

Assessing the Spatial Distribution of Visual Attention in a Virtual Environment: Development and Validation of a Novel VR-based *Attentional Visual Field (AVF) Task*

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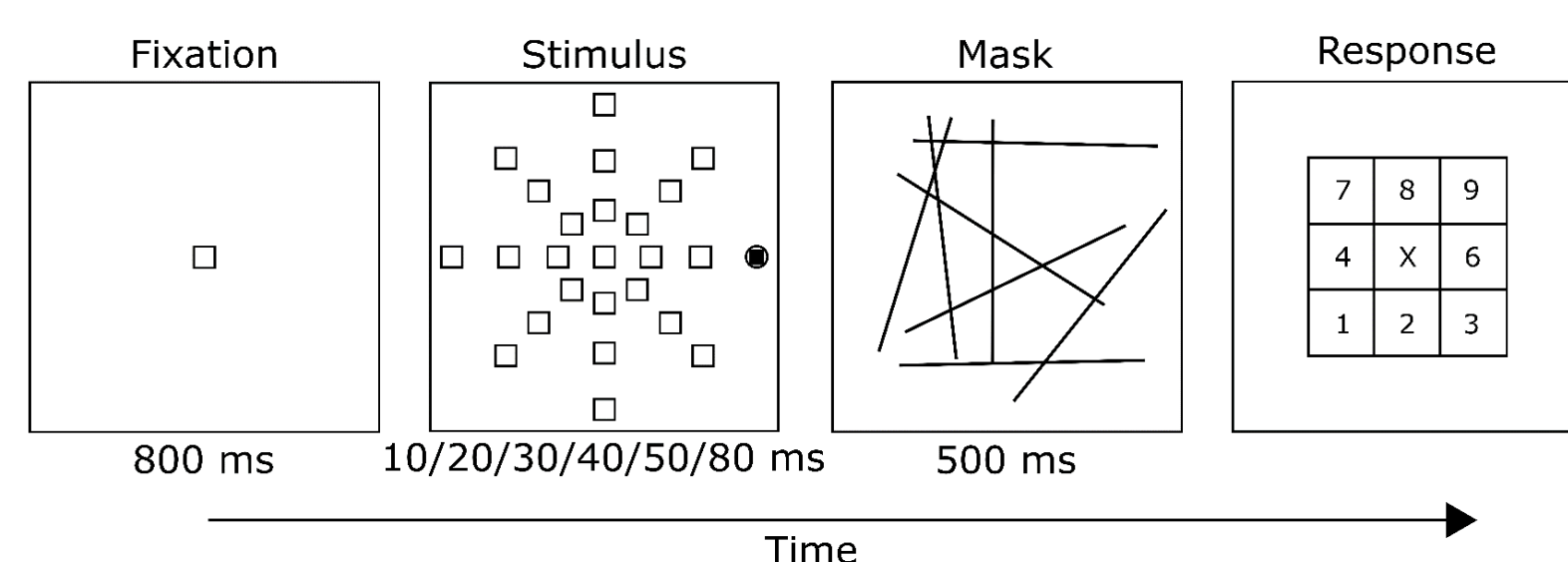
Introduction

Attentional Visual Field

- The visual field from which a person can process information with a single gaze [1]
- Declines associated with task performance and safety:
 - Motor vehicle crash risks [2]
 - Fall risks [3]

