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Innovative motorcycle headlight design for improving motorcycle visibility

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Context (1/2)

- The most frequent cause of Powered Two Wheeled vehicle (PTW) accidents involves another vehicle that violates the PTW's right of way at an intersection (ACEM, 2009)
- Two mains causes underlay these accidents:
  - Lack of detection (or late detection error, the famous "sorry mate I didn't see you")
  - Misperception of the PTW's speed and time to arrival

(Horswill et al., 2005).

Several works have been undertaken over years to determine a better visual signature for the PTWs (e.g. Maruyama, Tsutsumi & Murata, 2009), and to improve the speed perception of PTWs using additional lighting systems (e.g. Gould et al. 2012)

A previous research work, conducted using virtual reality, we have shown the interest of a vertical lighting configuration to improve the drivers' perception of motorcycles' motion (Cavallo et al., 2015)

Context (2/2)

- Digital conspicuity (work under progress)...
  - the time needed to design a reliable system and to spread the system to the whole PTW fleet is very probably more than 25 years (the ABS was introduced in 1988, but the current equipped PTWs' fleet is roughly 30%)
  - What about low cost PTWs, and about emerging country PTWs fleet?

→ it is a major stake to propose (in parallel to digital solution) improvements for the current analog solution

  - If possible 1) low-cost, 2) low power consumption, 3) easy to install on existing fleet

Problematic (just a reminder...)

- Improve PTW detectability
- Improve approaching speed evaluation

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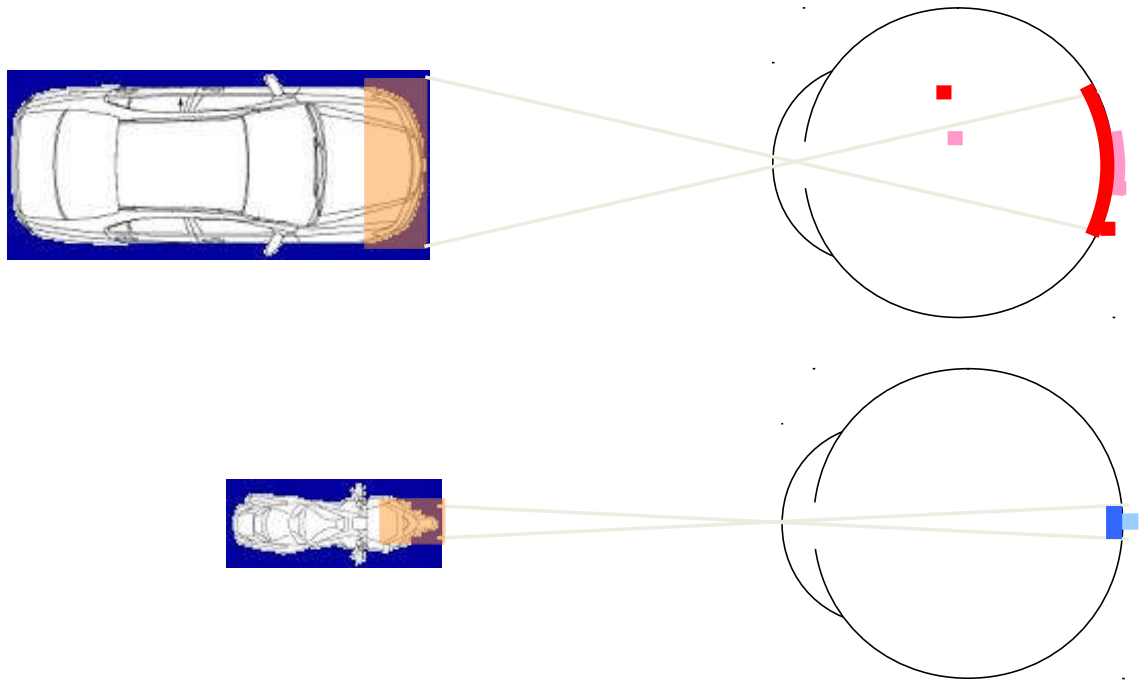
Lower angular speed for the PTW → no motion detection and under estimation of the approaching speed



Experiment

- On track, at dusk and night time
- Using a motorbike equipped with a cruise control
- OEM LED stripes on the at the bottom edge of each fork leg
- an helmet that hosted an OEM yellow LED light

Experiment on track

Four participants, in their own car were in a left turn situation (stopped).

