Abstracts from the Annual XR4REHAB Conference Lecco, Italy June 26–27, 2025

JOURNAL OF MEDICAL EXTENDED REALITY 00:e2–e11 (Month 2025)

DOI: 10.1089/jmedxr.2025.58801.abstract

JMedXR Abstracts: XR4REHAB Conference

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The use of a Virtual Reality headset intervention as an adjunct to rehabilitation following major trauma: A quality improvement project

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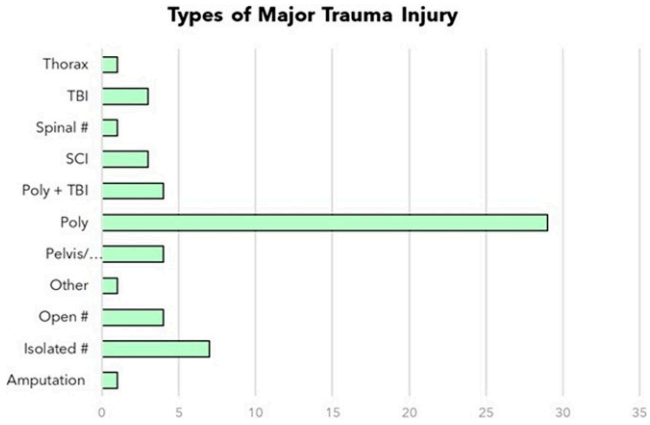
Background: This project aimed to assess the feasibility of using a physically active Virtual Reality (VR) headset intervention for hospitalised major trauma patients. While VR technology is increasingly being integrated into healthcare, no research exists on its use for major trauma patients within the national health service. However, studies in other healthcare populations suggest VR interventions can alleviate pain, reduce anxiety, and enhance functional recovery, addressing key challenges commonly faced after major trauma. Our primary objective was to understand the injury profile of major trauma patients who could safely use a physically active VR headset intervention. We also sought to explore patients experiences through surveys and measure potential benefits using validated outcome tools.

Methodology: Participants with major trauma injuries were recruited by physiotherapists. In the first project cycle, participants undertook a single session using a SyncVR Fit neo pro-3 VR headset. They could select a variety of physically active games to play using one or both upper limbs in a lying, sitting, or standing position. A pre-session survey was used to evaluate patients pain levels, safety concerns, and movement concerns. Post-session questionnaires evaluated the interventions influence on stress, pain, engagement, motivation and movement facilitation. The surveys utilised a 5-point verbal Likert scale (e.g. 'not at all', 'mildly', 'moderately', 'very', 'extremely'). In the second cycle, participants completed up to three VR sessions, complete pre- and post-intervention surveys and additional validated outcomes measures: Tampa Scale of Kinesiophobia (TSK), Pain Catastrophising Scale (PCS), and GAD-7 for anxiety.

Results: Fifty-four participants (mean age ± SD: 54 ± 19) used the VR headsets. Two minor adverse events occurred, a dislodged IV cannula and nasal cannula. Therapists delivering the intervention reported mitigatable concerns including falls risk, reduced spatial awareness and breathlessness. Eighteen participants were analysed in the first cycle. Of this cohort two patients reported that the VR intervention negatively impacted their Pain. Seventeen patients rated the intervention between moderately and extremely engaging and twelve patients found it extremely helpful for movement. No patients reported VR to negatively impact their movement. In cycle two, thirty-seven participants showed average reductions in TSK (3.5 points) and PCS (3.24 points), with minimal change in GAD-7 (0.43 points).

Conclusions: VR appears safe and beneficial for enhancing rehabilitation experiences in this population. A feasibility study is needed to evaluate the interventions acceptability in a major trauma population and understand its full potential as a rehabilitation adjunct.



Keywords: Virtual Reality, Major Trauma

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Early mobilization at ICU with XR

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Background: Patients at the Intensive Care Unit (ICU) have to start with early mobilization (EM) exercises as soon as possible to minimize physical deterioration. However, the motivation to start and continue exercise is low. Gamified applications using eXtended Realty technology (XR) can help motivate patients by creating a therapeutic, game-like environment where patients can engage in stimulating and safe therapy. Studies show the potential for virtual reality technologies for EM. However, less is known about potential benefits and limitations of other XR, which XR works best for which patients, and how to use XR in clinical practice. This study investigated how XR can contribute to EM of ICU patients, considering the complex care environment and specific patient needs.

Methodology: A qualitative study was performed (n = 17) in cooperation with 5 hospitals and 2 XR-companies comprising one focus group (3 nurses, 1 physiotherapist and 2 XR-experts) and 11 semi-structured interviews (3 nurses, 4 patients, 3 intensivists, 1 ventilation practitioner). The COM-B model was used to set up the focus group and interview guide, addressing the topics of capability, opportunity, and motivation for behavior. At start, participants were visual informed about current and foreseen possibilities with XR. The data was verbatim transcribed and analyzed using ATLAS.ti.

Results: The qualitative data is organized following the COM-B model:

Capability. Patient's psychological and physical status (type of injury, energy, time in the ICU) should determine if XR technology can be used for EM and which XR works best. For instance; headsets might not be suitable for patients with head injuries, and patients with muscle atrophy might struggle with controllers. Projection-based XR utilizing hand-gestures might be a good alternative. Interestingly, healthcare professionals expressed a preference for patients to maintain visual contact with their environment (to prevent delirium and preserve nonverbal communication), while patients indicated no such need.

Opportunity. To implement XR for EM at the ICU, healthcare professionals will need education and training. Management support and available budget are crucial, and hygiene of XR equipment must be considered.

