International Cartographic Association
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# Navigating Cognitive Challenges: How ADHD Affects Spatial Knowledge Acquisition

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**Keywords:** Spatial Cognition, ADHD, Navigation, Attention, Spatial Working Memory, Neurodiversity

**Abstract:**

One of the primary symptoms of ADHD is executive dysfunction, which impacts working memory and attention (Barkley, 1997; Rapport et al., 2008). Deficits in these cognitive abilities associated with executive dysfunction have an impact on the development of spatial knowledge—the mental maps and frameworks that guide our movement and decision-making in the world around us. Whether commuting to work, exploring a new city, or even finding one's way around a complex building, the capacity to move through different spaces efficiently is critical to maintaining personal independence and autonomy (Gramann et al., 2017). Therefore, it is vital that we explore further the impacts of ADHD and spatial engagement on spatial knowledge acquisition. This study aims to deepen the understanding of the deficits in spatial cognition that ADHD adults experience and apply those findings to improve the design and development of navigation aids with the intent of improving neurodiverse accessibility.

Previous work has explored both how attention and spatial working memory independently impact individual performance when it comes to spatial learning (Albert et al., 1999; Blacker et al., 2017; Garden et al., 2002). Attention supports spatial learning by enabling the encoding of environmental features and landmarks and filtering out distractions that might hinder effective wayfinding (Albert et al., 1999). When attention is weak or inhibited, individuals may fail to encode important information that's needed to support spatial knowledge development. Spatial working memory allows individuals to temporarily hold and manipulate spatial information, such as the positions of objects or the sequence of steps in a route (McAfoose & Baune, 2009). This is particularly important for route knowledge, where individuals must remember a series of landmarks or directions, and for survey knowledge, where the integration of multiple routes and landmarks is necessary to form a comprehensive mental map of the environment. When spatial working memory is impaired, an individual may face difficulties in keeping track of one's location, planning routes, and updating one's position in space, which can result in profound wayfinding difficulties (He et al., 2021; Uresti-Cabrera et al., 2015).

Furthermore, much of the prior research exploring the impacts of ADHD on spatial cognition and navigation has been done in children. However, the experience and impacts of ADHD in adults are developmentally distinct. To our knowledge there has not been a comprehensive study exploring the impacts of executive dysfunction in ADHD adults on spatial knowledge acquisition. Therefore, it is vital to explore spatial learning in adults due to their increased reliance on wayfinding abilities compared to children.

To further this work, this study seeks to develop a deeper understanding of how ADHD affects spatial learning, cognitive load, and navigational ability compared to non-ADHD control adults. To study this phenomenon, we use immersive virtual reality (VR) to simulate wayfinding and geospatial navigation scenarios. Immersive VR provides enhanced ecological validity and spatial embodiment (Riva et al., 2019). These advantages are critical in the study of spatial cognition and geospatial navigation as it allows researchers to control environmental variables while mitigating loss to the environmental and scenario validity for real-world contexts. Moreover, immersive virtual environments are reliable means for examining the effects of cognitive impairments (Belger, 2021). As such, immersive VR serves as an effective tool for investigating how impaired executive cognitive functions in adults with ADHD influence spatial

Abstracts of the International Cartographic Association, 10, 48, 2025
32nd International Cartographic Conference (ICC 2025), 17–22 August 2025, Vancouver, Canada.
https://doi.org/10.5194/ica-abs-10-48-2025 

navigation. We have designed an experiment that leverages the strengths of immersive VR. Participants navigate environments of increasing difficulty while we measure wayfinding accuracy, efficiency (time and distance), and performance. These insights will support and guide the development of an open access neuro-adaptive mobile navigation app by highlighting aspects of navigation tools that are failing for ADHD individuals.

**Acknowledgements**

I would like to thank my advisor Dr. P. William Limpisathian for his support and guidance.

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https://doi.org/10.5194/ica-abs-10-48-2025 