Detecting Lateralized and Non-lateralized Deficits in Visuospatial Neglect Using Immersive Virtual Reality

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Introduction

Patients with **visuospatial neglect** exhibit lateralized deficits that manifest as a failure to report, respond, or orient to stimuli in the contralesional, often left, hemifield [1]. These deficits, whether severe or subtle, profoundly impact patients' daily lives and independence [2] and are predictive of a reduced quality of life [3]. However, non-lateralized deficits are often underestimated despite their prevalence [4].

Furthermore, paper-and-pencil tests are unreliable and insufficient for identifying and quantifying the functional behavioral deficits associated with discrete neglect symptoms [2-4].

Immersive Virtual Reality (VR) offers a novel approach to assess cognitive deficits through the integration of realistic, three-dimensional environments in real-time. It facilitates the systematic simulation of dynamic and ecologically valid scenarios, thus enabling performance-based assessment of cognitive functions. This method enhances experimental control while preserving ecological validity and increasing participant engagement [5-6].

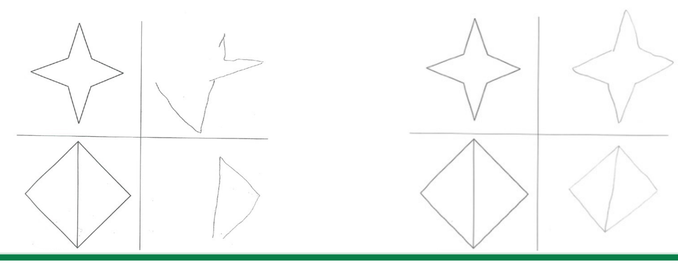
Study objectives:

I. **Identify discrete neglect** and
II. **Differentiate lateralized and non-lateralized** forms of neglect.

Line bisection task

Immersive Virtual Reality

Severe vs. discrete neglect



Methods

VR apparatus: HTC Vive Pro Eye

Outcomes: Error pattern, temporal measures, head rotation

Study design: Six sequential blocks, each containing four crossings

Manipulations: Traffic direction (◄, ►, ↔), Mailbox side (◄, ►)

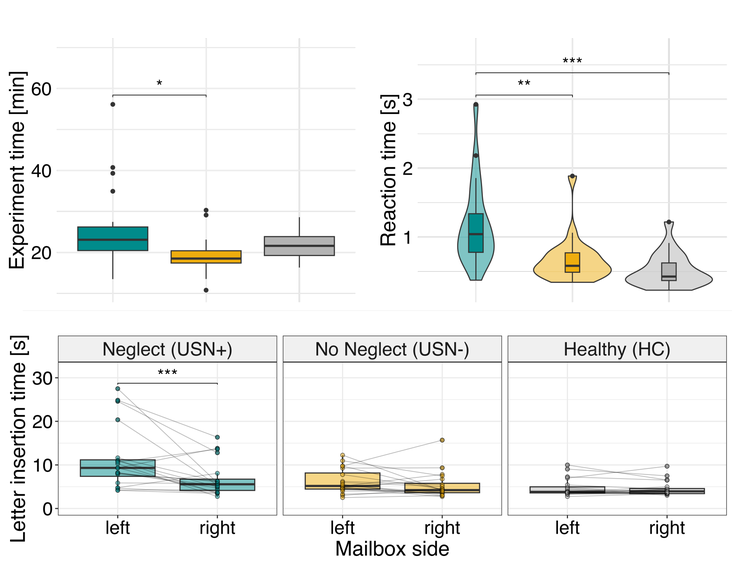
Analyses: Mixed-design ANOVAs, descriptive statistics, machine learning (feature selection, CART, random forest model)