Motivation. Participants have shown enthusiasm for using XR in the ICU. Both healthcare professionals and patients noted that XR can increase motivation, enjoyment, and provide distraction during repetitive exercises, particularly when healthcare professionals are absent. This can increase duration and number of practice moments, ultimately accelerating recovery.

Conclusion: In conclusion, XR technologies offer promising opportunities in motivating ICU patients to start and sustain early mobilization potentially leading to a more favorable recovery. Key challenges include determining the best XR for each situation and setting up a workable implementation process.

Keywords: Early Mobilization, ICU, eXtended Reality

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Examining therapist time allocation in digital mental health interventions: Impacts on patient engagement and symptom improvement

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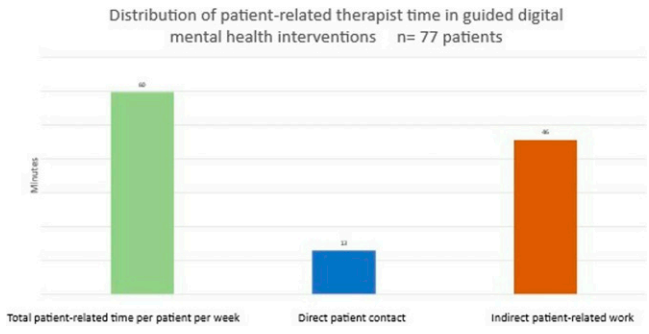
Background: Recent reviews on the effectiveness of Digital Mental Health Interventions (DMHIs) suggest they hold promise in treating common mental health disorders such as depression and anxiety. There are clear advantages, including increased access to mental health care in remote areas, support for disadvantaged communities, and conservation of therapist resources. However, the implementation and sustained use of DMHIs in routine healthcare remain limited. Guided DMHIs, which include some therapist support, have been reported to enhance compliance and adherence while still significantly reducing the time therapists spend compared to face-to-face interventions. Nonetheless, published figures on therapist time often only account for direct patient contact, which may present an overly optimistic view. Additionally, there is limited understanding of how therapist engagement—such as the number of messages sent—affects patient compliance and symptom reduction.



This study aims to examine actual patient-related time use and explore various features of therapists' time allocation in relation to self-reported improvement.

Methods: Nationwide, Norwegian therapists providing digital treatment for common mental disorders will be asked to register their patient-related time use during a regular work week. The study will focus on four different programs targeting individuals with ADHD, anxiety, social anxiety, and depression. Their data will be supplemented with information from the platform provider and from pretreatment and posttreatment disease-specific and generic evaluation tools.

Specific features to be analyzed include:

- Therapist time spent on the platform versus patient-related time outside the platform.
- The relationship between the time therapists engage with patients and the time patients spend on the platform, as well as their adherence to the programs.

Results: Pilot results indicate that therapists spend approximately two-thirds of their patient-related time outside the platform, engaging in activities such as updating medical records, conducting evaluations, and making referrals. Further preliminary results regarding time use and allocation in relation to patient engagement and symptom improvement will be presented.

Discussion: Understanding how much time therapists actually spend providing guided DMHIs, how they allocate their time, and how this correlates with patient engagement and symptom improvement will provide valuable insights for planning adequate resources for scaling up guided DMHIs.

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Co-designing Extended Reality systems to strengthen therapeutic alliance in rehabilitation practices

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Background: Extended Reality (XR) holds significant potential for advancing rehabilitation practices. However, its ability to enhance the Therapeutic Alliance (TA)—a fundamental element of effective therapy—remains underexplored. This study investigates how co-design with healthcare professionals can inform the creation of an XR system that incorporates key themes of the therapeutic alliance, including communication, collaboration, and connectedness, to improve rehabilitation outcomes.

Methodology: Co-design workshops were conducted with qualified and student occupational therapists and physiotherapists to design and evaluate an XR rehabilitation system. Participants were required to have clinical experience working with brain-injured patients, ensuring their insights were grounded in practical expertise. A pre-existing prototype was used, enabling

the real therapist to exist in the virtual environment alongside the patient. This prototype served as the foundation for discussions and roleplaying therapy scenarios, allowing participants to explore its features, offer real-time feedback, and engage in collaborative ideation to refine the system. AI tools supported participant ideation during the workshops, enabling the rapid generation of concepts and possible system features. Discussions centred on identifying features that could enhance connectedness, strengthen the therapist-patient partnership, and foster safety and confidence within the virtual and real-world environment.

Results: Key design insights emerged, emphasising the need for a patient-centred system that can adapt to individual needs. Participants highlighted the value of utilising passthrough technology for safety and enhancing communication through features such as gestural feedback and guidance in the virtual environment. The prototype's ability to support rapport and empathy by allowing the real therapist to interact directly with the patient in the virtual space was highlighted as a significant advantage. Features such as real-time feedback, agreement on tasks and goals, and personalised activities were identified as crucial for building trust. Themes of communication, collaboration, and safety were consistently recognized as critical to reducing perceived disconnect between therapists and patients and fostering active engagement.

Conclusion: This research underscores the value of co-design in developing XR tools for rehabilitation, prioritising the therapeutic alliance. By embedding adaptability, collaboration, and safety into XR design, this study contributes to the advancement of immersive rehabilitation technologies tailored to real-world clinical practices.