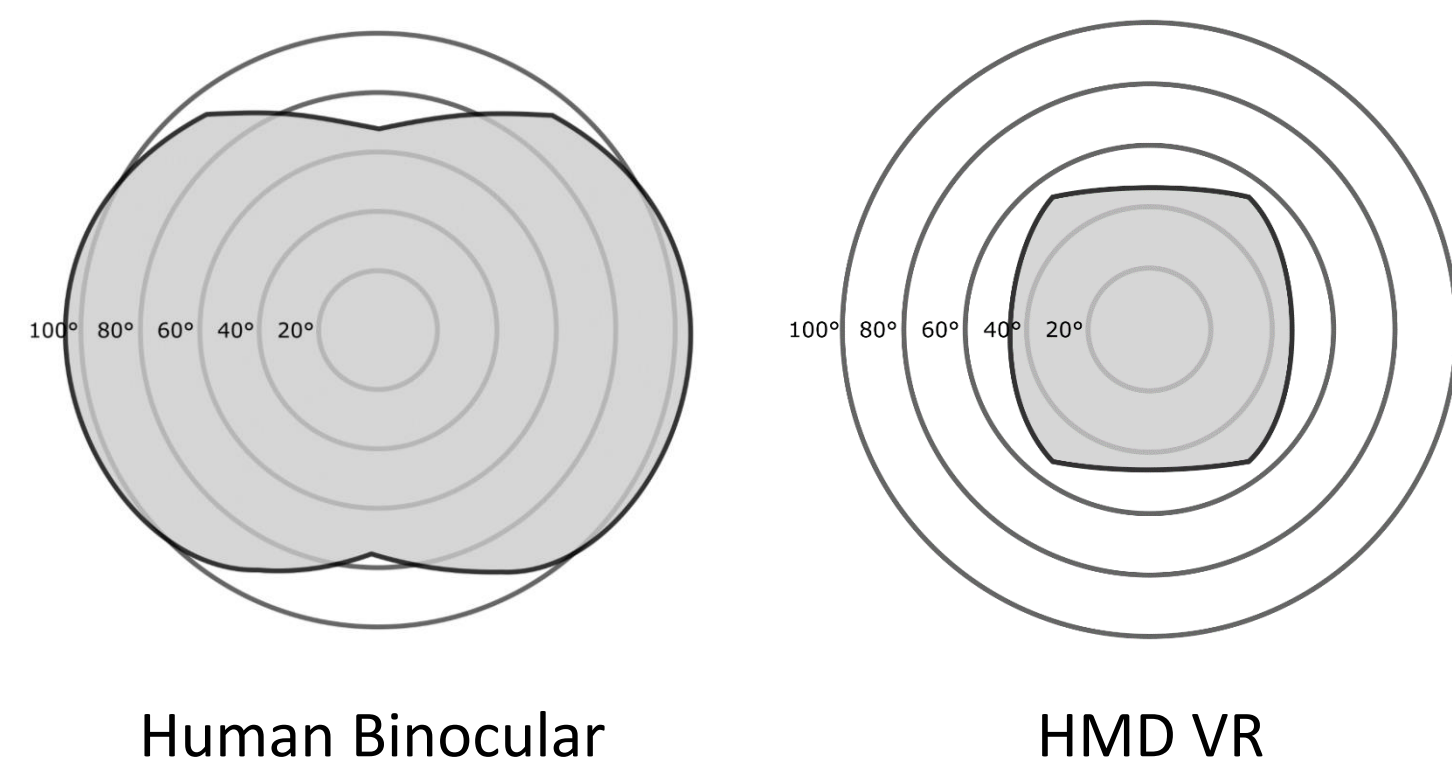
Attentional Visual Field (AVF) Task

- Computer-based task
 - Identifying a visual target among distractors on a computer display
 - Requiring a fixed position in a chinrest and a gaze fixated at the center of a screen



Potential and Concerns of Virtual Reality (VR) Technology

- VR enables assessing the spatial distribution of visual attention in a simulated environment without constraining participants to a fixed position or gaze point
- VR Field of View (FoV) is restricted compared to natural human FoV



Development of AVF-VE Task

- A new VR-based AVF task developed in Unity with *SteamVR* and *HMD-Eyes*
- Presenting stimuli at controlled visual angles regardless of eye movement, using **real-time gaze tracking**

