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Young drivers' perception of adult and child pedestrians in potential street-crossing situations

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ABSTRACT

Despite overall improvements in road traffic safety, pedestrian accidents continue to be a serious public health problem. Due to lack of experience, limited cognitive and motoric skills, and smaller size, children have a higher injury risk as pedestrians than adults. To what extent drivers adjust their driving behaviour to children's higher vulnerability is largely unknown. To determine whether young male drivers' behaviour and scanning pattern differs when approaching a child and an adult pedestrian in a potential street-crossing situation, sixty-five young (18–24) male drivers' speed, lateral position and eye movements were recorded in a driving simulator. Results showed that fewer drivers responded by slowing down and that drivers had a higher driving speed when approaching a child pedestrian, although the time of the first fixation on both types of pedestrians was the same. However, drivers drove farther away from a child than an adult pedestrian. Additionally, fewer drivers who did not slow down fixated on the speedometer while approaching the child pedestrian. The results show that young drivers behave differently when approaching a child and an adult pedestrian, though not in a way that appropriately accounts for the limitations of a child pedestrian. A better understanding of how drivers respond to different types of pedestrians and why could contribute to the development of pedestrian detection and emergency braking systems.

1. Introduction

Pedestrian fatalities make up an essential proportion of the overall number of road traffic deaths and thus require attention. Internationally, the number of fatalities has substantially decreased over the past decade, but less among pedestrians compared to drivers. From 2000 to 2013, fatalities among drivers decreased by 54% while pedestrian fatalities decreased by 36% (OECD/IFT, 2015). Moreover, indications of an increasing number of fatalities among vulnerable road users exist (OECD/IFT, 2015), and pedestrian accident injuries continue to be a serious road safety problem.

In 2015 more than one-fifth (21%) of children up to 14 years of age killed in traffic crashes were pedestrians (National Center for Statistics and Analysis, 2017). Therefore, research to support the development of targeted interventions aimed at young pedestrians is required.

Previous studies have aimed at identifying factors of child pedestrian risk. For instance, in relation to the most common road traffic accident situation among children, unsafe street crossing, studies show that advanced perceptual and cognitive skills are needed (Schwebel et al., 2012). Research shows that young children have lower hazard perception skills than adults (Meyer et al., 2014) and are more prone to impulsive actions in traffic (Briem and Bengtsson, 2000). Children have difficulty assessing a car's approaching speed and therefore interpret distance between themselves and a car as greater than it actually is (Connelly et al., 1998). Further, even if children may choose the same gap size for crossing the street, their risk of accident involvement is increased as they delay the start of the crossing, thereby reducing the available time to cross the street safely (e.g. Pitcairn and Edlmann, 2000). As can be seen, previous studies have successfully identified cognitive immaturity, lack of perceptual and motor abilities, and inexperience as factors contributing to the risk of accident involvement among child pedestrians. However, with regard to child pedestrian accidents, research has mainly focussed on the behaviour and skills of the child (Hamed, 2001; Jager et al., 2015; Schwebel et al., 2012; Zito et al., 2015), whereas the role of the driver – including driver errors and flaws in perceptual and motor processes – remains rather unexplored (Poschadel, 2006; Stewart et al., 1993). However, because of children's limited cognitive and motoric skills, knowledge of driver behaviour in relation to child pedestrians and driver awareness of the need for increased safety margins in relation to child pedestrians is highly relevant.

Additional emphasis has been placed on examining the role of the

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built environment and other infrastructural factors (Bennet and Yiannakoulias, 2015; Cloutier et al., 2017; Rothman, 2014) as they have been found related to accident risk: the risk of a pedestrian accident is higher, for example, in urban than in rural areas (National Center for Statistics and Analysis, 2017). Moreover, 72% of pedestrian fatalities occur in non-intersection locations, where there are no traffic controls (National Center for Statistics and Analysis, 2017); roads are wide, encouraging higher speeds; and parking is permitted, preventing drivers from detecting children from behind parked vehicles (Schieber and Vegega, 2002). Even though young children more often than older children and adults become victims in accidents with parked cars, as they are then not visible to the driver and cannot see the approaching vehicle themselves, situations with visible children crossing the street are among the most frequent accident situations among children 14 years of age or younger (Poschadel, 2006). In these situations, the driver clearly has the opportunity to detect the child and to react by speed adjustment. Why, in case of accidents, this did not happen often remains unclear.