Keywords: Co-Design, Extended Reality (XR), Virtual Reality (VR), Therapeutic Alliance (TA), Rehabilitation

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Development of Virtual Reality/GenAI therapy for enhancing treatment of female domestic abuse survivors

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Background: Domestic abuse affects millions of women worldwide, leaving lasting emotional and psychological scars. Traditional therapy methods, while effective, can sometimes fall short in engaging patients and providing immersive experiences that facilitate deeper healing. VR therapy has shown promise in various fields of mental health by creating immersive environments that can help patients process trauma more effectively. Here we integrate VR and GenAI technology to create a simulation of a therapy room and AI therapist for domestic abuse survivors.

Methodology: The pilot simulation was created using the Unity engine (https://unity.com) with natural language processing (NLP) and voice cloning supported by InWorld (https://inworld.ai). Simulations were developed for the Meta Quest 3 (https://www.meta.com/gb/quest/quest-3).

Software was evaluated using 46 domestic abuse survivors (aged 36 years and over), 25 of whom were out of crisis point and at the next phase of rehabilitation. Evaluation was performed using an online questionnaire that captured system usability and simulation specific experiences.

Results:

- Participants generally found the hardware and software easy to use, with some suggesting a clearer pre-session briefing or short tutorial video would have improved the experience.
- Therapeutic benefits scored 4 out 5, with participants finding the simulation relaxing, supportive, and empowering. Some volunteers stated that they preferred talking to an AI therapist as they felt it was less judgemental compared to a human therapist.
- Technical issues included freezing of the NLP for some participants (a bug that has now been fixed), and the headset battery running out. Improvement suggestions included making the environment less clinical and more homely, for there to be a variety of avatars, and for avatar voices to sound more natural.

Conclusion: Overall, participants expressed optimism about the potential of VR/GenAI therapy as a tool for healing and empowerment. They appreciated the innovative approach and believed it holds promise for addressing the needs of diverse survivor groups.

This feedback provides a robust foundation for refining the VR therapy software, ensuring it remains accessible, inclusive,

and effective for all users. Additional funding has recently been secured to build on this pilot.

Keywords: Domestic Abuse, virtual reality, Generative AI, Patients

P3

Perception of peripersonal space in Virtual Reality: An fMRI study

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Background: Over the past decades, virtual reality (VR) applications have gained increasing popularity in treating cognitive deficits such as attentional disorders and hemispatial neglect. These approaches are based on the assumption that VR presentations provide a sufficiently realistic rendering of 3D space to activate automatic cognitive processes related to size and distance perception, such as distinguishing between peripersonal space (PPS = near grasping space) and extrapersonal space (EPS = distant out-of-reach). The current study investigates the neural mechanisms of peri- and extrapersonal space encoding in VR.

Methodology: Forty-four healthy participants completed a visual discrimination task (determining whether objects were upright or inverted) while their brain activity was monitored using functional magnetic resonance imaging (fMRI). The virtual environment was displayed in 2D or 3D through MR-compatible video goggles (see *Figure section 1*). Objects were positioned in either PPS or EPS and varied in size to control for potential effects of retinal coverage.

Results: Objects in the PPS were primarily processed in the medial and dorsal visual areas, as well as in the intraparietal sulcus (see *Figure section 2a,f*). In contrast, objects in the EPS preferentially engaged regions in the ventral occipital cortex (*2b,f*). Smaller objects activated several attention-related structures in the frontal cortices when compared to bigger objects (*2d*). The 3D presentation also stimulated the intraparietal sulcus, further enhancing activation in the PPS network (*2c*).

Conclusion: In summary, the results demonstrate that VR can elicit differential PPS/EPS encoding, regardless of absolute retinal size. Notably, activation in the intraparietal sulcus, which is involved in preparing grasping motions and is part of the PPS network, could be further intensified by presenting the virtual environment in 3D. These findings suggest that VR is particularly well-suited to present virtual objects in a manner that activates automatic neural processes for action preparation and engagement, which could be exploited for clinical purposes.

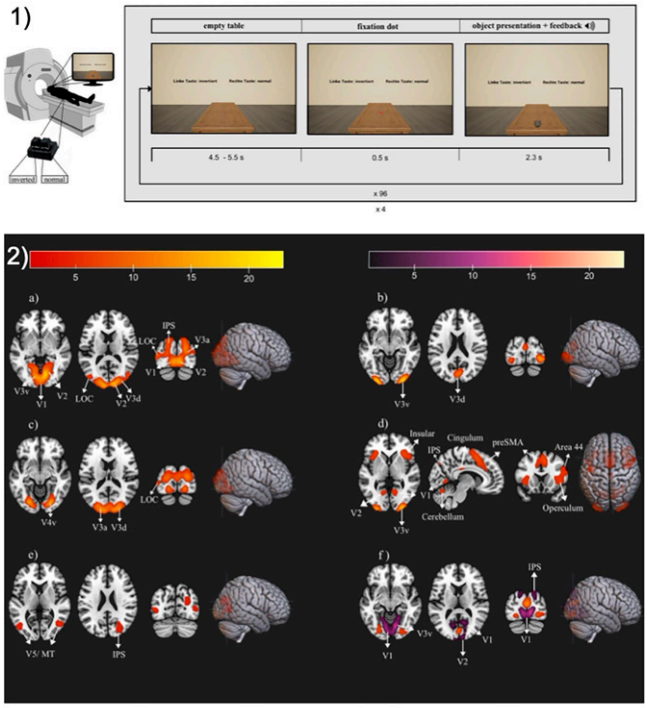

Figure: 1) Technical setup and trial sequence 2) Contrast images of experimental conditions peri-extra (a), extra-peri (b), big-small (c), small-big (d), stereo-mono (e), and peri-extra + extra-peri controlled for retinal size.

