

Investigating Driver Behaviour and Workload when Interacting with Cyclists or Pedestrians in an Urban Environment

Master's Thesis of Vinaya Murali

Mentoring:

Maya Santhira Sekeran M.Sc.
Dr.-Ing. Tanja Niels

1. MOTIVATION

- Intersections are critical for VRUs.
- Visual complexity and unpredictable VRU manoeuvres impose heavy cognitive loads.
- Behavioural metrics alone (e.g., braking) fail to capture internal cognitive overload; a multimodal comparison is required.

2. RESEARCH OBJECTIVES

- Investigate how behaviour differs when interacting with pedestrians versus cyclists at urban intersections.
- Analyse variations in cognitive and subjective workload, and attention allocation, across VRU interactions.
- Evaluate how driving experience and age influence behaviour and workload during these encounters.

3. EXPERIMENTAL METHODOLOGY

- **Participants:** N = 37 drivers (Mean Age: 26.4 years; 29 Male, 8 Female).
- **Setup:** Simulator study; urban route with crossing pedestrians and right-turning cyclists.
- **Synchronisation:** All measures aligned to the "Conflict Zone Entry" (t = 0).
- **Measures:** Pupil dilation, Gaze Entropy, Speed profiles, Braking intensity, and Subjective ratings.

4. BEHAVIOURAL DIFFERENTIATION: SPEED AND CONTROL

- 69% of cyclist encounters elicited anticipatory braking vs. 55% for pedestrians.
- Cyclists trigger a large pre-post speed contrast (d = 0.807, p < 0.001) not seen in pedestrian encounters.

VRU type	Variable	p-value	Cohen's d (Post - Pre)
Pedestrian	Speed	0.221	0.075
Cyclist	Speed	< 0.001	0.807
Pedestrian	Brake	< 0.001	-0.466
Cyclist	Brake	< 0.001	-0.661

5. COGNITIVE DEMAND AND VISUAL ATTENTION

- Cyclist interactions elicit significantly greater baseline-corrected pupil dilation than pedestrian interactions ($\beta = -2.17$, p = 0.018).
- Scanning complexity (Entropy) is strongly correlated with workload **only** among cyclists (r = 0.711, p = 0.0009).
- Intersection layout and occlusions drive fixation duration more than the VRU type itself.

Sub-Scenario	Pearson r	p-value	Interpretation
Cyclist Scenarios	0.711	0.0009	Strong Positive
Pedestrian Scenarios	-0.049	0.9002	No Relationship

This table shows the Pearson correlation between Gaze Entropy and Workload.

6. INFLUENCE OF AGE AND EXPERIENCE

- Driving experience is **not** associated with a reduction in cognitive workload (p = 0.21).
- Older and experienced drivers compensate by **reducing mean speed**, specifically for cyclists (r = -0.35, p = 0.045), rather than through reduced mental effort.

Predictor	Outcome Variable	Pearson r	p-value
Driving Experience	Mean Workload	0.21	0.21
Age	Mean Speed (Cyclist)	-0.40	0.021
Driving Experience	Mean Speed (Cyclist)	-0.35	0.045
Age	Mean Speed (Pedestrian)	-0.28	0.088

7. CONCLUSION AND FUTURE OUTLOOK

- **Baseline Strategy:** Early braking reflects normative intersection approach; VRU-specific actions are "layered" on top.
- **Implications:** Prioritize cyclist path prediction in ADAS and improve urban sightlines.
- **Next Steps:** Validate with balanced demographics and collect cyclist-specific subjective workload profiles.