Immersive Virtual Road Crossing Task

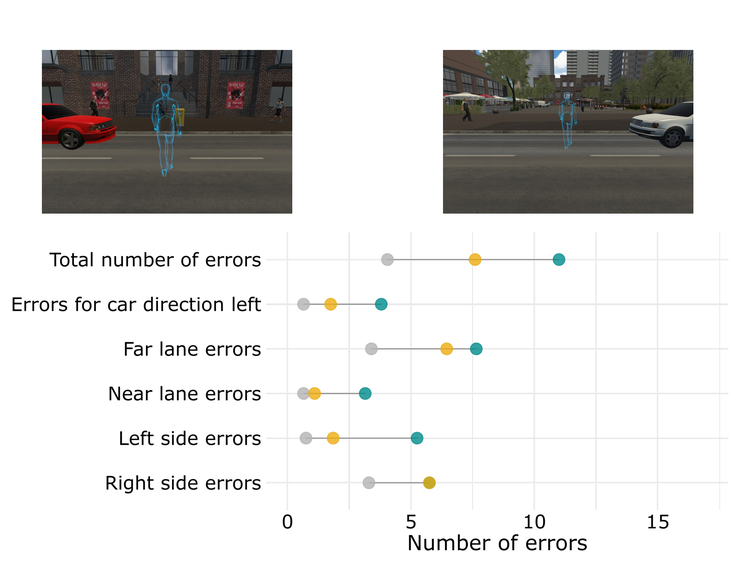
	Left neglect (n=20)	No neglect (*n*=20)	Healthy (*n*=20)
Age (years)	60.00 ± 6.93	57.34 ± 9.34	59.05 ± 9.52
Female/male	5/15	8/12	7/13
Post-stroke time (months)	37.80 ± 32.98	45.35 ± 49.53	-
Neurological deficits (n (%))			
Hemianopia	6 (30)	6 (30)	-
Sensitivity disorder	8 (40)	5 (25)	
Hemiparesis	14 (70)	14 (70)	-
Ataxia	0 (0)	3 (15)	-