P4

Advancing neuropsychological assessment: Machine learning-based detection of attention deficits in brain-injured patients using eye-tracking in immersive Virtual Reality

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Background: Attention deficits in alertness and Unilateral Spatial Neglect (USN) are common sequelae of Acquired Brain Injuries, leading to poor functional outcomes and impairments in daily functioning. To address limitations in current assessment tools, Immersive Virtual Reality (iVR) has been proposed as a valuable solution. By simulating real-world scenarios while offering precise control over stimuli, iVR enhances ecological validity and measurement reliability. Additionally, integrating eye-tracking (ET) into Head-Mounted Displays (HMD) enables capturing meaningful parameters, recognized as attention biomarkers. This study evaluates the ability of ET metrics, collected during novel iVR-based tasks, to detect alertness and spatial attention deficits in ABI patients.

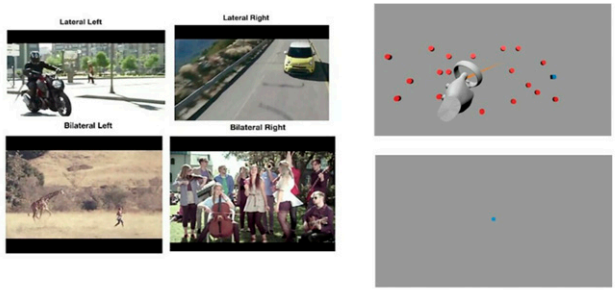

Figure 1. Examples of iVR-based tasks used in the study. On the left, the iVR-Free Viewing Exploration Test (iVR-FVE), a 3D adaptation of Nardo et al. (2019)'s task. On the top right, the iVR-based task for spatial attention. On the bottom right, the iVR-based task for alertness.

Methodology: Thirty-one brain-injured patients (80% stroke) in sub-acute stage (mean time since onset = 49 days) were recruited as part of a broader evaluating an iVR-based cognitive assessment and rehabilitation program. The included patients exhibit deficits in tonic alertness (18 patients) and/or spatial attention (16 left-USN patients), as assessed by the Test of Attentional Performance (TAP). In addition to standardized assessment, patients completed an iVR-FreeViewing Exploration test (iVR-FVE) and two iVR-based tasks evaluating alertness and spatial attention, (*Figure 1*) wearing an HTC Vive Pro Eye equipped with an ET system (Tobii®). The gathered ET data were processed offline to derive metrics already identified in literature as biomarkers of alertness or spatial attention capacities. Random Forest (RF) algorithms with Leave-One-Out-Cross Validation (LOOCV) were implemented to classify patients with alertness deficits and to detect USN patients. Model performance was evaluated using Receiver Operating Characteristic (ROC) analysis to determine the sensitivity and specificity of classifications.

Results: Among the different models tested, the highest classification accuracy (0.87) for alertness deficits was achieved by combining ET features from the iVR-FVE and the iVR-based alertness task, using as input fixation stability, blink frequency, fixation count and duration.

For USN classification, the best accuracy (0.82) was obtained by combining ET metrics from the iVR-FVE and the spatial attention iVR-based task, using as input gaze laterality (percentage of fixation on the left), gaze-index (percentage of time spent on one side), first fixation side, and refixation count on the left and right. ROC analysis indicated an Area Under the Curve (AUC) between 80-90% for both models, reflecting strong performance.

Conclusion: These findings suggest that combining iVR and ET into cognitive assessments offers a rapid, effective, and ecologically valid method for identifying alertness and spatial attention deficits. Importantly, this approach bypasses the need for motor or verbal responses, increasing accessibility for a broader range of patients.

Keywords: Virtual Reality; Assessment; Eye-Tracking; Attention; Brain Injuries

P7

VRCare: an Italian-language immersive Virtual Reality app combining natural environments and mindfulness-based techniques for emotional well-being

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Background: Virtual reality (VR) combined with mindfulness practices has emerged as a promising approach in mental health. A recent review highlighted the potential of VR-based mindfulness training to promote more positive mood, better sleep, reduced stress and anxiety, emotion regulation, and cognitive attention (Ma et al., 2023). The integration of nature environments facilitates attention restoration (Dillon et al., 2022) and it may further enhance meditation effectiveness.

Our research group has developed, in cooperation with Solid-Color srl, VRCare, a VR app offering an immersive experience combining nature exploration and mindfulness to improve emotional states and induce a positive attentional shift.

Methodology: VRCare includes five different natural settings. The virtual environments are 360° videos created in real footage, characterized by high realism and level of detail for enhancing sense of presence. A prerecorded Italian voiceover, crafted ad-hoc and recorded by a psychologist guides the user in a relaxing and emotional experience. The choice of an Italian human voice ensures clarity, overcomes language barriers and enhances emotional connection, trust, and relaxation.

The users can select through the interface the preferred environment and choose from a set of 10 available breathing exercises. To ensure interaction naturalness and accessibility, the app does not require controllers but interaction occurs through a pointer controlled by the head's movement.

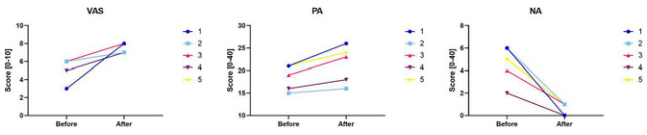
VRCare is potentially beneficial for hospitalized patients and for people with chronic pain. By utilizing attentional shifting techniques, the app helps patients to direct their focus toward new and non-harmful stimuli, providing a potential sense of relief and distraction.

A patient with chronic headache underwent a series of five sessions with VRCare. During each session, the patient chose one of the five environments and selected two breathing exercises.

