Cyclist Attention Patterns and Maneuver Behavior in Varying Traffic and Environmental Contexts

Master‘s Thesis of Arpan Ananda

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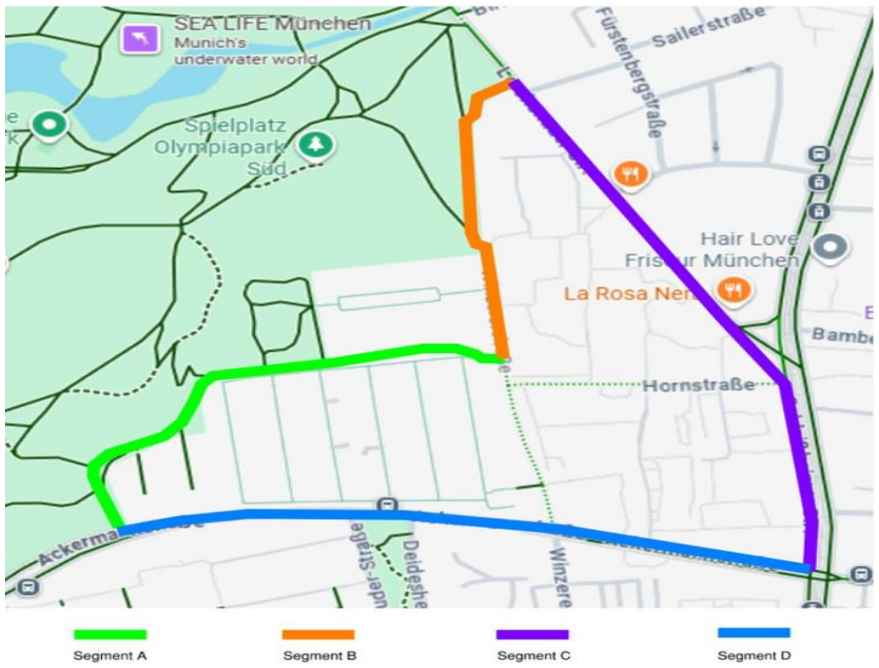


Figure 1 Scenario 3: Varying Traffic Cycling Route

Objectives and Motivation

Cycling is increasingly promoted as a sustainable and healthy mode of urban transport across Europe. However, safety remains a major concern due to rising cyclist exposure in complex traffic environments. Despite advancements in infrastructure, accident rates among cyclists have not significantly decreased, highlighting the need to better understand cyclist behavior. A key factor influencing cycling safety is **attention**, which continuously adapts to traffic conditions, infrastructure, and environmental complexity. Existing research has largely examined **gaze behavior** or traffic conditions separately, often neglecting the interaction between visual attention, physical movements, and real-world maneuvering. This study addresses this gap by analyzing cyclist attention as an integrated system, combining **eye-tracking, IMU (head movement), GPS, and survey data**. The goal is to understand how attention changes across different environments and how it relates to maneuvering behavior. The findings aim to support safer infrastructure design and policy-making by identifying conditions that increase cognitive demand and potential risk for cyclists.

