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Hougaard, Bastian Ilsø; Knoche, Hendrik; Brunner, Iris; Evald, Lars

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BASTIAN ILSØ HOUGAARD, Aalborg University, Denmark
HENDRIK KNOCHE, Aalborg University, Denmark
IRIS BRUNNER, Hammel Neurorehabilitation Centre and University Research Clinic, Denmark
LARS EVALD, Hammel Neurorehabilitation Centre and University Research Clinic, Denmark

Whack-A-Mole VR is an open-source neurorehabilitation platform that is co-developed with clinical personnel to be accessible for stroke patients with varying levels of spatial neglect and upper limb hemiparesis. The platform provides a fundamental structure and framework for development of VR point-and-shoot games, whilst designed to accomodate stroke rehabilitation. The platform leverages benefits of VR, through input and viewport manipulation and kinematic measurement of velocity, trajectory straightness, smoothness of movement to provide evidence-based treatment.

CCS Concepts: • **Human-centered computing** → **Empirical studies in HCI**; *Interaction paradigms*; *Interaction devices*; *Graphical user interfaces*;

Additional Key Words and Phrases: hemispatial neglect; virtual reality immersion therapy; stroke; acquired brain injury;

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1 INTRODUCTION

When stroke survivors undergo rehabilitation, rehabilitation technology must accommodate for the patients' individual cognitive and motor function. Virtual Reality (VR) rehabilitation games enable researchers and clinicians to use games for cognitive and motor training to help these patients with their deficits, such as spatial neglect [5] and upper limb hemiparesis. However, stroke patients often have limited physical ability, which creates an unfair disadvantage when solving tasks in Virtual Reality (e.g. due to inability to reach or interact). Stroke patients are prone to misinterpreting their performance due to low health numeracy (low capacity to access, process and act on numerical health information) [1, 2]. Whack-A-Mole is an open source virtual reality (VR) serious game designed to assess and diagnose spatial neglect and upper limb function in stroke patients e.g. from midline diagnostics [3]. It features a base interaction designed as a simple target-to-target pointing task, which can be customized to build a variation of games. Clinicians and researchers build treatment programs which define how and where targets appear and monitor patients' head and hand movements.

Authors' addresses: Bastian Ilsø Hougaard, Aalborg University, Rendsburggade 14, Aalborg, 9000, Denmark; Hendrik Knoche, Aalborg University, Rendsburggade 14, Aalborg, 9000, Denmark; Iris Brunner, Hammel Neurorehabilitation Centre and University Research Clinic, Voldbyvej 15, Hammel, Denmark, iris.brunner@clin.au.dk; Lars Evald, Hammel Neurorehabilitation Centre and University Research Clinic, Voldbyvej 15, Hammel, Denmark, iris.brunner@clin.au.dk.

2 ACCESSIBLE VR FOR REHABILITATION

Modern HMDs continuously track their rotation and position with high precision to create the sensation of interacting with a virtual world. This allows for detailed measurement of human body coordination over time [6] and opens up a space for a number of manipulations, which can benefit stroke rehabilitation. In particular, patients with spatial neglect benefit from treatment with full control over their entire field of view, because their attention can be directed to their neglected area. Whack-a-Mole implements several other benefits, which take advantage of a range of properties of Virtual Reality. **Viewport manipulations** challenge how patients can make use of their field of view in Virtual Reality. *Eye patching*, removes the picture from one of the two lenses in VR. *Visual constraint* removes the visibility of the task for either the right side or left side of patients' field of view. Whack-A-Mole allows clinicians and researchers to measure how these manipulations alter how people solve target-to-target pointing tasks and whether these novel treatments benefit successive task performance. **Virtual Motor Spaces** provide patients with the same underlying basis for solving the task to make it fair. Thus, patients with impaired upper limb motor function can reach outer borders of the virtual wall, despite a different level of motor function. Patients receive more training through increased movement of the upper limb, because the motor spaces rely on controller movement instead of following a direct pointing paradigm relying on controller orientation. **Input Modifiers** challenge how patient's perceive their own movements in the virtual world. *Movement mirroring* move the patient's controllers in the inverse direction of their movements in real life. This can be used to force patients to move their affected side in ways they would otherwise not. Controller offset moves the virtual representation of the patients' controller in a specified direction to mimic prismatic shift, which force patients to move their real body more towards the limits of their physical ability.

3 DEVELOPMENT PROCESS AND NEXT STEPS

Whack-A-Mole VR is a work-in-progress and freely available platform available online under an MIT license (see [4]). A series of pilot single case experiments will be carried out over the summer of 2022 to validate the game in terms of its design, treatment and diagnostic capabilities. An online clinician dashboard will accompany the game, where clinicians and researchers can analyze and visualize patient performance and kinematic measures.

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