Geographic Spatial Cognition Differences in Virtual Reality Environments

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Keywords: Virtual reality, Eye-tracking, Spatial cognition, Cognitive maps

Abstract:

The rapid development of virtual reality (VR) technology has positioned both desktop-based and immersive VR environments as critical tools in geographic spatial cognition research. However, differences in spatial cognitive abilities across cognitive subjects, particularly concerning gender, personality, and knowledge background, remain underexplored. This study investigates these differences by employing generative artificial intelligence and 3D modeling to reconstruct the Northern Song Dynasty painting 'Along the River During the Qingming Festival' by Zhang Zeduan, as shown in Figure 1 and Figure 2.
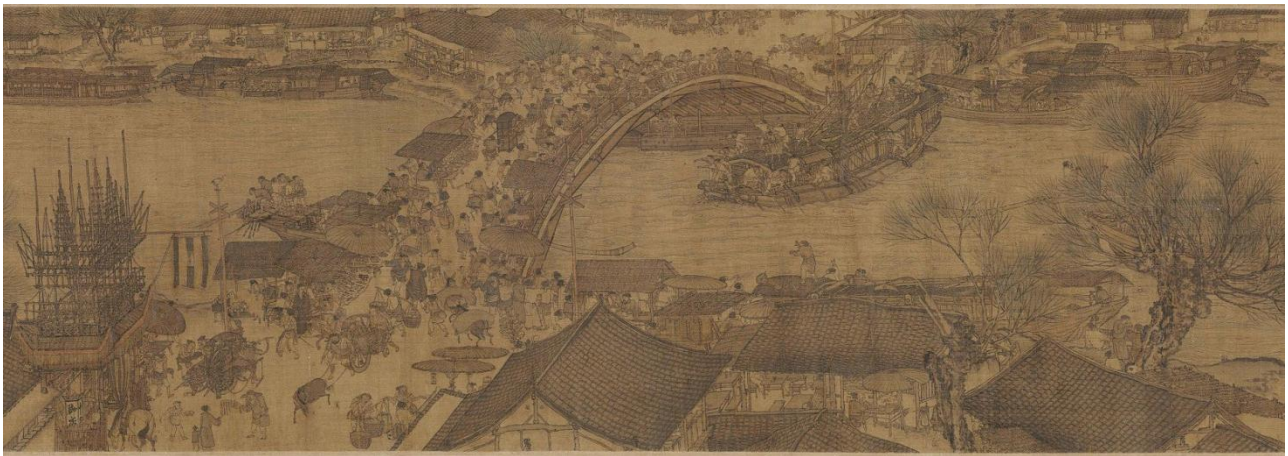
Figure 1. The Hongqiao Section of 'Along the River During the Qingming Festival'
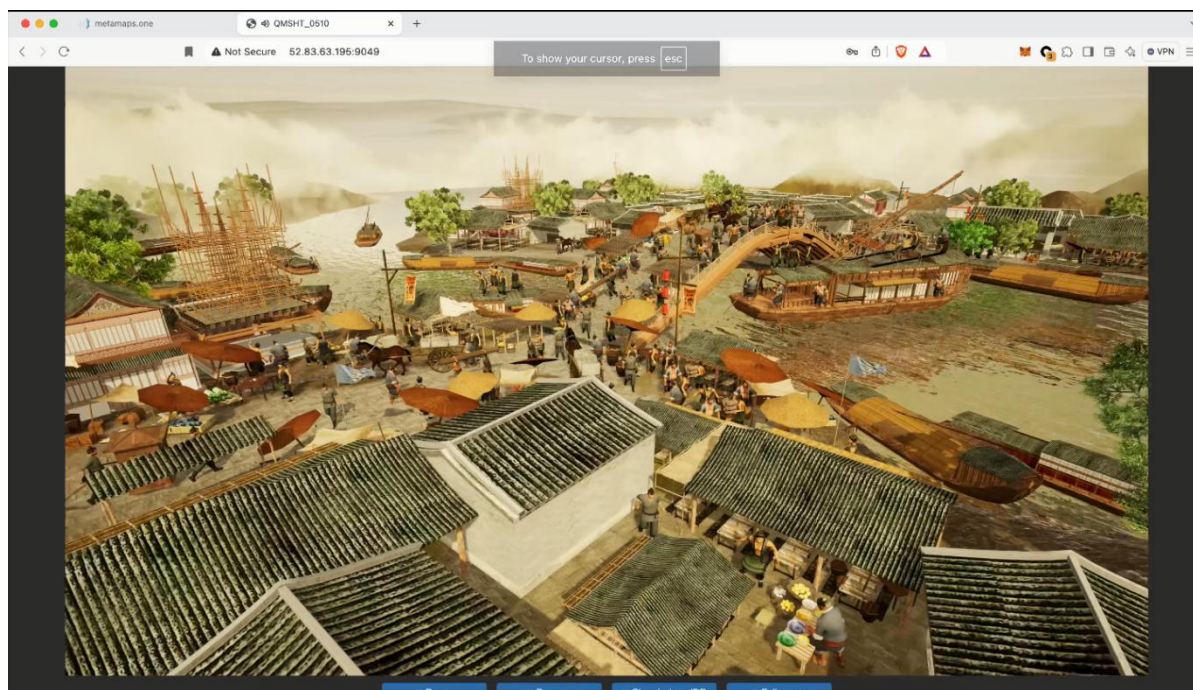
Figure 2. Screenshots of the Virtual Reality Environment Based on 'Along the River During the Qingming Festival'

A total of over 280 participants were recruited. First, they completed the standardized Revised NEO Personality Inventory (NEO PI-R) [1,2] to assess their Big Five personality traits. Based on the questionnaire results, 64 relatively introverted and 64 relatively extroverted participants were selected from the initial pool. Subsequently, these 128 eligible participants performed a wayfinding task in a desktop-based virtual reality (VR) environment. Eye-tracking technology was used to record visual attention during the experiment. Pre-experiment assessments included the STAT spatial thinking test, abstract reasoning test (ART), and mental rotation test (MRT) to measure participants' baseline spatial abilities [3]. Post-experiment evaluations incorporated structured interviews and sketch maps to reliably externalize participants' cognitive maps, reflecting their cognitive mapping processes [4].

The results demonstrated that gender differences were more pronounced than personality or knowledge background in VR environments (gender > personality > knowledge background). Eye-tracking data showed that males and introverts exhibited higher information processing efficiency, while males and extroverts experienced lower cognitive load and shorter task response times. Females and extroverts outperformed their counterparts in most information search metrics. Participants with a geography-related background displayed significantly greater attention to landmarks and road network structures compared to non-geographers.

This study provides empirical evidence on the role of gender, personality, and knowledge background in spatial cognition within VR environments. The findings may offer valuable insights for advancing research on behavior, processes, and mechanisms in VR-based geographic environments.

References

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