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Ping Pong Exergame for Cognitive Inhibition Training in Older Adults: A Reflection on the Engagement Design

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Abstract

Digital health interventions for older adults must not only deliver cognitive and physical benefits, but also sustain engagement in everyday community settings. This article examines how engagement can be designed and understood through the deployed Ping Pong exergame, a selective-attention training system that combines table-tennis movements with a Go/No-go cognitive task. The game engages older adults through culturally familiar visuals, natural Kinect-based interaction, immediate multimodal feedback, progressive cognitive challenge, and socially amplified play in community centres. Reflections from deployment highlight three key design questions: how to adapt difficulty while preserving user agency, how to measure engagement in real time rather than only after use, and how AI can support players as an empathetic coach or companion. Future DHIs should move beyond effectiveness alone toward adaptive, socially embedded, and human-centred engagement design for ageing populations.

Keywords: Engagement Design; Exergames..

I. Introduction

Digital Health Interventions (DHIs) leverage interactive technologies to deliver health-related rehabilitation or cognitive maintenance [10]. Among these, exergames that combine physical exertion

Fig 1 Example of the Ping Pong exergame interface. (a) Task selection page. (b) Task 1: a single-color task in which only one ball color is presented per session, and players are required to hit back all incoming balls.

with gameplay have emerged as promising DHIs for ageing populations, as they simultaneously address physical inactivity and cognitive decline [9]. The *Ping Pong* exergame [13] is a purpose-built DHI designed to train **selective attention** in healthy older adults through a dual-task paradigm that merges table tennis movements with a classic Go/No-go task. Developed at Nanyang Technological University's LILY Research Centre, the *Ping Pong* exergame has been **deployed in multiple community centres across Singapore**, reaching over 10,000 senior citizens to date. A five-week longitudinal study with 33 older adults demonstrated high usability (System Usability Scale = 72.1) and significant improvements in cognitive response times, validating its effectiveness as an engaging and impactful DHI [13].

A. Engagement Designs

The *Ping Pong* exergame embeds a set of engagement-oriented design strategies grounded in classic HCI principles, aiming to make the intervention accessible, intuitive, enjoyable, and socially meaningful for older adults in community-based settings.

1. Familiarity Enhances Technology Acceptance. Visually, the environment incorporates culturally resonant themes (dragons, auspicious clouds) that evoke comfort and recognition with Sin-

gaporean seniors, yielding immediate acceptance. Players may hold a physical paddle, and their real-world swings are mapped directly to the virtual environment via Kinect. This cultural and embodied familiarity lowers perceived technological barriers; even technology-naive seniors can begin playing without instruction, reducing anxiety and fostering early confidence.

2. Natural Interaction and Immediate Feedback Deepen Suspension of Disbelief. Beyond initial acceptance, the game prioritizes interaction simplicity. Users simply walk up and start playing. There is no controller to learn, no menu to navigate, just raise your hand and hit the ball. This seamless interaction supports a strong sense of presence. Players consistently report feeling they are genuinely playing the sport, not operating a computer. Immersion is further reinforced through immediate **multimodal feedback**: successful hits trigger ball-rebound sounds, score updates, and visual collision effects. Such real-time responses strengthen cause-effect perception and sustain attention [12]. In exergames, immediate multimodal feedback has been shown to enhance perceived competence and enjoyment [7], keeping players immersed in the experience rather than distracted by the interface.

3. Progressive Challenge Sustains Immersion. Csikszentmihalyi's flow theory posits that sustained engagement requires a continuous balance between perceived challenge and skill [6]. The *Ping Pong* exergame incorporates three difficulty levels (single-colour, two-colour single ball, two-colour dual ball) that progressively increase cognitive demand. The Go/No-go rule (e.g., "hit only green balls") inhibits responses to non-target colours while performing the intrinsically rewarding physical act of hitting a ball. Such dual-task interventions are not only more effective for cognitive training but also more engaging because they simulate real-world multitasking and give

purpose to the cognitive effort [4, 1].

4. Community Setting Amplifies Social Engagement. While *Ping Pong* is a single-player game, it is **designed for community settings**. In practice, one person plays while others watch, comment, and cheer. The elderly enjoy being the centre of attention, and spectators are often motivated to try the game themselves after watching peers succeed. The system includes **voice cheering** that triggers enthusiastic audio feedback during rallies, amplifying the social atmosphere. Critically, the Kinect sensor's wide field of view and robust tracking allow it to function reliably even with a group of people in the background, which makes the game suitable for busy community centre environments.

II. Measuring Engagement: Observations and Impact

The *Ping Pong* exergame has been deployed across multiple Singapore community centres, reaching over 10,000 senior citizens to date. Centre staff report that older adults frequently return to play, bring friends, and even request the game for home use. The social dynamics we observed, like cheering, playful competition, and intergenerational play with grandchildren, confirm that engagement extends beyond the individual to the community level. As one participant remarked, "I never thought I could play games at my age, but this makes me feel young again." The perceived usability was assessed using the System Usability Scale (SUS) [3], a ten-item, standardised questionnaire that captures subjective evaluations of effectiveness, efficiency, and satisfaction. The SUS has been widely validated and has been shown to correlate with engagement-related constructs, including perceived enjoyment and intention to use [11, 2]. Our five-week study with 33 older adults shows that the *Ping Pong* exergame achieved high usability (SUS = 72.1) and improved cognitive

response times, positioning it as an engaging and impactful DHI.

III. Reflections

Our deployment of the *Ping Pong* exergame highlights both strengths and unresolved challenges in DHI design. The three-level progression prevented boredom across diverse players, and multimodal feedback (e.g., voice cheering) amplified social engagement in community settings. These findings align with prior work linking perceived playfulness and usefulness to continued use [5]. However, despite promising cognitive outcomes, adoption barriers among older adults remain a challenge, and engagement determinants are still insufficiently understood [8].

1. Difficulty progression: automatic or user-confirmed? Most exergames rely on fixed or manually selected difficulty levels. Yet cognitive ageing is heterogeneous: players who progress quickly need steeper challenges; those who struggle need scaffolding. Algorithms that adjust difficulty based on performance can maintain flow seamlessly, but risk making older adults feel the system controls them. User-confirmed adaptation (e.g., "You did well! Try a harder level?") preserves agency but adds friction and depends on accurate self-assessment. The question is not which method is better, but *how to design adaptation that respects older adults' need for both challenge and control*.

2. Engagement measurement must capture the when, not just the what. Post-hoc SUS scores and perfect adherence can tell us that players were engaged, but not *when* or *why* engagement fluctuated. Did frustration peak during difficult transitions? Did boredom set in before level advances? Without temporal data, we cannot identify moments when players need support or greater challenge. The question is methodological: *How can we design unobtrusive, real-time engagement*

sensing that works in community settings and yields actionable insights for adaptive intervention?

3. Modern AI's role: from algorithmic adaptation to companionship. Recent advances in AI are transforming digital interventions. AI agents, driven by large language models, can provide empathic feedback, explain tasks, and adapt their communication style to users' affect, potentially fostering trust and sustained participation. In exergames, AI could move beyond performance-based adaptation to serve as a virtual coach or companion. The critical question is not whether AI *can* enhance exergames, but *how to design AI that feels like a supportive companion rather than a controlling or opaque algorithm*.

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