i-CREATe Student Innovation Challenge

STUDENT INNOVATION CHALLENGE 2025

ENTRY FORM

ORGANIZED BY:

Entry Number:

(Official use only)

1. Title of the Project / Device

**Please write a short of the project title / the device and should not exceed 50 words.*

Virtual Reality Mirror Therapy with Focused Objective Attention (VRMTFOA)

2. Particulars of Applicant (Advisor/ Supervisor)

**Please enter name(s) in full [no nicknames as name(s) will be use for certificate and documentation].*

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3. Particulars of team members (Student)

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4. Categories

Please tick on one of the following

☐ Design Category	☒ Technology Category

5. Project Description

Give a brief description of your project: Objectives of the project. Who are the target users? Why does the user need this? Have the users been consulted? Feature design or technologies used, safety precaution, etc. You may also include some pictures or illustrations of your project. ***(*Please try not to exceed 1000 words)***

Our team proposes an innovative rehabilitation strategy—Virtual Reality Mirror Therapy with Focused Objective Attention (VRMTFOA)—to help patients with hemiparesis from stroke or cerebral palsy regain function. While existing FDA-approved VRMT systems effectively combine VR and mirror therapy, they cannot ensure that users consistently attend to the affected limb. To address this limitation, we developed VRMTFOA, which further incorporates motor-cognitive dual-task training, eye-tracking, and real-time auditory feedback to redirect gaze when attention shifts. Initial testing with ten healthy participants assessed its effectiveness using eye-tracking, EEG, and neural coherence.

Hemiparesis, often caused by central nervous system damage from stroke or cerebral palsy, results in weakness or paralysis on one side of the body, severely limiting limb function. Patients may also experience cognitive impairments such as language difficulties, executive dysfunction, and visuospatial or sensory neglect, where the affected side of space is unconsciously ignored. These deficits reduce independence and quality of life. With 12 million strokes annually and up to 80% involving upper limb hemiparesis, more effective, integrative rehabilitation strategies are urgently needed.

Traditional mirror therapy uses a mirror to create a visual illusion, making patients perceive movement in the affected limb. This visual feedback can activate motor-related brain regions and promote neuroplasticity and functional recovery (Figure 1). Despite its benefits, traditional mirror therapy has several limitations—such as restricted viewing angles, repetitive and monotonous tasks, and susceptibility to external distractions—which may reduce patient motivation and engagement over time. More importantly, it lacks objective measures of gaze and visual attention on the affected side, making it difficult for clinicians to assess true patient engagement.

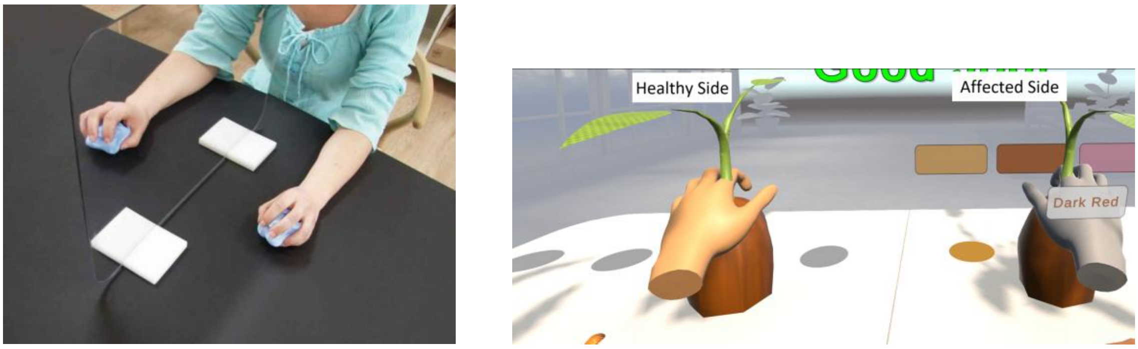

Figure 1. Traditional Mirror Therapy vs. VRMTFOA Diagram

This study introduces immersive virtual reality (VR) technology into the mirror therapy framework, creating a more dynamic, interactive, and engaging rehabilitation environment. VRMTFOA offers real-time, synchronized visual and motor feedback through virtual avatars, greatly enhancing visual freedom and task diversity.

