2.1 drone (Bitcraze AB, Sweden), pre-programmed with Python code to enable autonomous flight. During each trial, the drone was positioned in front of the subject at a distance equal to one arm's length. Subsequently, the drone flew up to eye level and hovered for 2 seconds before flying out, prompting subjects to grab the ball beneath it. The drone's leaving directions and speeds were randomized across trials, totaling six conditions (three directions and two speeds), each repeated five times, with approximately 15 seconds per trial. The study focused on analyzing reaction time (RT) and movement time (MT) from successful trials where subjects caught the drone without losing balance. Statistical analysis involved non-parametric Friedman and post-hoc Wilcoxon signed rank tests. **Results and Discussion** Statistical analysis revealed significant differences in RT and MT among the three directions (Table 1). The RT results showed that catching the drone in the upward direction took significantly more time compared to the other directions. It suggests that the narrower field of view in vertical-up planar may have contributed to the longer RT. Meanwhile, the MT results showed significant differences at the drone's fly-out speed of 0.8 m/s among the three directions. The MT result was significantly prolonged in the rightward and upward directions compared to the forward one. For the MT results, the drone's path was more obvious in the rightward and upward directions, which likely influenced the subjects to slow down their movement as the drone’s speed. However, when the drone flew out in the forward direction, the target was moving away at eye level, making it difficult to estimate how far the target was. As a result, the subjects tried their best to grab the target immediately once they knew the target was about to move.

Keywords: healthy aging, eye-hand coordination, playing catch exercise, indoor drone
Addresses: Department of Biomedical Engineering, National Cheng Kung University, Taiwan
Email: fcsu@ncku.edu.tw
Acknowledgement: This research was supported by the National Science and Technology Council (NSTC) Taiwan with grant no. 110-2221-E-006-011-MY3.

Table 1. The statistical analysis results of reaction time and movement time in each direction and speed

		Forward		*Rightward*		*Upward*			
	Conditions	*Median*	*Q1-Q3*	*Median*	*Q1-Q3*	*Median*	*Q1-Q3*	*χ2 (df = 2)*	*p-value*
Reaction Time (s)	*0.8 m/s*	***.1600**[b]*	*.1403-.1670*	***.1420**[c]*	*.1105-.1630*	***.2290**[b, c]*	*.1960-.2595*	*14.250*	***.001****
	1.0 m/s	***.1100**[b]*	*.0860-.1000*	***.0930**[c]*	*.0860-.1000*	***.1990**[b, c]*	*.1828-.2075*	*14.000*	***.001****
Movement Time (s)	*0.8 m/s*	***.5040**[a, b]*	*.4425-.5528*	***.5570**[a]*	*.5165-.7243*	***.6145**[b]*	*.5315-.6570*	*12.250*	***.002****
	1.0 m/s	*.4530*	*.4310-.5320*	*.4660*	*.4380-.5465*	*.4970*	*.4645-.5775*	*4.750*	*.093*

Note: p-value = significant value among three conditions, p < .05); a = there is a significant difference between rightward and forward direction; b = there is a significant difference between upward and forward direction; c = there is a significant difference between upward and rightward direction; a, b, c is based on Bonferroni adjustment (p < .017)