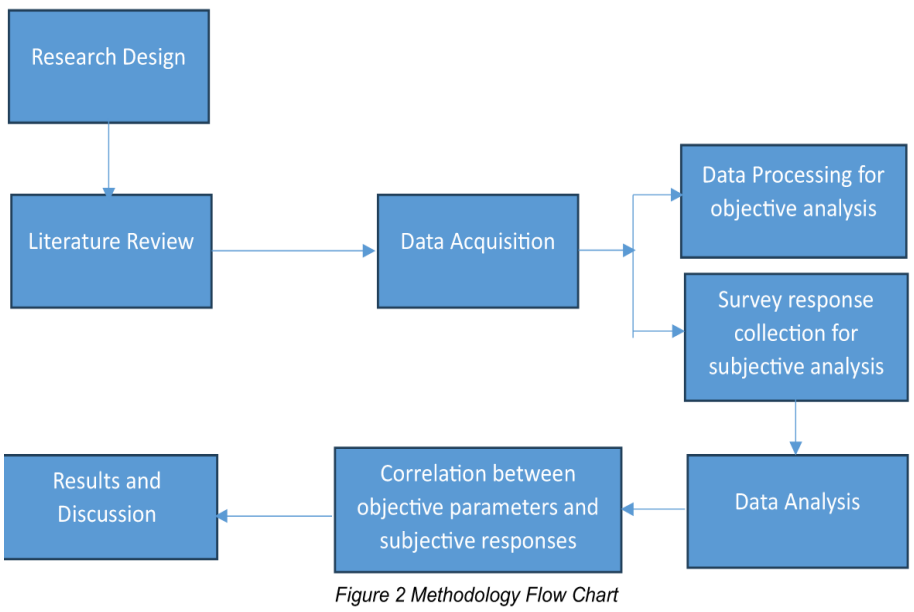


Figure 2 Methodology Flow Chart

Methodology

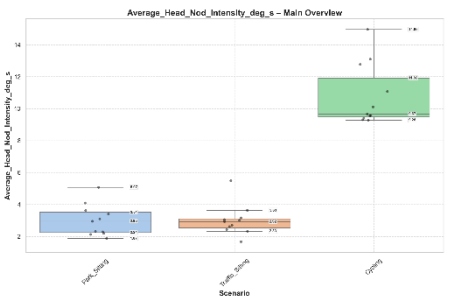
This study uses a multimodal experimental approach to analyze cyclist attention and behavior under different environmental conditions. Data were collected from 16 participants across three scenarios representing increasing task demand:

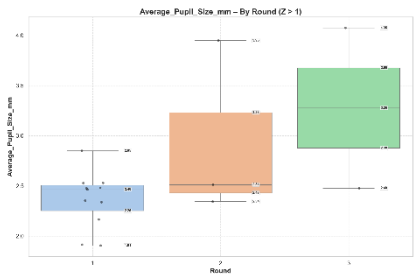
- Park Setting (low demand)
- Traffic Setting (moderate demand)
- Cycling in real traffic (high demand)

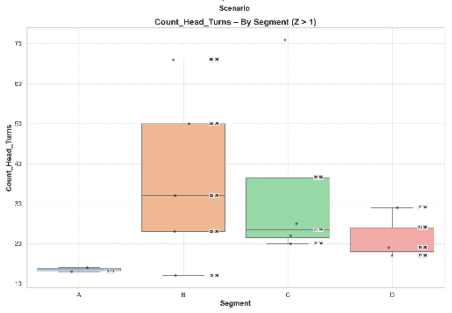
A combination of four data sources was used:

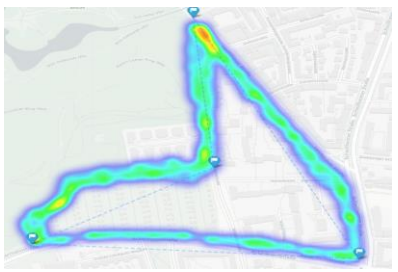
- Eye-tracking for visual attention (fixations, glances, pupil size)
- IMU (gyroscope)for head movements (nod, turn, tilt)
- GPS for speed, distance, and route segmentation
- Survey data for perceived experience and stress.

The cycling route was divided into four segments (A–D) and repeated over three rounds (R1–R3) to capture spatial and learning effects. Data processing involved: Fixation detection using velocity-based thresholds, Head movement and event detection from IMU signals, Z-score based peak identification to detect unusual behavior. Calculation of a composite Overall Peak Index (OPI), Finally, relationships between variables were analyzed using Spearman correlation, enabling robust analysis of attention, movement, and perceived stress.









Results (Key Findings)

Overall: Attention shifts from long, stable fixations in calm settings to short, frequent scanning in cycling, with significantly higher head movement in dynamic environments.
Round-wise: With repetition, cyclists show reduced visual and physical effort, indicating learning and more efficient attention allocation.
Segment-wise: Transition zones (Segment B) demand the highest attention and movement due to environmental complexity and interaction.
Spearman Correlation: Attention, head movement, and cognitive load form a strongly interconnected system, where higher demand increases movement but reduces attention stability.