Additionally, VRMTFOA places special emphasis on enhancing attention toward the affected limb—an aspect often neglected in traditional mirror therapy. The research team designed multiple dual-task scenarios to stimulate both cognitive and visual processing. Tasks involve active searching, recognition, and responses to targets, enhancing spatial awareness and attention resource allocation. Moreover, VRMTFOA includes a real-time attention feedback mechanism: when the headset detects gaze deviation or attention lapses, auditory cues prompt patients to refocus, reinforcing attention guidance and combating sensory neglect. Through repeated training, patients improve sensory processing and proprioceptive integration, thereby enhancing motor recovery. This approach may help improve motor performance and spatial attention, contributing to long-term functional gains.

The study designed multiple dual-task scenarios combining motor and cognitive challenges. For example, patients must solve simple arithmetic problems before moving items marked with specific numbers or colors to target areas (Figure 2). Another scenario involves sorting cards by suit and number (Figure 3). The numbers 2–13 appear in random suits. These scenarios include bilateral objects, but the cognitive tasks are randomly generated and limited to the affected side to enhance focused attention.

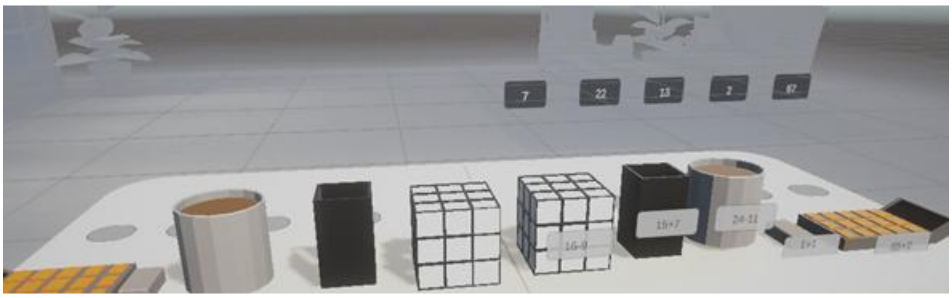

Figure 2. Dual-task Scene: Matching Numbers and Objects

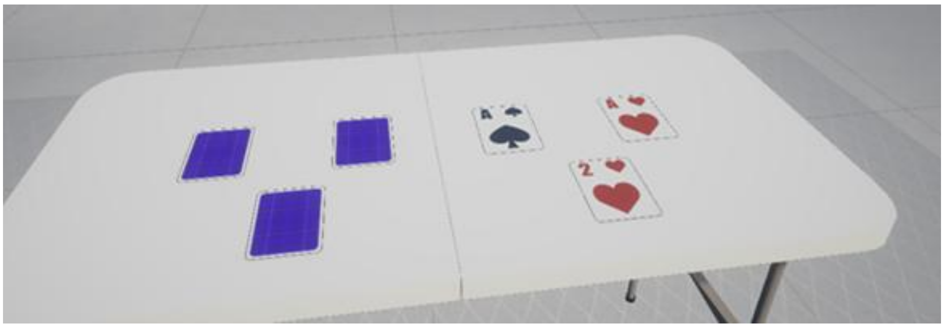

Figure 3. Dual-task Scene: Card Sorting by Suit and Number

To evaluate VRMTFOA's effectiveness, a randomized crossover trial design (Figure 4) was used to compare three therapeutic conditions: VRMT, VRMTFOA, and VRMTFOAAF (with auditory feedback triggered when gaze deviated from the affected side for more than 2 seconds). Participants were randomly assigned to different rehabilitation intervention groups (Figure 5).The VR headset's integrated eye-tracking system continuously recorded real-time gaze trajectories—including fixation points, durations, and counts—to quantify the strength and distribution of visual attention on the affected limb. Concurrently, EEG was recorded, with functional connectivity (FC) and event-related desynchronization (ERD) analyzed as neurophysiological markers. FC reflects synchronization across brain regions during tasks or rest, providing insights into neural coordination. This study focused on brain regions related to attention control, motor planning, and sensory integration to examine whether rehabilitation alters network structure and function. ERD indicated the degree of cortical activation during motor tasks, while the Theta/Beta Ratio (TBR) served as an additional marker of attentional regulation and cognitive engagement during rehabilitation.

