Improving the perceptibility of motorcycles through innovative headlight configurations

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• Motorcyclists are very vulnerable road users
• In-depth accident analyses show
  – that perceptual failures of car drivers are a frequent cause of motorcycle accidents (60% to 70 %, van Elslande, 2010; Hurt et al., 1981)
  – two kinds of perceptual failures of other vehicle drivers
    • No or late detection of motorcycles – « looked but failed to see » errors => low visual conspicuity => improved by DRL
    • Misperception of the motorcycle’s motion (speed, time-to-arrival)
• **Aim of our study:** test of motorcycle headlight configurations that remedy simultaneously the two perceptual errors when interacting with motorcycles
First study: Perception of motorcycle motion

- **Reasons for misperception of motorcycles’ motion**
  - Small size of motorcycles -> small angular size -> low angular velocity
  - Influence of ambient lighting conditions that determine the visible extent of the motorcycle: whole outline or only headlight

  => **motorcycle motion difficult to be perceived, sometimes below perceptual threshold**

- **Countermeasure**
  - Increase of the motorcycle’s apparent dimensions

  => Additional motorcycle headlights
Previous studies

Tsutsumi & Maruyama (2008): LONG lighting system

- tested in real world conditions
- gap acceptance judgement task

- larger accepted gaps with LONG system
- at night-time and daytime conditions
Previous studies

Gould, Poulter, Helman & Wann (2012)

- Laboratory experiment: speed discrimination task
- 2 additional headlights at different positions
- Lower speed discrimination threshold for triangle configurations
- In nighttime conditions only
First study: Perception of motorcycle motion

Test of innovative headlight configurations

• in different lighting conditions: night-time, dusk, daytime
• use of the maximal possible vertical and horizontal dimensions

![Motorcycle configurations](image)
First study: Perception of motorcycle motion

**Method**

- 3 groups of 23 participants each (M=31 years)
- Driving simulator
- HDR (High Dynamic Range) image generation

- Left-turn task
First study: Perception of motorcycle motion

- Groupes of vehicles (motorcycles, cars, vans and trucks) approaching head-on at different speeds and with different gaps
- Two approach speeds: 40 km/h and 60 km/h
- Task: participant had to turn left when he judged turning possible
First study: Perception of motorcycle motion

Night-time conditions
First study: Night-time

Accepted gap (s) as a function of headlight configuration

Time gain: ~ 1 s
First study: Perception of motorcycle motion

Vehicle approach speeds: 60 and 90 km/h

Dusk

Daytime
First study: Dusk

Accepted gap (s) as a function of headlight configuration

Time gain: ~0.7 s
First study: Daytime

Accepted gap (s) as a function of headlight configuration

<table>
<thead>
<tr>
<th>Configuration</th>
<th>60 km/h</th>
<th>90 km/h</th>
</tr>
</thead>
<tbody>
<tr>
<td>standard</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>horizontal</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>vertical</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>combined</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>car</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

Time gain: ~ 0.3 s
First study: Conclusions

• Light arrangements that accentuate the *vertical dimension* of the motorcycle/motorcyclist were the most effective
  – They provided substantial improvements as compared to a standard headlight
  – The accepted gaps were equivalent to gas accepted in front of cars
• The beneficial effect of vertical configurations depended on ambient lighting conditions:
  night-time > dusk > daytime
• Recommended configuration:
  « Vertical »
Second study: Motorcycle detection

- **Low visual conspicuity of motorcycles**
  - Due to small size, irregular contours, dark colors
  - Conspicuity is improved by motorcycle DRLs (Muller, 1984; Zador, 1985)
  - Conspicuity is reduced by competing car DRLs (Brendicke et al., 1994; Cavallo & Pinto, 2012)

- **Countermeasure:**
  Headlights that clearly distinguish motorcycles from cars and give them again a new visual signature
Second study: Motorcycle detection

Gershon et al., AAP, 2013

Pinto, Cavallo, Saint Pierre AAP, 2014

Yellow light   Helmet light

Fig. 1. (a) Conventional frontal view headlight ON, (b) T configuration, and (c) T configuration plus helmet lights.

Système FACE Honda Maruyama et al., 2009
Second study: Motorcycle detection

Test of innovative headlight configurations

• in a motorcycle detection task
• in different car light environments (distractors)

White standard  Yellow standard  White vertical  Yellow vertical
Second study: Motorcycle detection

1) DRLs (LEDs)

2) Dipped beams

3) DRLs (LEDs) + dipped beams
Second study: Motorcycle detection

**Method**
- 3 homogeneous groups of 19 participants
- Participants seated in a mini driving simulator
- Computer-generated urban traffic scenes presented for 250 ms on large HDR screen
- Complex traffic (four lanes) approaching at 50 km/h
- Presence of vulnerable road users (targets): motorcyclists, cyclists, pedestrians
- Targets at different distances and eccentricities
- Distractor trials containing no targets
Second study: Motorcycle detection

Motorcycle detection rate (%) as a function of configuration

Best detection with yellow standard and **yellow vertical configuration**

=> Effectiveness of color coding in generating distinctive features (dissimilar to car lights) and creating a new visual signature for motorcycles
Second study: Motorcycle detection

Motorcycle detection rate (%) as a function of car light environment

Motorcycle detection was impaired when many car lights were present and acted as visual distractors

=> necessity of better car light regulation
Conclusion

- Best movement perception
- Best detectability
- Best motorcycle perceptibility
Thank you for your attention

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