Before and after each session, the Visual Analogue Scale (VAS) was administered to evaluate changes in emotional states; the Positive and Negative Affect Schedule (PANAS) was used to measure affective responses.

Results: Results show that VRCare sessions improved the emotional states and conveyed positive affective states. The average improvement across the sessions was 2.4 ± 1.52 points for the VAS, 3.00 ± 1.68 for positive affective states while negative affective states were reduced by 4.00 ± 1.58 points.

Conclusion: This work presents VRCare, an immersive VR application based on mindfulness relaxation techniques. Data on a single case provide first insight on the feasibility and potential of VRCare for inducing positive affective states and emotions in patients in a stressful condition. The VRCare-based program of five sessions was well accepted by the patient who showed perceived benefits supported by quantitative assessments. Future works will validate in a pilot study the potential of VRCare for emotional well-being.



Keywords: virtual reality, mindfulness, emotional well-being, nature environments

References

Ma, J., Zhao, D., Xu, N., & Yang, J. (2023). The effectiveness of immersive virtual reality (VR) based mindfulness training on improvement mental-health in adults: A narrative systematic review. Explore (New York, N.Y.), 19(3), 310–318. https://doi.org/10.1016/j.explore.2022.08.001

Dillon, D., & Cai, J. (2022). Virtual Reality Greenspaces: Does Level of Immersion Affect Directed Attention Restoration in VR Environments? J, 5(3), 334–357. https://doi.org/10.3390/j5030023

P11

Exploring the effects of associative recognition training on associative recall in Virtual Reality: A pilot study

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Introduction: Associative memory, crucial for episodic memory formation, is continually formed and consolidated as individuals explore their environments daily. While virtual reality (VR)-based associative memory training improves memory, studies investigating the effect of associative recognition training on associative recall within a VR context remain limited. This study aimed to develop a VR-based associative memory training intervention and evaluate its impact on performance accuracy.

Methodology: Five participants (mean age = 24.6, SD = 2.70) completed a two-session VR-based cognitive training intervention (4 repeated trials per session) over two days in a week. The VR training program consisted of encoding, training, and testing phases. Participants learned and mentally associated 3D toy objects with their names, moved to the training room to perform object-name matching task, and finally completed associative recall memory test.

Results: Comparison between associative recognition and associative recall using repeated measure ANOVA revealed a significant main effect of Trial, $F(7, 28) = 7.358$, $p < 0.001$, $\eta^2p = 0.648$ and a significant effect of Task Type, $F(1, 4) = 12.598$, $p = 0.024$, $\eta^2p = 0.759$, with performance favouring associative recognition over associative recall, as shown in Figure 1. Also, there was a significant interaction effect between Trial and Task Type, $F(7, 28) = 5.344$, $p < 0.001$, $\eta^2p = 0.572$. Linear regression analysis revealed that the associative recognition training significantly predicted associative recall score, accounting for 83.8% of the variance ($R^2 = 0.838$, Adjusted $R^2 = 0.812$, $F(1, 6) = 31.150$, $p = 0.001$). For every one-unit increase in associative recognition, associative recall increased by 2.487 units ($\beta = 0.916$, $p = 0.001$). These findings indicate a strong positive relationship between associative recognition training and recall performance.

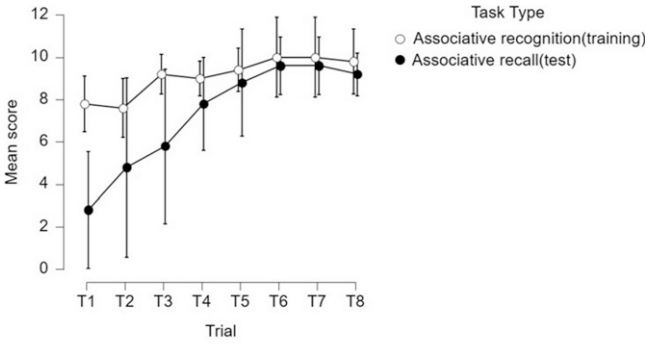

Fig. 1. Mean score of associative recognition (training) and recall (testing).

Conclusion: This study highlights the underexplored potential of VR-based associative memory training interventions. Progressive improvement in training performance and corresponding gains in testing performance demonstrate the effectiveness of repeated and targeted cognitive practice. These findings underscore the potential of VR-based interventions for memory rehabilitation.

P19

Changes in oculomotor functions influenced by training in Virtual Reality among patients with stroke

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Background: Medical rehabilitation for patients with stroke using virtual reality (VR) environments represents a promising approach to restoring oculomotor functions. Optokinetic nystagmus (OKN) refers to the physiological compensatory eye movements in response to the movement of visual stimuli. Studying OKN can help identify oculomotor dysfunctions in stroke patients and monitor their progression. The common pathophysiological mechanisms underlying motor disorders and oculomotor impairments in stroke allow for the assessment of rehabilitation effectiveness through non-invasive evaluation of oculomotor function.

Methodology: The study involved 28 patients with stroke. All participants underwent vertical and horizontal OKN registration using video oculography to assess their oculomotor responses. For each patient, the amplitude and velocity of both the quick and slow phases of OKN were measured and analyzed before the first VR training session and after completing the course. The data were analyzed using non-parametric statistical methods. The training sessions involved controlling an avatar in a virtual environment to complete various gaming tasks such as fishing, balancing on an ice floe, and ice skating (https://ncip.by/avtorskie-i-smezhnye-prava/registraciya-kompyuternyh-programm/reestr-kompyuternykh-programm/). The duration of each training session ranged from 5 to 20 minutes, depending on the patient's condition, with a total of 8-10 VR training sessions conducted.