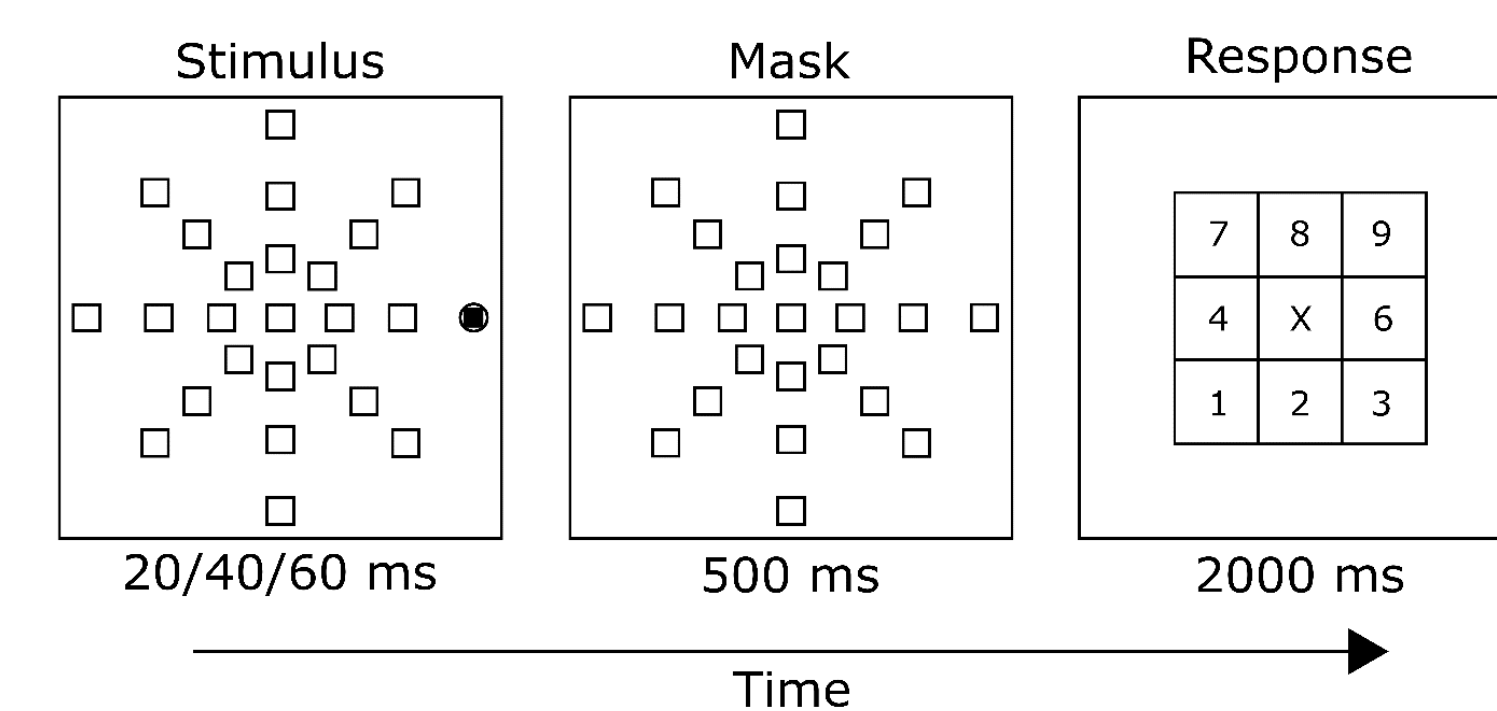


Validation Study

Participants

	N = 40
Age: Mean (SD)	18.72 (1.78)
Gender: Male Female Other	10 29 1
HMD VR Experience (yes)	15
CAVE VR Experience (yes)	2

AVF-VE Task



- Presentation of a target and distractors
 - 3 eccentricities: 10°, 20°, 30°
 - 8 directions
- Participants responding to the target direction on a number pad
- 72 trials x 4 blocks

