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## Mental workload of cyclists in different urban road layouts : towards a study with a bicycle simulator

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### 1 INTRODUCTION

Mental workload of cyclists in real traffic is higher in complex traffic situation, such as intersections in mixed traffic, than in simple ones, such as secluded bicycle paths [1]. To avoid overload in those complex situations, cyclists may engage in inappropriate behaviors [2]. Road design may help to reduce mental workload of cyclists at intersections or in mixed traffic situations. Because investigation of different road layouts in real traffic is expensive and would be unsafe in real complex situations, bicycling simulator would be a more appropriate tool to investigate mental workload and behavior of cyclists [1]. Our research project aims to investigate mental workload of cyclists in complex road traffic situations such as intersections or in mixed lanes with different road layouts using a bicycle simulator composed of a virtual reality headset with embedded eye-tracking. Mental workload assessment will rely on different measures, i.e perceived mental workload measured with a standardized subjective scale, the secondary-task technique and physiological parameters based on eye-tracking measures. A preliminary study was conducted to test the possibility to use the eye-tracker embedded in the headset to measure blink rate and pupil diameter to evaluate cyclists' mental workload.

### 2 MATERIALS AND METHODS

8 participants (one female) were recruited. Data were excluded for one participant who was unable to ride in a straight line. The seven remaining participants (one female) were between 25 and 34 years old.

The experiment was conducted using the bicycle simulator under development at ESTACA'Lab. It was composed of a virtual reality headset with a built-in eye-tracker and a bicycle fixed on a home trainer through the rear wheel. To get the unprocessed eye-tracking data directly, some modifications to the original Unreal Engine based plugin were needed to create a dedicated interface for eye-tracking in the bike simulator.

The virtual reality environment was developed with Unreal Engine (version 4.26). The simulated route was a two-way urban road consisting of distinct straight sections of 300 m each, a bike lane was present only in one out of two sections. Each section contains a T-junction in which the participant had priority and traveled straight through without turning.

All the participants filled out an informed consent form. Then, they were installed on the bicycle simulator, and they were equipped with the headset. After the completion of the calibration, the procedure consisted of one familiarization session with the bicycle simulator and one experimental session. During this session, all participants traveled through two sections but depending on their starting position in the virtual environment, they encountered the section with the bike lane in first or second. Participants were randomly assigned to the two different groups with the restriction that each group contains four participants. Finally,

participants filled out a form to gather demographic information and two standardized questionnaires to gather respectively, their perceived sense of presence [3] and their perceived sense of simulator sickness [4].

Pupil diameter and the occurrence of eye blink were recorded for each section to analyze the mental workload of cyclists depending on the presence of a bike lane, as they are recognized indicators of mental workload [5, 6]. Because the work is in progress, only descriptive statistical analysis for blink rate is available.

### 3 RESULTS

Blink rate (the number of blinks per minute) for each participant in the section without bike lane versus with bike lane are available in Table 1.

Percentage of change in blink rate based on situation without bike lane was calculated for each participant and are reported in the last column in Table 1. According to previous research, the higher the mental workload, the lower the blink rate. Thus, it can be concluded that if the values about percentage of change in blink rate in Table 1 are positive, it means that participants have a lower mental workload on roads containing bike lanes; if they are negative, it means that participants have a lower mental workload on roads that do not contain bike lanes. The results in Table 1 show that one participant (id: 5) may have experienced similar workload in the presence and in the absence of a bike lane, three participants (id: 3, 6, 7) may have experienced lower workload in the presence of a bike lane and three participants (id: 1, 2, 4) may have experienced lower workload in the absence of a bike lane.

*Table 1 : Blink rate in section without a bike lane versus with a bike lane for each participant.*

ID	SECTION WITHOUT BIKE LANE			SECTION WITH BIKE LANE			% of change in blink rate
	Duration (s)	Number of blinks	Blink rate	Duration (s)	Number of blinks	Blink rate	
1	120	21	10.5	120	14	7.0	-33
2	132	45	20.5	134	36	16.1	-21
3	142	11	4.6	124	29	14.0	202
4	148	86	34.9	120	46	23.0	-34
5	124	99	47.9	142	115	48.6	1
6	126	35	16.7	121	51	25.3	52
7	166	2	0.7	166	10	3.6	400

### 4 CONCLUSIONS AND FUTURE WORKS

The preliminary analysis of the blink rate suggests that it may change depending on the road environment. Nevertheless, those results merit further investigation with a larger number of participants and with a larger set of trials. Furthermore, we must consider other indicators of mental workload such as the perceived mental effort, the performance to a secondary task such as the detection-reaction task [7] and other psychological indicators as the pupil diameter before to make assumptions about the mental workload of

cyclists in different traffic situations. Further work is planned to measure those different indicators of mental workload in an extended experiment to study the effect of different road layout in more complex traffic situations and with cyclists with different levels of expertise.

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