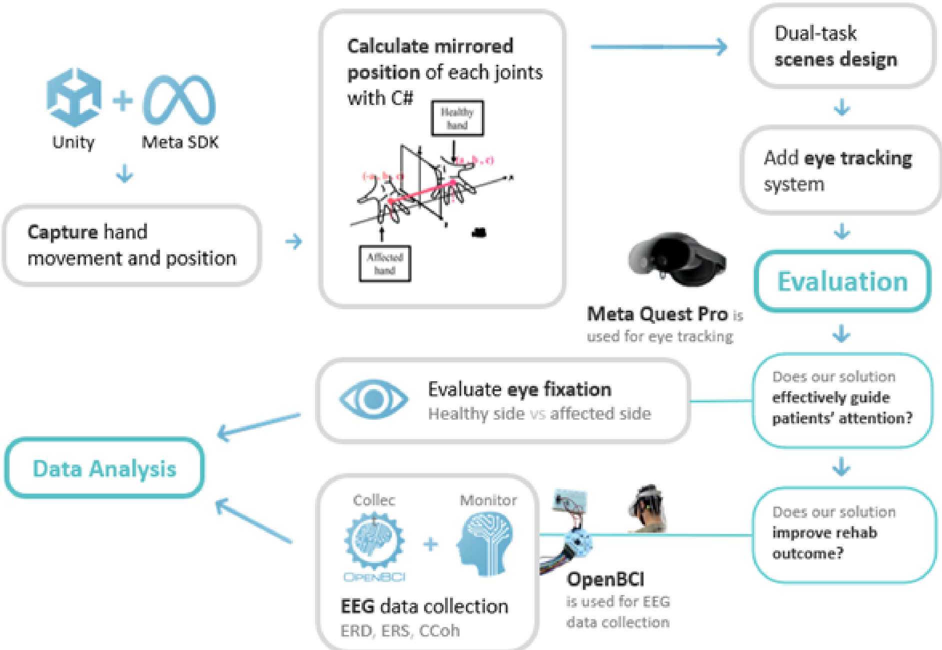

Figure 4. System Design Flow

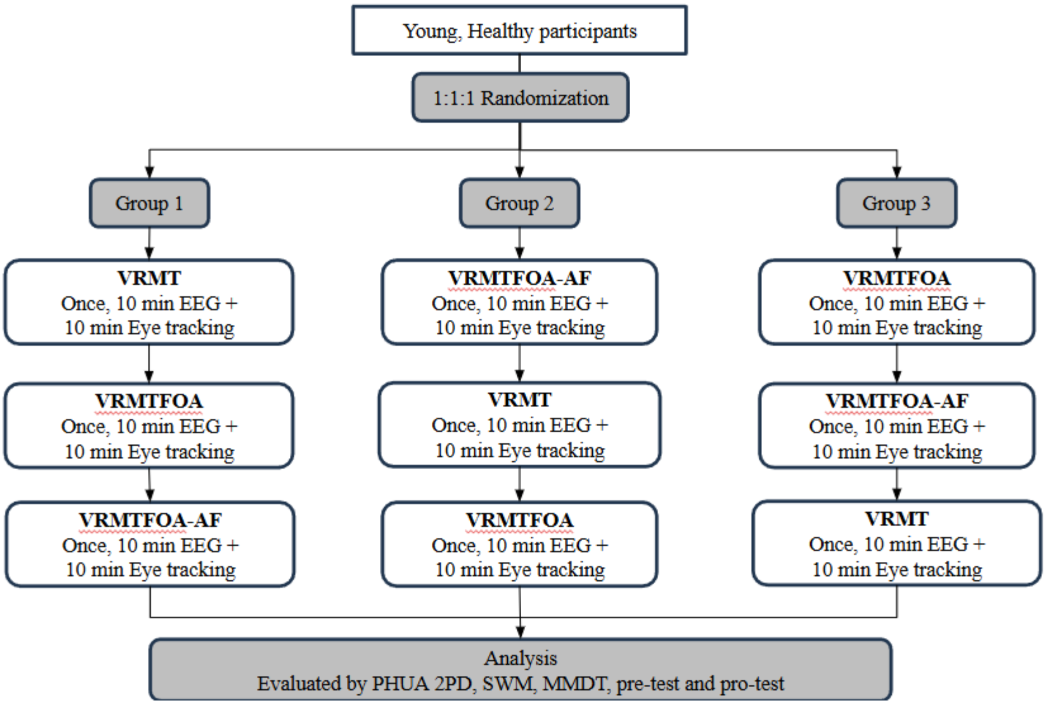

Figure 5. A randomized crossover trial

In preliminary results, VRMTFOA was analyzed through three perspectives: eye tracking, EEG ERD, and neural coherence. Eye tracking showed that Average gaze duration on the affected side was shortest in VRMT (18.48 s), improved in VRMTFOA (36.32 s), and peaked in VRMTFOAAF (41.56 s), representing a 125% and 154% increase compared with VRMT, respectively (Figure 6). In percentage terms, affected-side gaze accounted for 39.7% in VRMT, 58.9% in VRMTFOA, and 70.9% in VRMTFOAAF (Figure 6). This indicates progressively stronger visual focus and reduced attentional distraction as attentional guidance increased. For EEG, Topographic maps revealed that both VRMTFOA and VRMTFOAAF elicited stronger Mu-band ERD compared with VRMT, especially in contralateral motor cortex regions (C3/C4). VRMTFOAAF, which adds auditory feedback when gaze deviates >2 seconds, produced the most pronounced desynchronization (deep-blue patterns), reflecting enhanced motor cortex activation (Figure 7). Since the left hand was modeled as the impaired limb, this contralateral activation pattern aligns with known motor control mechanisms. Connectivity matrices showed that VRMT displayed dispersed, less-organized motor-related networks. In contrast, VRMTFOA demonstrated more concentrated and coordinated coherence patterns in both Mu and Beta bands, while VRMTFOAAF exhibited the strongest and most centralized activation (Figure 8). This progression indicates greater neural efficiency and functional integration when attentional feedback is incorporated. These results suggest that integrating cognitive attention control with VR-based mirror therapy substantially enhances engagement, strengthens cortical motor activation, and improves network coherence. Importantly, the addition of auditory feedback (VRMTFOAAF) yields the highest improvements across all three measures, supporting the role of multisensory attentional cues in optimizing rehabilitation.