Equipment

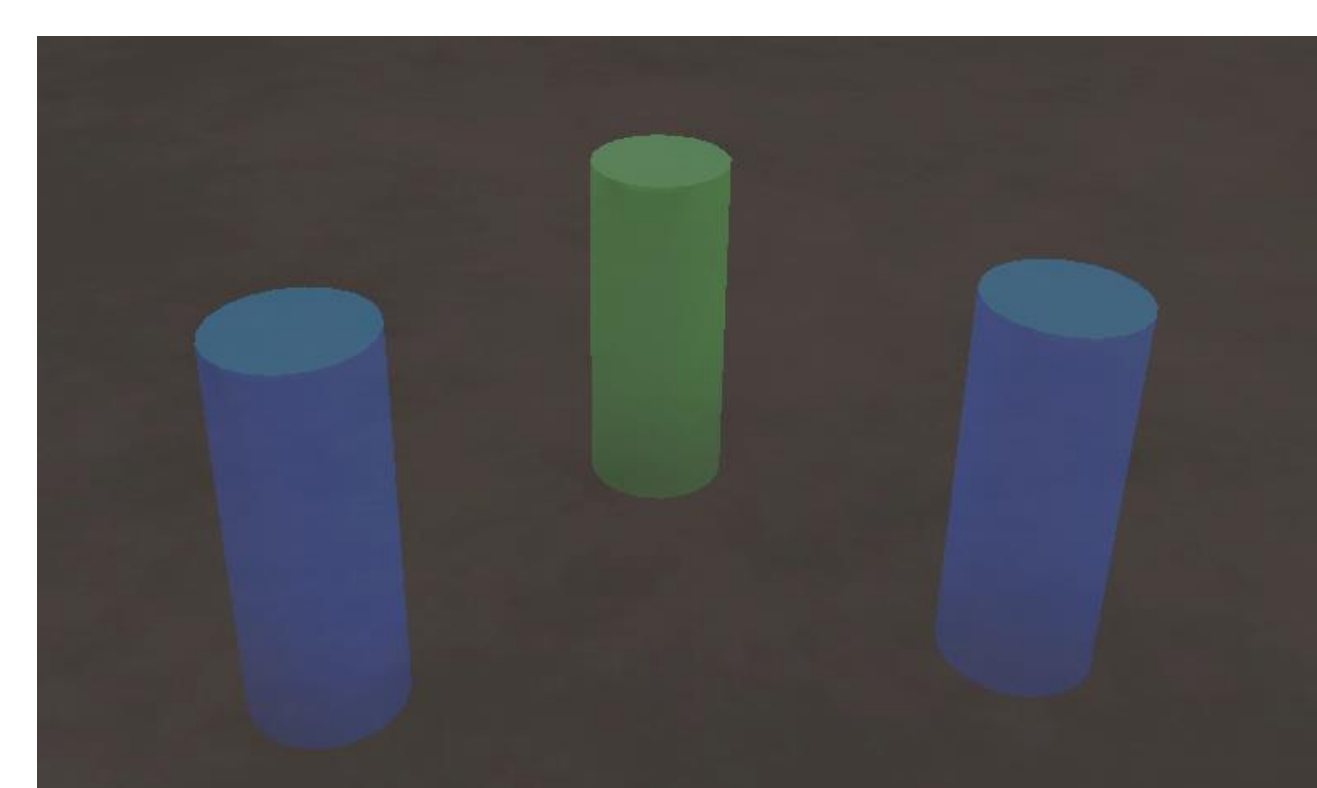
- HTC Vive Pro HMD



- Pupil Labs Vive add-on eye-tracker
