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Judgments of approach speed for motorcycles across different lighting levels and the effect of an improved tri-headlight configuration

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ABSTRACT

The misperception of vehicle approach speed is a key contributory factor to road traffic crash involvement. Past research has indicated that individuals use the rate of visual looming to calculate the time to passage (TTP) of a vehicle, and that smaller vehicles loom to a lesser extent than larger vehicles. Despite a disproportionate number of fatal injuries occurring on the road after dark, and a higher than average number of accidents involving automobile drivers violating the right of way of a motorcyclist occurring in low light conditions, there has been very little consideration of the accuracy of TTP for smaller and larger vehicles under low levels of luminance. We investigated drivers' judgments of motorcycle and car approach speeds across a number of levels of luminance within a virtual city scene, as well as the effectiveness of a tri-headlight formation on motorcycle speed judgments. The accuracy of car approach speed judgments were not affected by changes in lighting conditions, but speed judgments for the solo headlight motorcycle became significantly less accurate as lighting reduced in the early night and night-time conditions. Incorporation of a tri-headlight formation onto the standard motorcycle frame resulted in improved accuracy of approach speed judgments, relative to the solo headlight motorcycle, as ambient light levels reduced. The practical implications of the findings are discussed in terms of road safety and motorcycle design.

1. Introduction

The misperception of vehicle approach speed is a key contributory factor to road traffic crash involvement (Hurt et al., 1981; Pai et al., 2009; Peek-Asa and Kraus, 1996; Brenac et al., 2006; Department for Transport, 2010a). For example, the risk of collision is increased if an observer underestimates the distance and speed of an oncoming vehicle, as the vehicle will be perceived as reaching them later than it actually would, thus leaving less time available to perform a manoeuvre such as pulling out from a junction. Furthermore, perceptual limitations in judgments of vehicle approach may be compounded in lower light conditions. Indeed, a disproportionate number of fatal injuries occur on the roads after dark (Pai et al., 2009; Plainis et al., 2006). According to the Community database on Accidents on the Roads in Europe (CARE), while the number of drivers on the road during low level lighting conditions is far fewer than during daylight hours, statistics indicate that approximately 50% of all fatal accidents occur between the hours of 6 pm and 6 am (ERSO, 2008).

Research has provided a substantial amount of evidence to suggest that drivers are less capable of avoiding collisions under reduced lighting conditions compared with daylight conditions, and accidents involving pedestrians (Sullivan and Flannagan, 2002) and rear-end collisions with other motor vehicles (Sullivan and Flannagan, 2003) are particularly prevalent. Consequently, there is little disagreement that driver vision in the dark is seriously impaired when compared with daylight conditions (Sullivan et al., 2004). Very little research, however, has focussed on the perception of vehicle approach under low light conditions.

Gauging the time-to-passage (TTP) of an oncoming vehicle has traditionally been expressed as a ratio of the vehicle's distance (z) and speed of approach (v) for a given period of time (t). However, estimating metric properties such as relative distance is problematic as judgments can be biased by other cues such as the vehicle's height in the scene (see Wann et al., 2011 for further discussion). A more reliable indicator of relative distance and speed is the vehicle's optical size $\theta(t)$ divided by its rate of expansion $\dot{\theta}(t)$ (Lee, 1976):

$$\mathrm{TTP} = \frac{z(t)}{v(t)} = \frac{\theta(t)}{\dot{\theta}(t)} \tag{1}$$

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