A Virtual Reality Stroop Art Exergame for Cognitive-Motor Rehabilitation in Chronic Stroke Survivors

Christos, Hadjipanayi.[1] Domna, Banakou.[1,2] Abraiz Azhar.[3] Despina, Michael-Grigoriou.[1*]

[1]GET Lab, Department of Multimedia and Graphic Arts, Cyprus University of Technology, Limassol, Cyprus

[2] Interactive Media, Arts and Humanities Division, New York University Abu Dhabi, UAE

[3] Computer Science, Division of Science, New York University Abu Dhabi, UAE

**Corresponding author: despina.grigoriou@cut.ac.cy*

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Introduction

This abstract introduces a prototype VR exergame that blends creative artmaking with social facilitation elements and integrates a VR adaptation of the Stroop test - already a staple pen-and-paper counterpart exercise for promoting cognitive flexibility in stroke therapy. Recent reviews on VR artmaking for well-being revealed the applicability of VR artmaking to rehabilitation (Hadjipanayi, Banakou, et al., 2025; Hadjipanayi, et al., 2023). Yet most interventions rely on bespoke software and hardware (Baron, et al., 2021; Iosa, et al., 2021; Zhang et al., 2021). Among the few commercial tools mentioned, "*Google Tilt Brush*" (used with Oculus or VIVE headsets) appeared in (Alex, et al., 2021), where it served primarily as a community-building tool among stroke survivors rather than direct rehabilitation. In surveying the current marketplace, we found no readily deployable VR art-making application that adequately meets the ergonomic and cognitive needs of chronic-stroke survivors—underscoring the need for a purpose-built solution.

A VR Rehabilitation Exergame integrating the Stroop Test and Artmaking

Following a systematic evaluation of four commercial VR platforms—VRChat, Mozilla Hubs, Multibrush, and Hand Brush with Friends—conducted alongside an experienced physiotherapist, none met the minimum clinical and usability thresholds required for an artmaking rehabilitation intervention (Table 1). VRChat and Mozilla Hubs achieved strong social co-presence yet lacked flexible gesture mapping and fine-grained environmental control. Multibrush VR delivered the richest drawing toolkit but was restricted to Quest hardware and imposed a very high cognitive load. Hand Brush offers a low-complexity interface but sacrificed online collaboration and full avatar embodiment. Across all candidates, the absence of intuitive gesture-based interaction—a prerequisite for motor-impaired users—and limited affordances for manipulating virtual agents or the scene emerged as critical shortcomings. These gaps motivated the creation of the solution we present here:

a VR exergame that gamifies the Stroop test (Jensen and Rohwer, 1966) and integrates collaborative artmaking features expressly geared toward the rehabilitation of chronic stroke.

Table 1. Affordance comparison of four commercial VR artmaking applications with the potential of being used as part of a chronic stroke rehabilitation regimen.

Affordances	VRChat	Hand Brush with Friends	Mozilla Hubs	Multibrush VR*
Device compatibility	Most commercial VR devices	Oculus Quest	Most Commercial VR devices	Oculus Quest
VR embodiment	Allowed	Not found	Allowed	Allowed (waist up only)
Avatar options	Custom avatar from photo (Ready Player Me)	Not found	Custom avatar from upload	Meta's avatars only
Virtual Agent options	Not Available	Not Available	Not Available	Not Available
Drawing options	Allowed (gesture-based)	Allowed (gesture-based)	Allowed	Allowed (controller-based)
Drawing tool options	Not found	Not found	Not found	Allowed
Pressure sensitivity options	Not found	Not found	Not found	Allowed
Drawing space	3D	3D	3D	3D
Color palette	Not found	Allowed	Not found	Allowed
Eraser options	Allowed (gesture-based)	Not found	Not available	Allowed (controller based)
Audio	Allowed	Not found	Allowed	Allowed
Open source	Not available	Not available	Available	Not available
Collaborate online	Yes	Not found	Yes	Yes
Estimated Level of Cognitive Load	High (but can be regulated)	Low	High (but can be regulated)	Very High

* Multiplayer version of "Google Tilt Brush"

While motor impairments due to stroke usually tend to improve with time, the accompanying cognitive decline tends to linger and can markedly undermine stroke survivors' well-being long-term (Mijajlović et al., 2017). Targeted cognitive training can stall the occurrence of adverse neurodegenerative effects (Rost et al., 2022), making VR an appealing medium to explore – especially for dementia prevention in high-risk populations. Gradl et al. (2019) propose that a gamified Stroop test within multiplayer virtual environments, where users feel socially observed, could reveal new insights about how VR stressors influence executive function performance. The Stroop test measures interference, the condition in which two separate cognitive functions, namely the automatic "word reading" and non-automatic "color naming", conflict due to incongruent stimuli (Belletier et al., 2019). It is hypothesized that the added cognitive load of co-acting peers may divert attention from the incongruency of these cues, thus reducing interference (Muller and Butera, 2007). Recent evidence links Stroop interference to fluctuations in attentional focus, affective state, and neural circuits involved in social cognition (Arioli et al., 2021), underscoring the value of investigating this paradigm within socially immersive VR environments while focusing on the rehabilitation of chronic stroke survivors (Hadjipanayi, Sokratous, et al., 2025).