- 200 Hz sampling rate



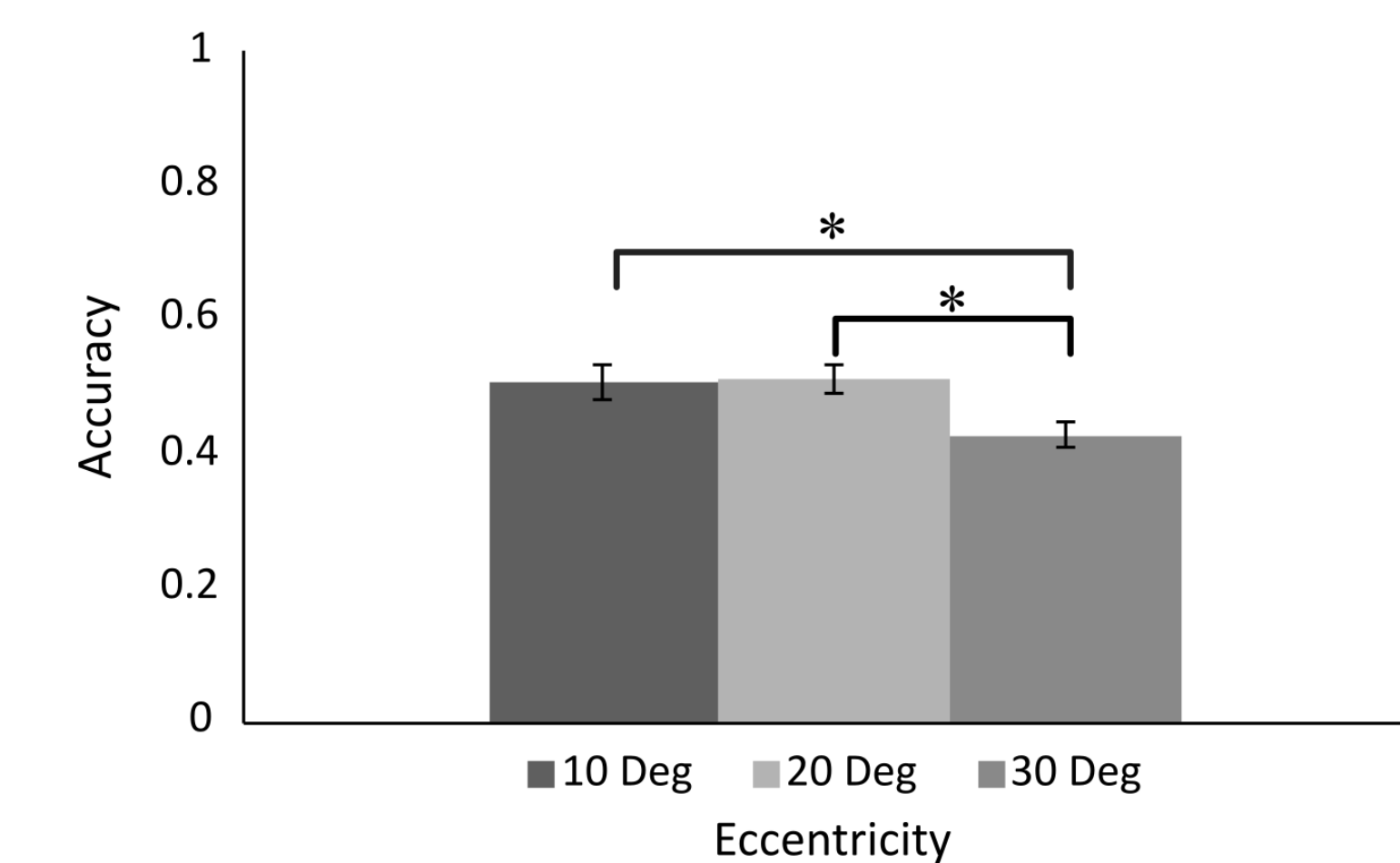
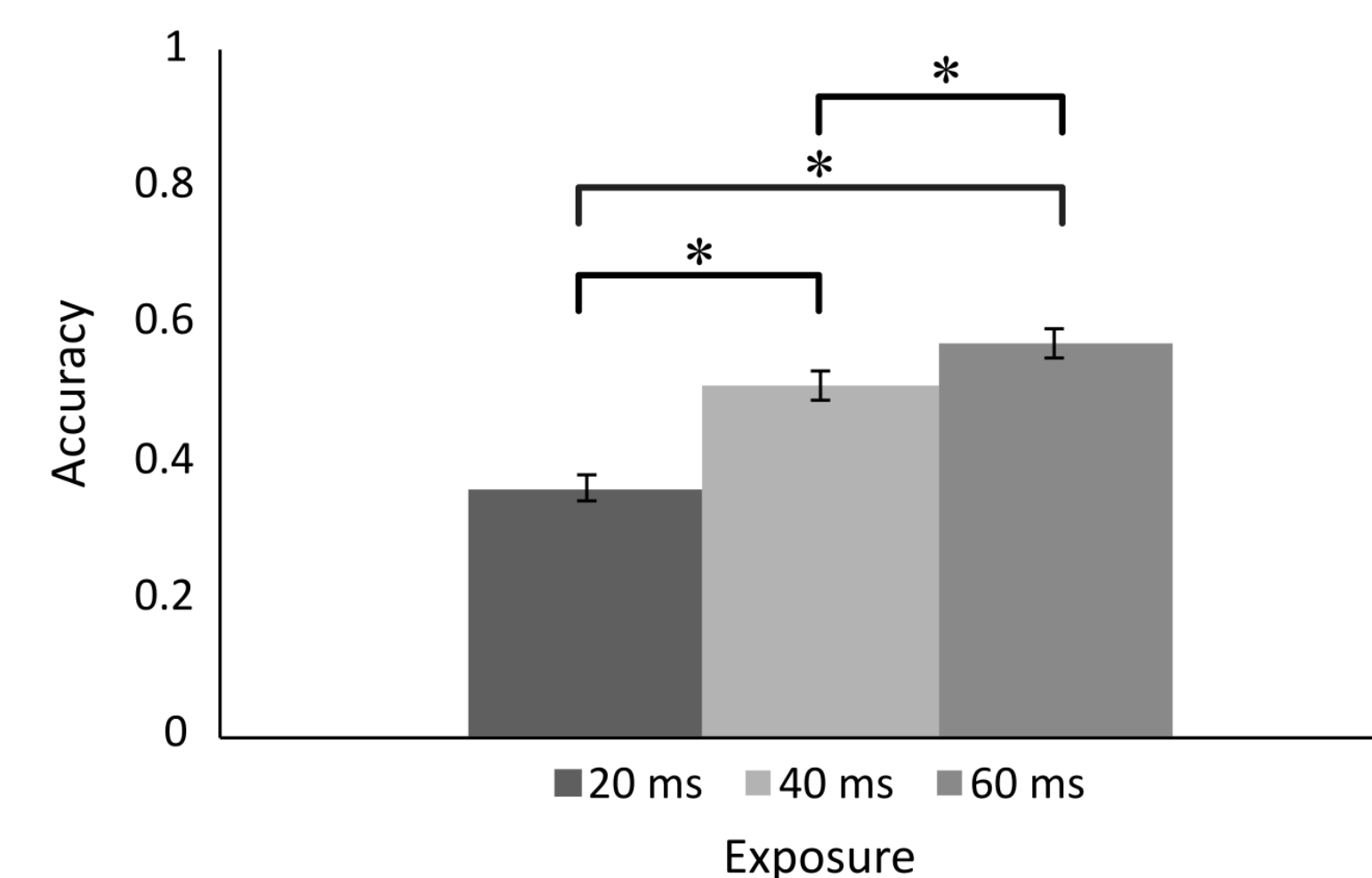
Secondary Walking Task*



