PUBLISHED PROJECT REPORT PPR600

EC project '2 BE SAFE' briefing note for Deliverable 18;
Experimental studies on powered two-wheeler visual conspicuity

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Prepared for: DfT,
Project Ref: 2 BE SAFE

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2012
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Contents amendment record

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D18: Experimental Studies on Powered Two-Wheeler Visual Conspicuity

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Executive Summary (adapted from the project deliverable)

The report focuses on phenomena related to the conspicuity of Powered Two-Wheelers (PTWs) as a critical factor in between-vehicle interactions. Previous studies indicated that the lack of PTWs’ conspicuity is one crucial factor of causation of car–PTW accidents. PTWs are seen as less conspicuous because of their relatively small frontal surface, often dark coloured appearances and their irregular contours.
Due to their specific characteristics in terms of vehicle dynamics and vehicle contours, PTWs are particularly susceptible to blending with a cluttering background and to be obscured, in particular, by other vehicles. PTWs’ speed and distance are harder to estimate for other vehicle drivers because of the smaller retinal size (visual image) of PTWs. In addition drivers’ inadequate expectations regarding the occurrences of PTW riders seem to contribute to the higher risk of late detection or neglect of PTW. So, a perceived lower exposure rate of PTWs compared to cars might lead to disadvantageous expectations – and beyond this – also to suboptimal anticipation of PTW riders by other road users. Furthermore, due to their manoeuvrability, PTWs often appear at locations which are unfamiliar and therefore unexpected for car drivers.

Based on the literature, significant visual situations which are known as particularly risky for PTW riders were highlighted. Several experimental studies were conducted in order to examine the effects of PTWs’ conspicuity on drivers’ perception, on their roadway decisions and driving behaviour in relevant traffic situations.

A starting point was the question about the effects of PTWs’ visual saliency (how easily they are understood to be PTWs) on drivers’ attention and roadway decisions in highly relevant traffic situations. Previous accident research studies and studies from the field of vision research provided somewhat contradictory results: accident studies suggest that greater visual saliency is associated with lower accident risk for vehicles whereas
findings from vision research indicate that the visual saliency of objects has less influence on attention capturing when individuals have an object-based purpose to the inspection of a scene (that is, if someone is actively searching a scene for cars, even objects that have all the attributes of conspicuous PTWs may be missed).

The findings of the experiments in the 2BESAFE project show that PTWs’ saliency affects drivers’ decisions in intersection and lane change scenarios, with more cautious decisions and faster decision-making by drivers when visually more salient PTWs were present in the scenarios. These findings correspond with faster attention capturing by highly salient PTWs and earlier detection for highly salient PTWs.

Furthermore, the impacts of various environmental conditions on the conspicuity were examined. Results show that the complexity of the traffic situation impairs the detection of PTWs (as expected). The detection rate of PTWs in inter-urban road environments was significantly higher than the rates obtained in urban scenarios with a more crowded traffic environment. Concerning the surrounding luminance level, results indicate that detection rate of PTWs is substantially lower under dusk time conditions compared to during daytime time conditions, especially when subjects were not explicitly instructed to look for PTWs. In addition, the results also suggest that the traffic environment, including cars with daytime running lights, potentially reduces drivers’ ability to perceive PTWs.

In order to identify effective conspicuity aids, the effects of several conspicuity treatments were systematically varied and tested across several experiments. The effects of motorcycle low-beam headlights during daytime were evaluated by assessing driver’s decision making in a driving simulator study of gap acceptance. Particularly for short time gaps ahead of a PTW, the odds of accepting the gap and turning in front of the PTW are lower for PTW with headlights on than for PTW with headlights off. Results from further experiments indicate that varying riders’ clothing (bright clothes, reflective warning vests, and dark clothes) can enhance riders’ conspicuity in certain situations but the effects are strongly mediated by the background conditions (e.g. lighting conditions) and by the characteristics of the driving situation (e.g. urban vs. rural traffic environment).

Variations of specific frontal light configurations were found as promising solutions to enhance PTWs conspicuity. Due to the distinctive features of such a frontal light configuration, it is proposed to provide a unique visual signature/signal pattern for PTW to other road users, and thus, to facilitate recognition and identification processes. So, distinctive frontal light configurations are intended to make PTWs clearly distinguishable from the background and from other road users.

Variation of the light colour (yellow headlights), additional helmet lights (‘Alternating Blinking Light System’ or ABLS) and specific frontal light arrangements with additional lights installed on the front of the PTW (as T shaped, V shaped, FACE design) were considered as possible approaches to implement such a visual signature. Results reveal advantages in terms of a better detection and faster identification for yellow coloured headlights, ABLS and additional lights on the fork and handlebars for motorcycles (T Light configuration).

Furthermore, the results clearly emphasize that drivers’ awareness and expectations about PTW riders strongly impacts their detection of PTWs and subsequent decision-making. If subjects were made aware of the possible occurrence of PTWs during
experiments (e.g. by experimental instructions) the detection rate drastically increased compared to subjects who were not explicitly made aware to the occurrence of PTWs.

These findings highlight the importance of road users’ expectations referring to PTWs. This hints at – besides effective treatments which predominately focus on visual aspects of the PTW and its rider - the need for measures which aim to increase the awareness of other road users to PTWs in everyday traffic situations, and thus, to enhance PTWs’ conspicuity for other road users.

Technical requirements (lamp separation, light intensity) of a PTW frontal light configuration were tested under different background lighting conditions and observer distances. Overall, the results show that the surrounding luminance level had a significant effect on the time and the correctness of subjects’ response with faster and more correct responses made during daytime conditions. A greater lamp separation generates faster decision times and also a higher percentage of correct answers towards a light configuration.