The Design of the Exergame

The prototype is a single-player, first-person exergame that embeds a Stroop-style color-naming task within a creative artmaking scenario. The player enters the virtual environment, which is designed to resemble an art-studio, while embodying a humanoid avatar (Figure 1A). Positioned in front of an easel-mounted canvas, the user can freely draw using the index finger of the impaired upper limb (Figure 1B) while the contralateral hand acts as an eraser. Across the avatar stands a virtual physiotherapist - remotely controlled by the session administrator through a screen menu - who can deliver guidance or encouragement as needed (Figure 1A). The art studio can be populated with other virtual humans occupying neighboring easels to provide a sense of social co-presence. Gameplay begins when the user presses a start button beside the canvas (Figure 1C). The virtual physiotherapist welcomes the user to the session and provides gameplay instructions. Each prompt points towards either a color word-naming (automatic response) or color ink-naming (non-automatic response) request in a fashion reminiscent of the Stroop test (Figure 1D). For each prompt, the player has a configurable time window to choose the appropriate hue from a palette and render a drawing. The drawing should ideally portray the object-word of the displayed phrase (Figure 1D), but the user is free to draw whatever comes to mind, as the fidelity of the painted object to its real-life counterpart is irrelevant to the objectives of this game and game points accrue solely from brushstrokes executed with the correct color. Rounds repeat until the session ends.

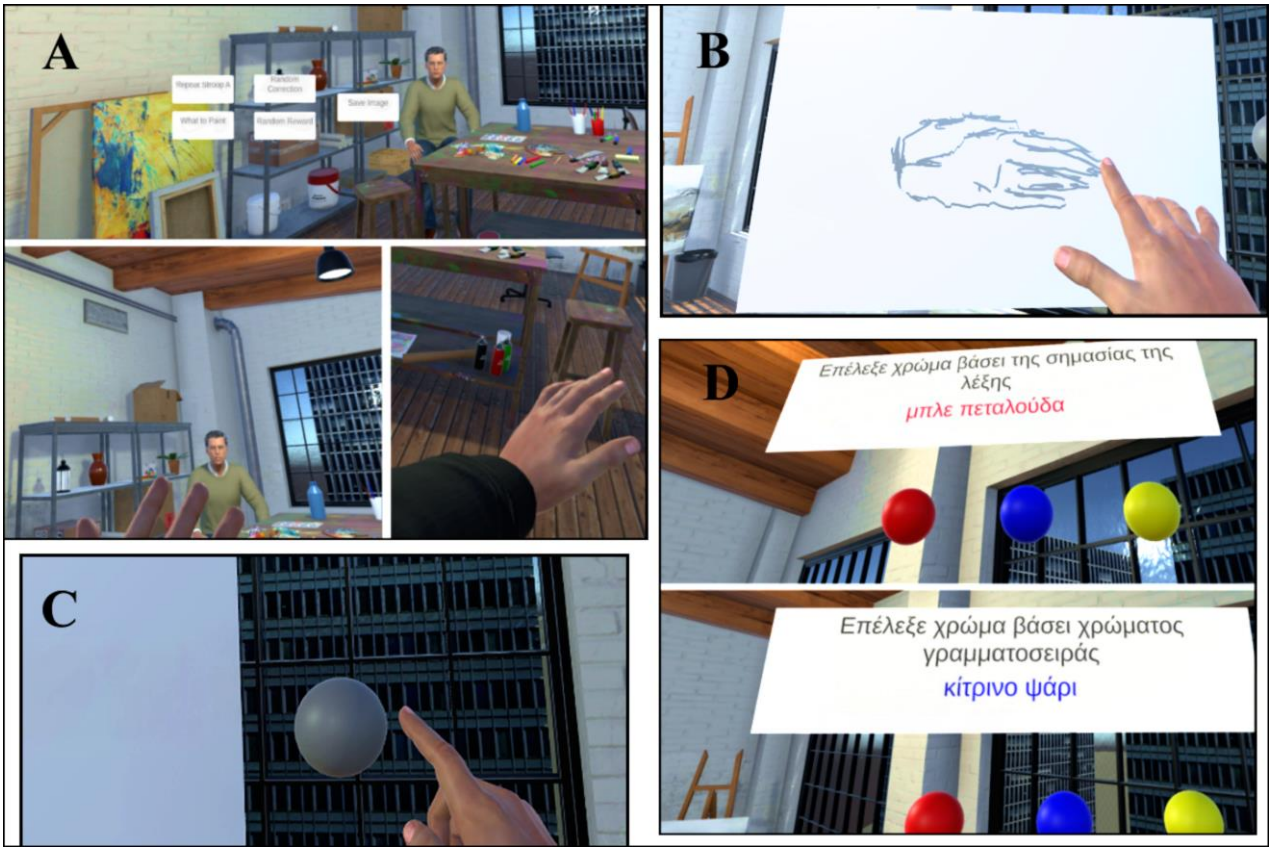

Figure 1. The environment and gameplay of the featured VR application. **A.** Interactions between the player and the virtual physiotherapist. **B.** Free drawing on the canvas. **C.** Starting the exergame. **D.** The Stroop task.

The prototype currently runs on an Oculus Quest 3 headset, employing its upper-body tracking for avatar control and its native finger-tracking to drive the drawing interaction.

Conclusions

The prototype is now in pilot trials with stroke survivors to gauge its therapeutic impact and acceptability for both patients and physiotherapists. Results from this phase will inform a larger study that will compare the gamified application's effects on rehabilitation and well-being and assess its viability for future at-home use.

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