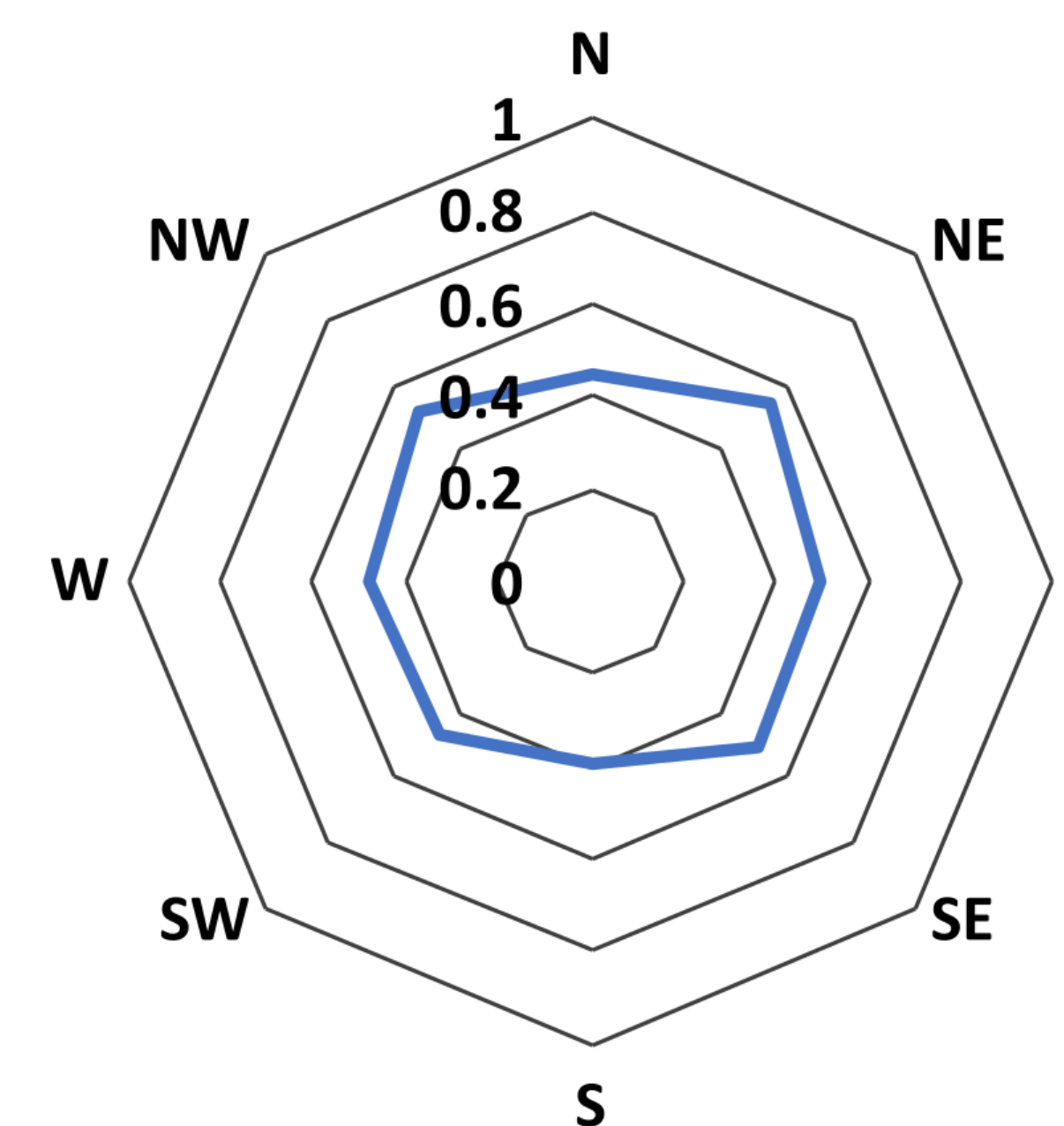
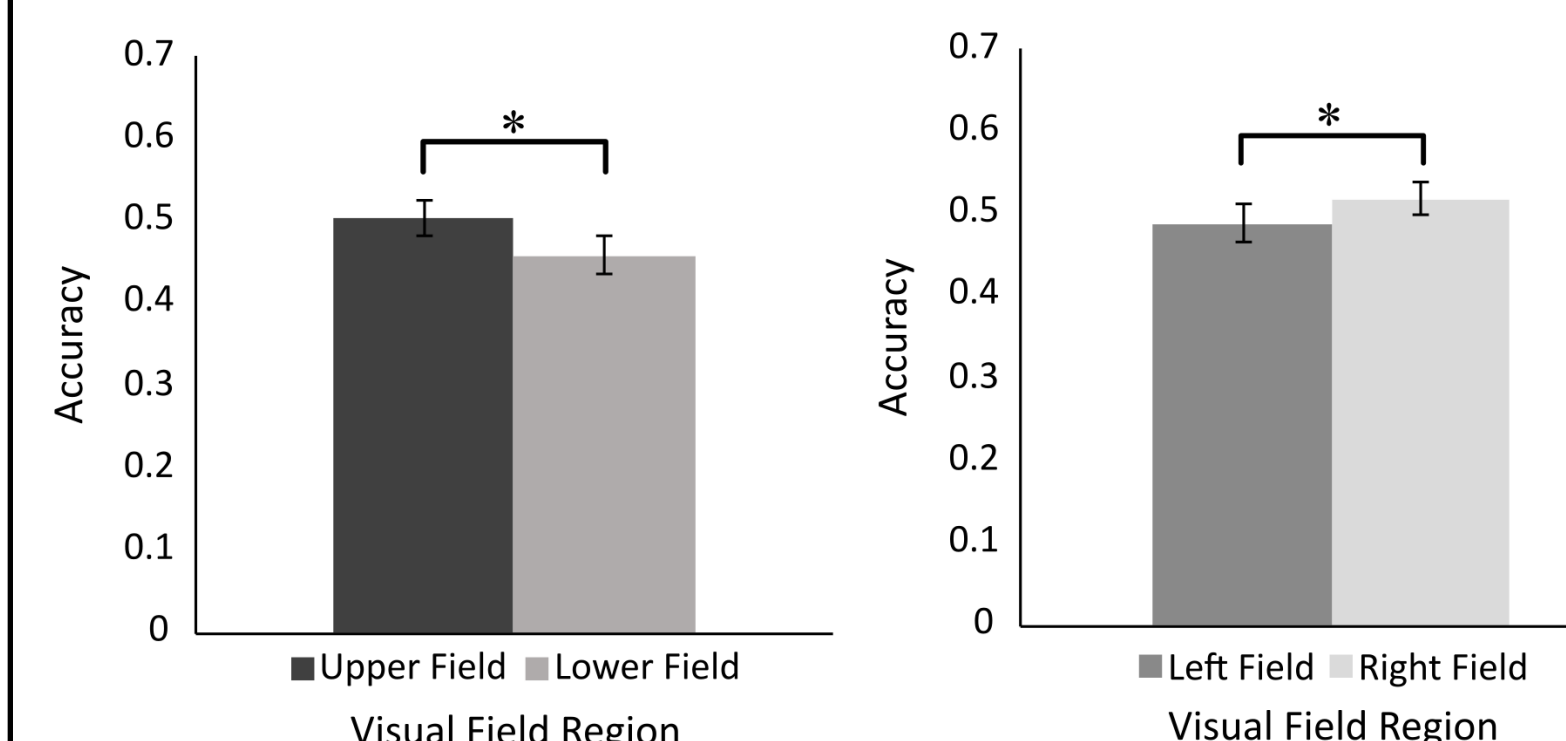
* No correlation between walking performance and AVF-VE performance, $r(39) = .02, p = .90$

