



Danderyds Sjukhus

The Effectiveness of Virtual Reality Based Interventions on Cognitive Function After Brain Injury

Clinical Trials

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Research Questions

The overarching aim of this project is to evaluate the effectiveness of CogTech's technology-assisted interventions on cognitive and visual functioning in patients undergoing rehabilitation following acquired brain injury. Within the scope of this umbrella project, the initial intervention to be evaluated is VR gaming. First, the feasibility of a VR-game clinical trial will be investigated.

Background

Cognitive deficits are common after brain injury and various rehabilitation interventions have been developed to address them.¹ One widely used method is direct attention training, though its effectiveness remains debated. Two major expert guidelines offer conflicting views - one supports the method,¹ while the other does not.² It is established that patients improve on the specific tasks they train on (e.g., decontextualized working memory tasks), but it remains uncertain whether these improvements transfer to similar tasks or to everyday activities. Ponsford et al. argue that such transfer is unproven,² while Cicerone et al. concludes that there is some evidence.¹ Notably, Cicerone emphasize therapist involvement in the interventions to promote awareness and generalization. The degree of therapist involvement varies across studies and may contribute to the inconsistent findings. Another possible explanation for the modest effects is that the training tasks often differ significantly from the real-life situations in which attention and working memory are essential.² One potential way to enhance the effect of direct attention training is to make the tasks more contextualized, engaging, and realistic.

There is growing interest in the use of virtual reality (VR) in brain injury rehabilitation. VR employs computer technology to immerse individuals in artificial environments,³ offering the potential for more realistic and engaging training experiences compared to traditional methods. However, existing studies on the effect of VR interventions are few and inconclusive.⁴⁻⁶ Notably, the degree of therapist involvement is seldom specified in the studies conducted. An active therapist could support patients in evaluating their performance and facilitate discussions about the similarities and differences between the training and real-life tasks, potentially enhancing the intervention's effect and promoting transfer to daily life.

CogTech, located within the Department of Rehabilitation Medicine at Danderyd Hospital, offers a unique environment for studying technology-driven interventions in brain injury rehabilitation. Since 2020, the necessary hardware, software, and personnel have been co-located in a dedicated space. Both inpatient and outpatient patients are offered interventions at CogTech, which is trademark protected in terms of name, logo, and content. In 2024, 70 patients received interventions at CogTech. All were invited to complete a survey, with 96% rating the interventions as highly motivating and 95% reporting a perceived positive effect. However, the actual impact of these interventions on functioning, symptom reduction, and rehabilitation motivation has not yet been formally evaluated. The aim of this project is to systematically evaluate the effects of selected CogTech interventions on cognitive and visual functioning, as well as their influence on patients' motivation for rehabilitation.



Project Description

The feasibility study will be conducted with approximately ten patients. The primary aim of this phase is to inform key design decisions for a subsequent RCT (including 90 patients). Specifically, the feasibility study will evaluate: the suitability of different VR games and headsets, the optimal intensity and duration of the VR-based training sessions, and the appropriate level and format of therapist involvement during the intervention.

Participants and Study Setting

Participants will be recruited from both the inpatient and outpatient units at the Department of Rehabilitation Medicine, Danderyd Hospital.

Inclusion criteria: (1) Patients with acquired brain injury in need of multiprofessional rehabilitation admitted to the clinic are eligible if they (2) are between 18 and 65 years; (3) present with attention deficits and (4) are deemed suitable for direct attention training by the rehabilitation team.

Exclusion criteria: (1) Epilepsy or suspected epilepsy; (2) non-fluent in Swedish (3) severe fatigue or/and cognitive dysfunction that makes participation difficult.

Procedure and Randomization

Before enrollment in a rehabilitation program, all patients are comprehensively assessed by the rehabilitation team ("the assessment phase", with a typical duration of two to three weeks). During this phase, a neuropsychological assessment is performed by a neuropsychologist and an activity-based assessment is performed by an occupational therapist. Based on these assessments, the rehabilitation team concludes whether attention deficits are present and direct attention training is indicated (Attention Process Training¹¹ is the standard at the clinic). Participants will be recruited among these patients. The VR intervention will be offered as an add-on to the other interventions in the rehabilitation program. The content of the rehabilitation program varies between patients, but typically includes attention process training for attention deficits, strategy training for executive deficits and physiotherapy for physical and motor deficits. The length of the rehabilitation program is typically 12 to 16 weeks.

In the feasibility study, eligible patients will consequently be informed about the study after the clinical assessment phase and will be asked for informed consent (n=10). Following the recruitment to the VR-intervention, five patients will be asked to serve as control participants. They will undergo the baseline assessment and the post-intervention assessment, but will not do the VR-based training.

Pre - assessment

Following informed consent, baseline assessments will be conducted and demographic and injury-related data will be collected. Some of the tests that will be used in the study will already have been administered as part of the clinical routine (these are marked below). These tests will not be re-administered in the pre-assessment. Following informed consent, the clinical psychologist who has assessed the patient will hand over the test results along with demographic and injury-related data to the responsible researcher.