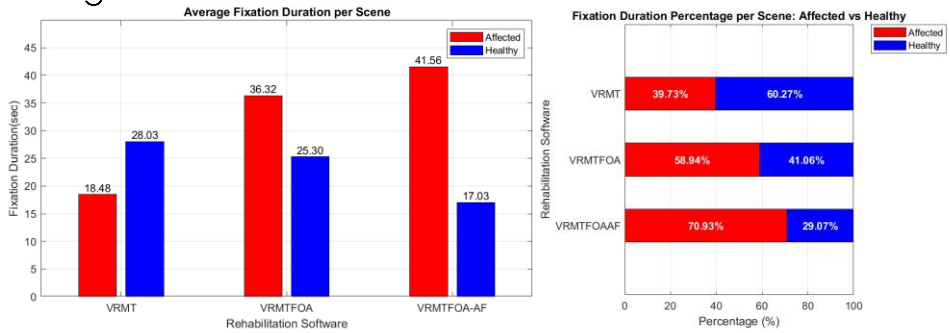

Figure 6. Gaze Duration and Proportion

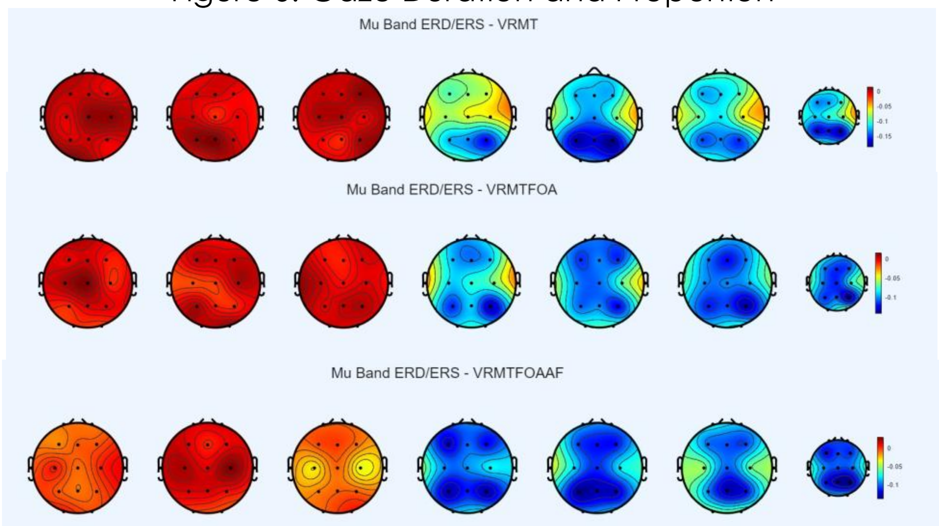

Figure 7. EEG Mu and Beta Band ERD Topographic Maps

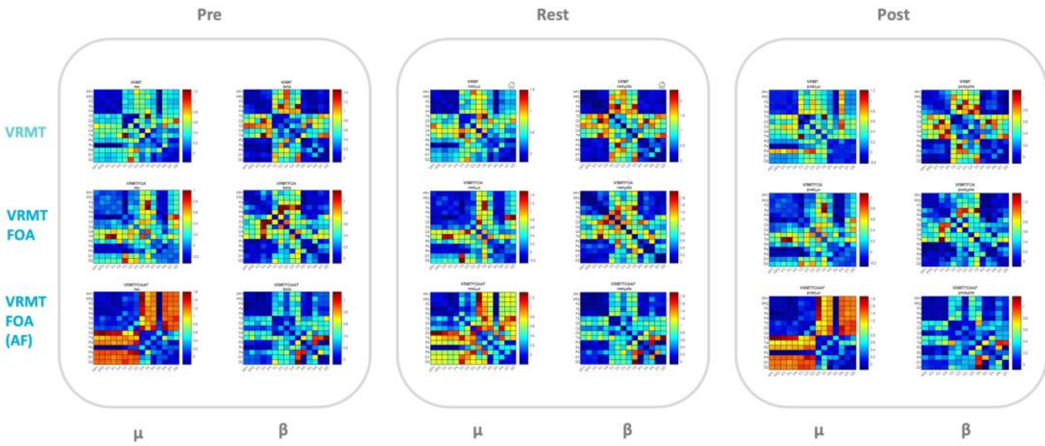

Figure 8. Mu-Beta Coherence Comparison Across 3 Conditions

Future plans include recruiting stroke patients for clinical validation, examining detailed gaze–attention–ERD relationships, deploying the VRMTFOA/VRMTFOAAF applications on the Meta Store, and developing adaptive task modules. The ultimate goal is a high-performance, scalable, data-driven smart rehabilitation tool to improve stroke recovery outcomes.

6. Additional Information about the Project/Device

Has your Project/Device been submitted to any other competition or won any award? If yes, please provide details.

1. We won the **Golden Prize** in the **2025 gSIC Global Student Innovation Challenge in Rehabilitation Engineering and Assistive Technology – Taiwan Selection**.

Other points or aspects that you would like to highlight, if any.

1. Using virtual reality mirror therapy combined with dual-task training, in which cognitive tasks are randomly generated and shown only on the affected side to maintain user attention.
2. Eye-tracking technology verifies attention toward the affected limb, while EEG confirms its effect on neural activation.
3. The treatment process includes auditory feedback to help the patient pay more attention to the affected side.

Has your Project/Device been patent? If yes, please provide details.

We will submit the US provisional before presenting in the gSIC 2025.