Study Results

AVF-VE Validity



Spatial Distribution of Visual Attention



- Rectangular shaped AVF
 - Inferior vertical performance
 - Superior diagonal performance

Discussion

AVF-VE Task Development

- The computer-based AVF was transferred to HMD VR
 - Using an eye-tracker to control visual angles of stimuli in a wide visual field

AVF-VE Task Evaluation

- An empirical study demonstrated the effects from computer-based AVF were observed in the AVF-VE task
 - AVF-VE Accuracy:
 - Increased with increasing exposure time
 - Lower with higher eccentricity
 - Upper visual field > Lower visual field

Characteristics of the Spatial Distribution of Visual Attention in VE

- Higher accuracy in horizontal and diagonal directions than along the vertical meridian
 - Leading to rectangular distribution
 - The size and shape of HMD VR's FoV may impact the visual attentional field.
- Novel result of higher accuracy in right than in left visual field
 - Possibly due to participants' hand dominance

Conclusions

- VR technology gives us the opportunity to assess human visual attentional field with a more ecologically valid method
- AVF-VE is valid and useful for examining visuospatial attention in VR
- The spatial distribution of human visual attention may be affected by the field of view of HMD VR.
- Future directions:
 - Direct comparisons between performance on computer vs. VR-based AVF
 - AVF-VE with 3D visual stimuli and more ecologically valid targets
 - Augmented Reality (AR)-based AVF

[1] Shirin E. Hassan, Kathleen A. Turano, Beatriz Muñoz, Cynthia Munro, Karen Bandeen-Roche, and Sheila K. West. 2008. Cognitive and vision loss affects the topography of the attentional visual field. *Investig. Ophthalmol. Vis. Sci.* 49, 10, 4672–4678.
 [2] HeeSun Choi, Daniel Grubin, and Jing Feng. 2015. Self-reported attentional failures during driving relates to on-road crashes and simulated driving performance of older drivers. *Transp. Res. Board* 919, 16p.
 [3] Aimee Teo Broman, Sheila K. West, Beatriz Muñoz, Karen Bandeen-Roche, Gary S. Rubin, and Kathleen A. Turano. 2004. Divided visual attention as a predictor of bumping while walking: The Salisbury Eye Evaluation. *Investig. Ophthalmol. Vis. Sci.* 45, 9, 2955–2960.