A motorbike or car, driven by an operator, approached in the opposite direction at fixed speed.

A vehicle was parked to occult the on-coming vehicles, and to let the participants see them when they were at about 10 s time to arrival.

Participants were each equipped with a push-button. The time spent by the on-coming vehicle from the push of each button to the cross an optical barrier was measured. As the on-coming vehicle speed was known, as well as the distance between each participant and the optical barrier, one could easily infer the individual time to arrival for each participant.

In total 24 participants (7 W, 17 M) , mean age 36.4, all normal or corrected vision, license > 2y, regular drivers

Experimental variables / setup

Variables

Headlight configuration: Only one innovative condition was selected for the PTW, thanks to the pre-selection achieved using on the simulator. So the two lighting modalities for the PTW were: the “standard” white lighting, and the vertical “yellow-white” lighting (“standard” white lighting + helmet “yellow” + fork “white” called later in this paper “vertical enhanced”).

Speed: The oncoming vehicles (car or PTW) used a fixed speed (2 modalities: 60 and 90 km/h).

Repetition: Each experimental conditions were repeated 4 times.

Setup

The combination of the experimental variables: headlight configurations$_3$ (PTW$_2$ + car$_{1)}$, speed$_{2,}$ repetition$_4$ led to a total of 24 trials (16 with PTW, 8 with car). The trial for PTW and car were presented by block. Half of the participants started with the car block, half with the PTW block. The order of trials within the block was random.

Procedure

Dusk and night time.

4 participants were convened at the same time (consent form). Vehicles placed on predetermined locations on the track. Subjects provided with push buttons.

After being instructed, the participants practised then two practice trials to become familiar with the protocol.

Experiment: approach of a oncoming vehicle following a predetermined configuration (speed, vehicle type and headlight configuration) to the operator. The vehicle was visible for the participant about 10 seconds before the “time to arrival”. Each trial lasted about 2 minutes.

Two experimental sessions occurred at night: the first one from 6:30 pm to 8:00 pm, the second one from 8:15 pm to 9:45pm. The experiment took place in winter and lasted 3 nights.

Movie…

Data treatment

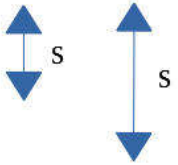
The average minimal Time to Arrival (TA) estimated for the 4 repetition has been calculated for each experimental condition (headlight/vehicle$_3$ x speed$_2$).

The data have been analysed by ANOVA. The α-level was set at 0.05 for all statistical analyses.

The significant effects have been furthermore analysed using the post-hoc Fisher LSD test.

Results

vehicle/headlight configuration	Minimal TA
PTW «standard»	6.47
PTW «vertical enhanced»	6.87
Car	7.13



Headlight configurations moto / car

Results

Confirm the previous experiment conducted on simulator

Show a significant safety improvement provided by the vertical "white/yellow" configuration.

- Allows to gain in average 0.40 s in the minimal arrival time compared to the "standard" headlight system
- this correspond to an increase of the safety distance:
- **6.7 m at 60 km/h** and of **8.8 m at 90 km/h**

→ these distances are additional safety margins for riders and drivers in conflictual interaction situations!

Conclusion

The experiment we conducted on track used the same methods as those previously used on simulator ("standard" vs "vertical", 60 km/h vs 90 km/h, night or dusk conditions, on-coming vehicles on a straight road,…) and showed the same trends:

- A significant effect of the headlight configuration, with higher safety margins for "vertical enhanced" configuration compared to "standard"
- A significant effect of the approach speed, with higher gap when approaching speed are slower
- The lack of interactions between the speed factor and the headlight configuration factor.

Perspectives

The solution, that use very low cost and very low power consumption LEDs, enable to imagine the deployment of safer headlight systems not only for large PTWs but also for light ones, up to mopeds. One can also imagine after-market solutions to speed-up the dissemination of "enhanced vertical" lighting solutions.