7. Abstract

Please write a short summary of the overall Project/Device and should not exceed 200 words.

This study introduces an innovative rehabilitation strategy—Virtual Reality Mirror Therapy with Focused Objective Attention (VRMTFOA)—to improve motor recovery in stroke and cerebral palsy patients with hemiparesis. Building on conventional VR-based mirror therapy, VRMTFOA incorporates motor-cognitive dual tasks, real-time eye-tracking, and auditory feedback (VRMTFOAAF) to maintain attention on the affected limb. Ten healthy participants underwent a randomized crossover trial, with outcomes assessed through eye-tracking, EEG event-related desynchronization (ERD), and neural coherence.

In a preliminary study, average gaze duration on the affected side increased from 18.48 s in VRMT to 36.32 s in VRMTFOA, peaking at 41.56 s in VRMTFOAAF (+154%). EEG analyses revealed stronger Mu-band ERD in contralateral motor cortices for VRMTFOA and VRMTFOAAF, indicating greater motor engagement. Connectivity mapping further showed more concentrated and coordinated motor networks compared with the dispersed patterns in VRMT. These findings suggest that integrating attention guidance and multisensory cues into VR mirror therapy enhances visual engagement, strengthens cortical activation, and improves neural efficiency, offering potential to accelerate neuroplastic recovery. Future work will recruit stroke patients for clinical validation and deploy VRMTFOA/VRMTFOAAF applications with adaptive task modules as scalable, data-driven rehabilitation tools.