Results: A significant reduction in the asymmetry coefficient (AC) for the velocity and amplitude of both the quick and slow phases of horizontal OKN was observed following VR training ($p = 0.06$). The AC for the amplitude of the quick phase before VR training was 13%, which decreased to 6% after VR-rehabilitation ($p < 0.05$). The AC for the amplitude of the slow phase of OKN decreased from 34% before VR rehabilitation to

7% after its completion ($p < 0.05$). The AC for the velocity of the slow phase of OKN reduced from 27% to 8% ($p < 0.05$), while the AC for the quick phase of nystagmus velocity decreased from 15% to 6%. Prior to VR training, 23 out of 28 patients (82%) exhibited no vertical OKN. After completing the training, restoration of vertical OKN was recorded in 8 out of these 23 patients (35%). These results demonstrate recovery and normalization of the rhythm and direction of OKN through VR training.

Conclusion: Restoring OKN in stroke patients is a crucial aspect of medical rehabilitation. Monitoring the dynamics of OKN can serve as an effective tool for evaluating the outcomes of rehabilitation efforts in stroke patients. The restoration of vertical OKN and reduction in asymmetry of oculomotor responses following VR training highlight the significant rehabilitative potential of VR for restoring motor functions in individuals who have experienced a stroke.

Keywords: Virtual reality, stroke, rehabilitation, nystagmus

P20

Self-directed exergaming for upper limb rehabilitation post-stroke: a multicentre pilot randomised control trial

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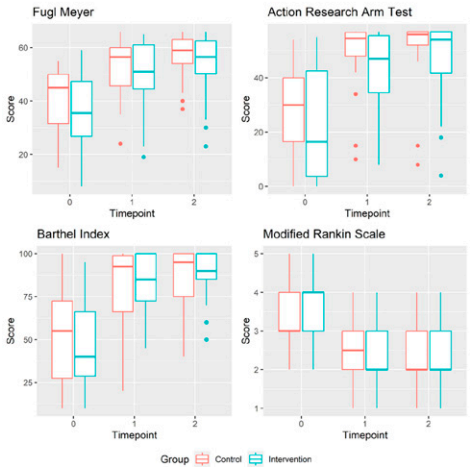
Background: High dose upper limb (UL) rehabilitation is associated with improved UL outcomes after stroke; conventional care dose is subtherapeutic, hampered by resource constraints, organisational issues and personal factors. Technological innovations present pragmatic solutions to dose enhancement; research is needed to understand clinical implementation parameters and evaluate clinical efficacy.

Methodology: The aims of this research were to; assess stroke survivors' level of adherence with a technology-facilitated, self-directed exer-gaming intervention (non-immersive virtual reality); explore factors associated with intervention adherence and; prepare for a definitive randomised controlled trial (RCT). Stroke survivors with UL paresis, within 30 days of stroke onset, were randomised to the intervention or conventional care. The exer-gaming intervention was implemented from enrolment until 3 months post-stroke, as an adjunct to conventional care. Intervention dose was self-selected, with supplementary education, coaching and technology support. Adherence was automatically, electronically logged. Assessment time-points were prior to randomisation, 3 and 6 months post-stroke. Associations between intervention and outcomes were tested using mixed-effects models for repeated measures.

Results: A heterogeneous sample of 55 participants were recruited; 40 completed. Intervention group participants ($N = 28$) undertook a median of 10 training sessions (IQR: [3, 18]) over a duration of 81 days (IQR: [73, 86]). Session duration (intra-user average) was 12 minutes (IQR: [6, 232]) and consisted of 452 repetitions per session (IQR: [175, 624]). Training dose increased over time and positively correlated with user competency rating ($P = < 0.001$) and participants' level of engagement with researcher support ($P = 0.003$). The intervention group demonstrated marginally greater improvements in primary and secondary outcomes at 6months (Figure 1.); these results did not reach statistical significance. A positive dose-response was observed; ≥10 hours training over 12weeks was associated with a clinically important difference in outcomes. A sample size of approximately 300 will be required for a full-scale RCT.

Figure 1. Box plot of Confidence Rating results in the control (red) and intervention (blue) groups measured at pre-intervention ("Timepoint_0"), 3-months post-intervention ("Timepoint1") and 6-months post-intervention ("Timepoint2").



Conclusion: Technology-facilitated, self-directed UL rehabilitation offers a pragmatic solution to dose enhancement and may improve UL outcomes. Further work is needed to refine and evaluate complex intervention components (human and technological factors) prior to progressing to a definitive trial.

P21

Leaving stroke survivors to their own devices: a qualitative study exploring experiences of technology-facilitated, self-directed upper limb rehabilitation early after stroke

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Background: There is limited research exploring stroke survivor experiences with self-directed technology-facilitated interventions, particularly during the pivotal acute and early subacute

Figure 1. Themes and subthemes

recovery phases. This study aimed to explore factors influencing stroke survivors' adherence with self-directed, technology-facilitated upper limb (UL) rehabilitation early after stroke.

Methodology: This study adopted a nested qualitative design within a multicentre pilot randomised controlled trial. Design, analysis, and reporting were underpinned by a relativist ontology and an interpretivist-constructivist epistemology, which accepts the existence of "multiple realities", emphasizing the subjective, context-dependent nature of reality and the co-construction of knowledge through interpretation. Semi structured interviews were conducted with a purposive sample of 10 stroke survivors engaging in a technology-facilitated, self-directed UL intervention (interactive gaming/non-immersive virtual reality) within the first 3 months after stroke. Interviews were recorded and transcribed verbatim. Reflexive thematic analysis was used to generate codes, sub-themes and themes which reflected the perspectives and experiences of participants engaging in the intervention.