With higher luminous intensity, a shorter lamp separation, particularly for the distance of additional lights to the headlamp, can be adopted. On the other hand, results suggest that additional lights with higher luminous intensity will outshine the signal of the turn indicator.

Based on the settings used in these experiments, for daytime usage a luminous intensity of 90cd appears to offer the greatest advantage when the turn indicator is used and 360cd when the turn indicator is not used.

For night-time usage, results indicate a luminous intensity for an additional light of 90cd as the best option. If dimming of the luminous intensity is not an option, 360cd for day and night-time usage is still advised; otherwise the conspicuity treatment will lose its effect when using 90cd during daytime.

When using 360cd at day and night-time, greater separation between an additional light and the turn indicator should be considered as well, in order to guarantee a reliable turn signal perception.

**UK Relevance**

This report covers a lot of ground and can act as a source document for future discussions on vehicle standards and behavioural change. The introductory review of conspicuity makes several important points about how we must consider the concept within the applied setting of traffic safety. Conspicuity of an object is a function of its physical characteristics and those of the background. It is also a function of the physical and psychological state of the viewer. The authors, recognising this, applied several different methods of investigation – detection performance – gaze behaviour - risk taking to provide a rich picture of the potential contribution of factors such as motorcycle headlight colour and the arrangement and brightness of additional light configurations.

It should be noted that the various experiments reported here used a range of stimulus materials and environments – still photographs, videos and driving simulators; but not field trials of real systems. Indeed the simulators used in these experiments seemed to cause a very high dropout rate of participants. As such some caution must be exercised in respect of absolute values presented, though the relative merits of say, additional lights in a T formation as opposed to a V formation, should be robust and repeatable.
Salience (how easily recognisable as a distinct PTW) was shown to improve the distance at which motorcycles and riders were identified in the forward field of view. That is, vehicles with high colour contrast to the background, with riders wearing high contrast clothing and high contrast helmets were, on average identified around 10% further away than low salience PTWs. This result is not surprising, nor does it present a firm product design criterion. It is presented with the caveat that higher salience had less effect when the PTWs were presented in a rear or side view.

The results from experiments considering specific conspicuity treatments are of greater value in the policy field.

Unfortunately those results dealing with Daytime Running Lights (DRLs) for motorcycles (normal dipped beam) were mixed, though the authors claim a (statistically) significant benefit in short time gap conditions. However when the configuration was changed such that the front headlight was yellow in colour, recognition rates improved reliably in all viewing conditions considered. The improvement in detection rates (how often the PTW was spotted by an observer) ranged from around 10 to around 20% (p26) and thus seem to justify further consideration.

The report concludes with a firm recommendation that improved saliency of PTWs helps with recognition and the behaviour of other road users. Exactly how to best improve saliency is a little difficult to determine from the report. High contrast clothing and helmets seem to help, but the degree is dependent on background scene complexity and the vehicle manoeuvres being considered. Riders need to be aware that in many situations the benefit they expect to receive from using high visibility clothing and livery may be far less than they might hope and this should be built into training and awareness campaigns.

DLRs are less susceptible to influence from background scenes but the results point to an interesting and potentially harmful interaction with DLRs of cars (p40). That is, if the majority of cars adopt DLRs it becomes less likely that PTWs even with their DLRs will be spotted by other road users. This phenomenon was first presented many years ago in the scientific literature and deserves specific investigation under UK traffic and lighting conditions.

Research here showed an advantage for riders using some form of additional helmet mounted lights, but the exact configurations used in the experiment were somewhat contrived and not likely to be truly representative of something that might find favour in the market. More work could be conducted here.

The work reported on additional lights (T formation or V formation) is equivocal and requires more thorough testing in a range of traffic environments.

However, a reasonably consistent picture emerges; improvement in conspicuity can result from improved (colour) and additional (T or V) lighting alongside recommendations for high visibility clothing and livery.

In the deliverable the terms ‘Triangle’ ‘T’ and ‘V’ are used for lighting additional lighting arrangements, The ‘Triangle’ on a motorcycle refers to use of the existing central headlamp with two additional raised lamps above the handlebars.

As shown in the report (p25) the concept behind ‘T’ and ‘V’ are similar and refer to arrangements on motorcycles and scooters respectively and take advantage of some of the natural outline characteristics. The ‘T’ is formed by additional lights along the
handlebars, the existing headlight and additional lights down the front forks. The ‘V’ for a scooter (a traditional Vespa model in the experiment) was formed by an array of additional lights, the base of the V being on the front mudguard and the other lights being attached to the front fairing and to the ends of the handlebars accordingly. The exact configurations seem of less importance in the report, than the general concept of additional lights that are congruent with the expected outline of the vehicle.

Very interesting and specific recommendations are given for the luminous intensity of these additional lights in both dusk and daylight conditions and in relation to the potential veiling effect upon existing indicator lights.

The report recommends additional light sources at daytime luminous intensity of 90 cd (at edge to edge distance of 60 mm to the turn indicator) when the turn indicator is used. When it is not in use the report recommends 360 cd (at 100 mm edge-to-edge distance to the headlight). For night time usage they recommend 90cd at 100 mm edge-to-edge distance to the headlight. The dimming of the additional lights when the indicators are in use and the different setting for night-time use are technically feasible but will require further support from research that also addresses a wider range of lighting conditions than those used in the experiments here.

The final result of significance is that which shows the beneficial effect of ‘priming’ car drivers to actively look for PTWs in the traffic scene. The result supports recent initiatives such as the ‘THINK’ campaigns.