Measures

Cognition: **WAIS-IV Matrix Reasoning** (part of clinical routine) measures logical functioning and is considered an estimate of premorbid cognitive functioning. **WAIS-IV Coding** (part of clinical routine), measures processing speed. **WAIS-IV digit span** (part of clinical routine),



digit span forwards measures short-term memory, attention and auditory processing ability. Digit span backwards measures working memory and mental processing ability. **Color-Word Interference Test** (part of clinical routine) measures cognitive flexibility and selective attention. **Rey Auditory Verbal Learning Task** (part of clinical routine) measures verbal learning and memory. **Rey Complex Figure Task** (part of clinical routine) measures visual memory. **CPT-III**, measures sustained attention, reaction time, and impulsivity. **Ruff 2 & 7** measures visual attention. **d2 Test of Attention** measures selective and sustained attention, concentration, and processing speed

Fatigue: **Mental Fatigue Scale (MFS)** (part of clinical routine), a 15-item self-report questionnaire used to assess mental fatigue, often after brain injury, neurological illness, or concussion. It measures difficulties such as fatigue, lack of initiative, mental exhaustion, and recovery time

Emotions: **Hospital Anxiety and Depression Scale (HADS)** (part of clinical routine), a 14-item questionnaire used to screen for symptoms of anxiety and depression, particularly in medical settings.

Symptoms: **The Rivermead Post-Concussion Symptoms Questionnaire (RPQ)**, a 16-item self-report tool used to measure the severity of post-concussion symptoms after a traumatic brain injury.

Functioning: **Canadian Occupational Performance Measurement (COPM)** (part of clinical routine) is a client-centered assessment that identifies daily activities a person wants, needs, or is expected to do but has difficulty performing. It uses a structured interview to help the client rate the importance, performance, and satisfaction of chosen activities. The scores are then used to guide treatment and measure change over time. **Patient Competency Rating Scale (PCRS)** is a 30-item questionnaire in which the respondent on a 5-point Likert scale rate his or her degree of difficulty in a variety of everyday tasks.

Motivation: **Situational Motivation Scale (SIMS)** The Situational Motivation Scale (SIMS) consist of 16 items and measures intrinsic and extrinsic motivation in different situations and activities.

Post-assessment

Post-intervention assessments will be conducted after the 5-week training period and before the patient is discharged. All measures from the pre-assessment will be readministered, except WAIS-IV Matrix Reasoning, Rey Auditory Verbal Learning Task, Rey Complex Figure Task. We do not expect an intervention effect on these measures but they are potentially modifiers of treatment effect.

A satisfaction questionnaire developed in house will be used and will only be administered post-intervention:

Study Interventions

Participants will engage in cognitively demanding games such as *Beat Saber*, *Zooma*, or *XR Brain Stimulation* for 30-60 minutes, 3 days a week for 5 weeks using an augmented reality (RehAtt® XR) or VR headset (i.e., Meta Quest 3 or Oculus Rift S). *Beat Saber* and *Zooma* are both commercially available games. In *Beat Saber* players use two colored sabers to slice incoming music-synchronized blocks in the directions indicated, while also dodging obstacles like walls and bombs. *Zooma* involves shooting rolling colored balls to create matches before they reach the endpoint ("snapdragon"), using both hands for faster



color-matching. *XR Brain Stimulation* is developed to be used in brain injury rehabilitation and involves 3D games in the form of holograms integrated in the real surroundings.

Analyses

In the feasibility study, the focus will be to evaluate different VR games and headsets, the optimal intensity and duration of the VR-based training sessions, and the appropriate level and format of therapist involvement during the intervention. Results on the SIMS and the satisfaction questionnaire will be emphasized, but pre- to post changes on all measures will be calculated.

Resources and Time Plan

The project will be conducted at Danderyd Hospital and Karolinska Institutet. At the Department of Rehabilitation Medicine, around 700 patients with acquired brain injury receives assessment and/or rehabilitation each year. The multi-professional research environment at the department provides opportunities for broad contacts with different professional competences within clinical research. The department has one KI professor, three senior associate professors and nine docents.

Since CogTech is already established at the clinic, the project benefits from existing technical expertise as well as most of the necessary hardware and software.

The feasibility study will be initiated during the first half of 2026. Results will be published in 2028.

Preliminary Results

Results from the patient satisfaction survey clearly shows that the interventions in CogTech are highly appreciated, with 96% rating the interventions as highly motivating and 95% reporting a perceived positive effect.

CogTech's innovative approach has also attracted considerable external interest, with many national and international study visits each year. The approach has received attention in popular media, further highlighting its uniqueness and relevance in the field of neurorehabilitation

Significance

Approximately 70 000 persons sustain an acquired brain injury in Sweden each year and attention deficits are a common and disabling consequence, yet the real-world effectiveness of current training methods remains unclear. The project evaluates whether VR-based cognitive training can improve attention, functioning, and motivation more effectively than traditional methods. By using an ecologically valid and engaging platform, and examining the role of therapist involvement, the study aims to generate high-quality evidence to improve rehabilitation outcomes.

References

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