Results: Six key themes were generated, these themes related to 1.) the complexity and competing demands of life after stroke 2.) the impact of the physical and social environment 3.) issues in accessibility and reliability of the technology 4.) the perceived benefits of technology-facilitated training needing to outweigh associated effort or risk 5.) the importance of everyday functional activities and 6.) beliefs about recovery and rehabilitation.

Conclusion: Themes highlight the complex experiences of life after stroke and the ways in which these impact upon participation in self-directed rehabilitation activities, the challenges and opportunities presented by technology-facilitated rehabilitation, the importance of social and emotional support (formal or informal) and the drive of stroke survivors exercise autonomy through supported self-management within the context of their rehabilitation. These findings will help inform intervention considerations as technology-facilitated and/or self-directed rehabilitation is increasingly utilised along the stroke recovery pathway.

P22

SensiVR: an Extended Reality (XR)-based Digital Therapeutic solution (DTx) for the hybrid care of children with fine motor function disorders, using Virtual Reality (VR) and hand tracking technology

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Background: The problem of limited availability and accessibility for traditional hand therapy for children is significant at both European and global levels. The dyspraxia condition, which causes a child to perform less well than expected in daily activities for their age and appear to move clumsily, affects 5-6% of the paediatric population. To address this issue, there is an urgent need to shift from paternalistic and expensive hospital-based treatment to individualized, hybrid outpatient intervention in pediatric care understanding patients' requirements. SensiVR is a unique, innovative VR-based and AI-driven serious game in the form of a *Sensory Virtual Room (SVR)* that provides monitoring with a personalized and digital therapeutic (DTx) approach to patients in both clinical and community settings. SensiVR reduces health inequalities in children's fine motor function skills, focusing mainly on prevention of mental health and improvement of movement skills with neurodevelopmental disorders such as *Developmental Coordination Disorder* (DCD), also known as dyspraxia syndrome related to the *Sensory Processing Disorders* (SPDs).

Methodology: Patients with diagnosis of various motor impairments and healthy volunteers will be included in the study. The structure of the study involves validation of AI models and ML models allowing us to observe the physical effects of muscle tone on the other motor skills through real-time biofeedback data analytics, while hand immersive training aims to mimic natural gesture sequences. The intended application is to improve fine motor function skills using VR and hand tracking technology in a sensory feedback and gamified Virtual Environment (VE). We chose a comparison group in which 50% have a diagnosis of various motor impairments and 50% have no disorders.

Results: The results obtained will highlight how SensiVR could improve children's school performance, such as writing, reading or speech as well as social interaction and emotional balance. Additionally, planned clinical trials in different countries might be a crucial step in the more patient-oriented and effective diagnosis of neurodevelopmental disorders among children.

Conclusion: The project aims to show that SensiVR has enormous potential in paediatric somatosensory and neuromuscular rehabilitation approaches and underline the importance of as well as early intervention for a variety of neurodiverse disorders affecting children.

Keywords: Neurodevelopmental disorders, fine motor function, real-time biofeedback data analytics, AI-driven digital therapeutic (DTx) early intervention, hybrid care

P23

XR training system for people with spatial orientation disorders following acquired brain injury – usability and feasibility

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Background: Spatial orientation disorders often occur as a result of acquired brain injury (ABI), making it difficult to cope independently with everyday life. In many cases it arises together with heterogeneous and sometimes severe neuropsychological comorbidities, such as memory disorders, agnosia, apraxia and spatial neglect. Effective spatial re-orientation training is time-consuming and requires a high level of human resources, which is difficult to realise under current conditions in neurorehabilitation. Technologies that enable high-frequency independent orientation practice under realistic and safe conditions are conceivable as support.

Extended reality (XR) applications are increasingly being used in neurorehabilitation. While there is increasing evidence for the virtual rehabilitation of cognitive functions, there is a lack of specific applications for improving spatial orientation skills. In the *PAN-Assistant* research project a customised XR assistance and training system was developed in a participatory manner with patients, therapeutic and educational staff.

Methodology: Due to the heterogeneous requirements identified in the comprehensive participatory process, the system is executed on 3 different devices: VR application via goggles, AR application via Tablet and a wearable in the form of a small portable device. A usability and feasibility study was conducted with persons with spatial orientation deficits following ABI. The short version of the User Experience Questionnaire [UEQ], Intuitive Interaction [INTUI]), the System Usability Scale [SUS] and the Simulator Sickness Questionnaire [SSQ]) was deployed. The main focus is on the structured observation during the use of the PAN-Assistant system. Observation aspects were safety, handling, task understanding and workload.

Results: First results of the usability and feasibility study will be presented. People with navigation disorders following ABI show high adherence with the system. Unpleasant side effects are rarely reported.

Conclusion: The PAN-Assistant system was developed and implemented in a participatory manner with all stakeholders. Initial results indicate that the training with all three different systems is feasible and safe.

Keywords: acquired brain injury, spatial re-orientation training, neurorehabilitation, assistive technologies, participatory development

P29

Strengthening healthcare partnerships: The impact of COVID-19 visitation restrictions on families of older adults in acute care

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Background: The COVID-19 pandemic profoundly disrupted healthcare delivery, particularly affecting families of hospitalised older adults due to restrictive visitation policies. This study aimed to explore the experiences of these families, focusing on their emotional, social, and logistical challenges in Northwest Ireland, encompassing rural, urban, and cross-border regions.