Results

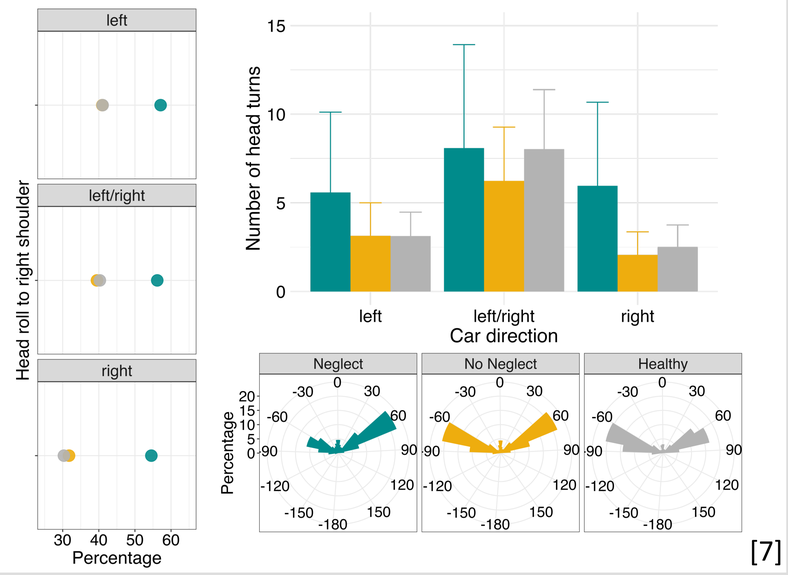
1 Temporal parameters



2 Error pattern



3 Head rotation



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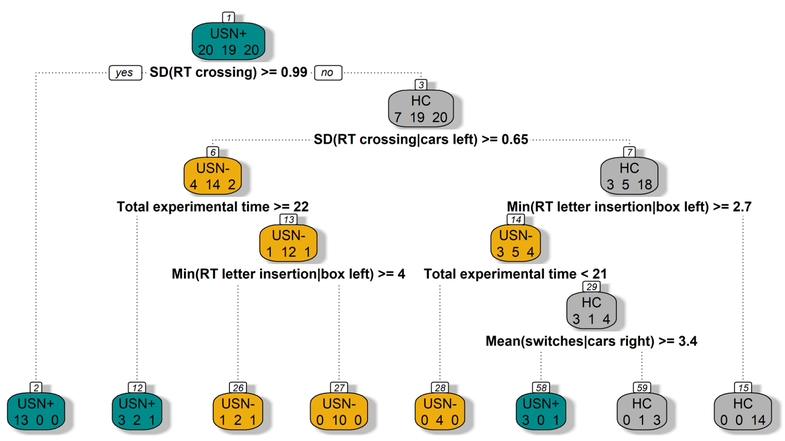
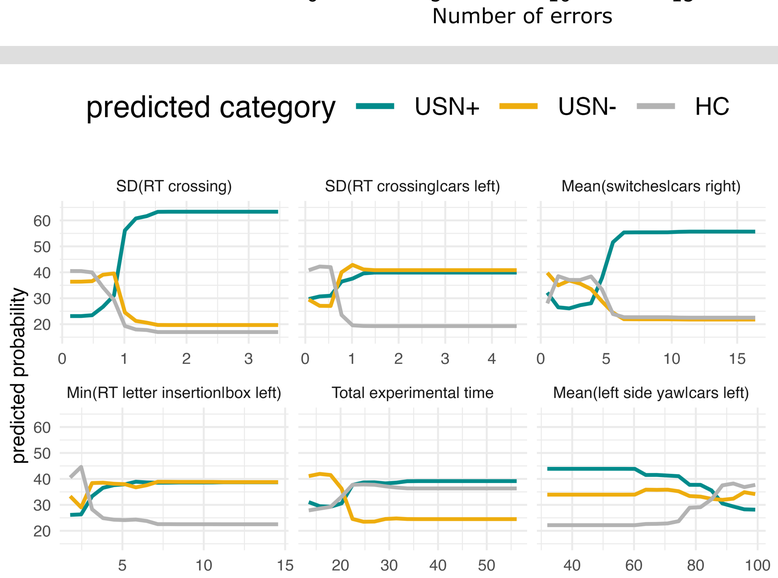
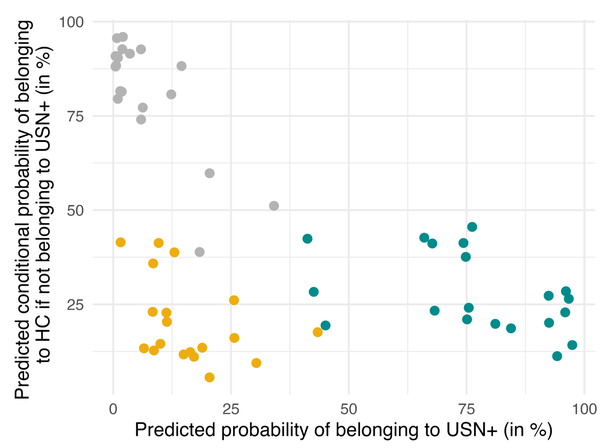
4 Prediction of neglect





Training (96.6%) and cross-validation accuracy (76.8%)



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Discussion

We classified chronic right hemisphere stroke patients with left neglect, no neglect, and healthy controls based on features assessed with iVRoad (4). Our research advances the understanding of discrete neglect by highlighting the utility of **VR and machine learning** in neuropsychological assessment and cognitive function evaluation.

The results indicate that patients with neglect exhibit both **lateralized and non-lateralized deficits** (1-3). Specifically, they experience prolonged reaction and letter insertion times, particularly for left-sided traffic and letters. With regard to non-lateralized deficits, they had slower information processing speeds, which were reflected in longer experimental and reaction times.

This study emphasizes the significance of VR in identifying subtle manifestations of visuospatial neglect. This implies that neglect comprises a **spectrum of deficits beyond spatial impairment**. Our findings support the necessity of comprehensive and multifaceted clinical evaluations for an accurate clinical assessment of neglect.

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