Methodology: A qualitative research design was employed, incorporating twenty semi-structured interviews with family members aged between 23 and 81 years. These interviews provided critical insights into how different age groups and geographical contexts navigated and perceived visitation restrictions between March 2020 and December 2022. The study's research questions and interview protocols were grounded in family-centered care, resilience, and communication frameworks, supported by a comprehensive literature review and adherence to COREQ guidelines.

Thematic analysis identified key themes, including *Compassion and Control: Balancing Health Policy, Ethics, and Human Connection in Times of Crisis*, *Fragmented Lives: The Emotional and Social Disruptions of Pandemic Hospital Practices*, and *Isolated Farewells*. Findings indicated that visiting restrictions imposed a profound emotional toll, significantly varying experiences based on age and geographical location. The study highlights the need for policies that balance infection control with preserving human connection.

A key consideration emerging from this research is the role of virtual reality (VR) and extended reality (XR) technologies in mitigating the negative impact of visitation restrictions. The study highlights the potential of telecommunication devices, including VR-enabled interactions, to facilitate remote family engagement, improve patient-family communication, and provide immersive training for healthcare professionals on compassionate care in crisis settings.

Key recommendations include implementing flexible visitation policies prioritising emotional well-being, integrating VR/XR-assisted communication tools in hospital settings, improving family-provider communication, training healthcare professionals in virtual care strategies, and offering targeted support for bereaved families. The findings underscore the need for further research, particularly with diverse populations and longitudinal studies, to assess the long-term impacts of visitation restrictions and the effectiveness of VR/XR interventions. This study provides valuable insights for healthcare policymakers and practitioners seeking to enhance family support and crisis preparedness in future health emergencies.

Keywords: COVID-19 Visiting Restrictions, Advocacy, Family Care, Bereavement, Discharge Planning, Healthcare Policies, Virtual Reality, Telecommunication in Healthcare.

P30

AI-integrated VR and EEG diagnostic framework for early detection of Alzheimer's and cognitive impairments

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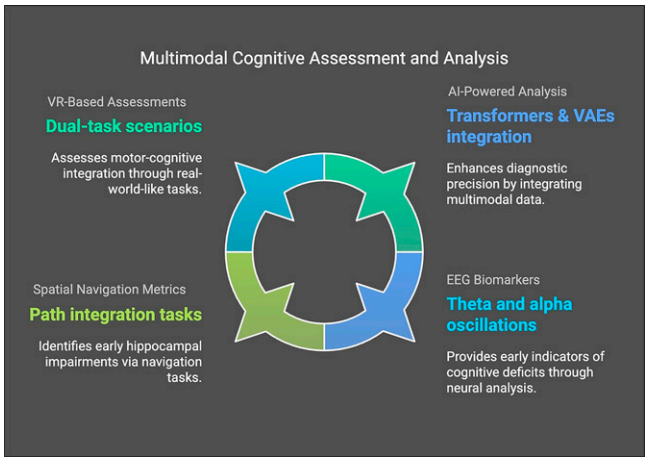
Background: The early detection of Alzheimer's disease (AD) is crucial for improving patient outcomes and enabling timely interventions. Traditional cognitive assessments, such as the Mini-Mental State Examination (MMSE) and tahe Montreal Cognitive Assessment (MoCA), often lack ecological validity and fail to capture early-stage impairments. Spatial navigation



deficits, linked to hippocampal dysfunction, have been identified as early indicators of AD. However, conventional tools are insufficient for detecting these subtle impairments. This study proposes an AI-powered multimodal diagnostic framework integrating virtual reality (VR)-based cognitive assessments, electroencephalogram (EEG) biomarkers, and AI-driven spatial navigation analysis to enhance early detection accuracy.

Methodology: Our framework integrates VR-based cognitive tasks, EEG neurophysiological monitoring, and AI-powered data fusion to improve the early detection of Alzheimer's disease (AD) and mild cognitive impairment (MCI).

- **VR-Based Cognitive Assessments:** Real-world-like tasks evaluate memory, attention, and executive function, tracking behavioral metrics such as reaction times, error rates, and decision-making patterns. Dual-task scenarios assess motor-cognitive integration.
- **EEG Biomarkers:** Neural activity is analyzed through theta, alpha, and beta oscillations, providing early indicators of hippocampal dysfunction, cognitive slowing, and executive deficits. Event-Related Potentials (ERPs) offer additional insights into cognitive decline.
- **Spatial Navigation Metrics:** VR-based tasks assess path integration, wayfinding efficiency, and route optimization, identifying early hippocampal impairments that precede memory loss in AD.
- **AI-Powered Multimodal Analysis:**
  - Deep Learning (CNNs, RNNs) extracts patterns from EEG signals.
  - Reinforcement Learning evaluates spatial navigation strategies.
  - Transformers & VAEs integrate multimodal data, enhancing diagnostic precision.
  - SHAP Analysis improves model transparency by identifying key diagnostic features.

Results: Preliminary findings suggest that VR-based spatial navigation assessments and EEG biomarkers significantly improve early AD detection compared to conventional cognitive tests. AI-driven models can effectively identify subtle cognitive impairments, distinguishing early-stage AD from healthy aging and mild cognitive impairment (MCI).

Conclusion: This AI-powered multimodal framework bridges the gap between clinical research and real-world applications, providing a scalable, cost-effective, and accessible diagnostic tool for early AD detection. By integrating VR, EEG, and AI-driven analytics, this approach supports precision medicine and home-based cognitive monitoring, paving the way for innovative neurodiagnostic strategies.

Keywords: Digital Therapeutics (DTx), Virtual Reality (VR), Artificial Intelligence (AI), Cognitive Assessment, Medical XR