One potential reason is that the distance to a pedestrian is mainly estimated based on reference size, so drivers often falsely perceive that children are farther away than they actually are, overestimating the time-to-collision (Stewart et al., 1993). This factor is less relevant where other cars are present that can serve as a reference to the size of the pedestrian. Therefore, there is a necessity to understand driving behaviour in situations of approaching pedestrians where other vehicles are present (and are not hiding the pedestrian). While studies show that drivers make inadequate speed and lateral position adjustments when passing child pedestrian on the roadside (Thompson et al., 1985), it remains unclear if this is a problem particularly related to child pedestrians or of similar relevance for adult pedestrians.

Driver characteristics also contribute to child pedestrian injuries (Stewart et al., 1993; Thompson et al., 1985). Specifically, young male drivers are more likely to be involved in accidents with child pedestrians (Thompson et al., 1985), which may be related to their lower hazard perception skills (e.g. Borowsky et al., 2007) and higher risk acceptance (e.g. Clarke et al., 2005; Williams, 2003).

Due to limited cognitive skills, children are more unpredictable in road-crossing situations but, so far, it is not clear whether young drivers are considering any differences when encountering child or adult pedestrians on the road. Based on the above, this study aims to determine whether driving behaviour and scanning patterns among young male drivers are different when approaching a child versus an adult pedestrian.

When deciding on methods and measures to use in research on drivers' behaviour in pedestrian crossing situations, one must balance the goal of testing drivers in realistic and controllable traffic with the ability to keep them safe. The driving simulator meets these conditions. Even though behavioural data can give an indication of how pedestrians are perceived and responded to, eye movement data provide a more profound insight into the detection of pedestrians. The visual skills required for safe driving are gained with practice (e.g. Borowsky et al., 2007; Chapman and Underwood, 1998; Konstantopoulos et al., 2010; Underwood et al., 2002). Experienced drivers detect hazards earlier (e.g. Deery, 1999), while novice drivers have longer (e.g. Chapman and Underwood, 1998) and fewer (Pradhan et al., 2007) fixations on hazards, representing a slower processing speed.

Recently, cars have become increasingly well-equipped with technical systems to warn the driver of hazards and automated braking systems to prevent crashes with pedestrians (Coelingh et al., 2010; Rosén et al., 2010). However, one of the major challenges of these systems is to balance their performance against the possibility of unwanted system activation (Lubbe and Davidsson, 2015). Therefore, they still need to be optimised to provide drivers with feelings of comfort and involvement in the driving activity. Gaining more insight into how drivers respond and scan for pedestrians, not only of varying physical aspects but also of different predictability, could help in the development of more sensitive and smoother performance of these technical systems.

To increase the understanding of the role of drivers in situations with child pedestrians, this study compared young male drivers' detection of child and adult pedestrians with and without parked cars partly obstructing the view of the driver. We simulated potential pedestrian crossing situations to examine the driving performance and eye movements of drivers. We expected that drivers would adjust their driving performance more when a child than when an adult pedestrian was present (i.e. by lowering driving speed and/or driving farther away from the pedestrian).

2. Method

2.1. Participants

Sixty-five male drivers between 18 and 24 years of age (M = 21.91, SD = 1.48) participated in the experiment. All participants had self-reported normal or corrected-to-normal vision and had valid drivers' licences for between 0.5–6 years (M = 3.82, SD = 1.35). They were recruited among university students, and each received a gift card (worth 30 Euros) or credit points for participation.

2.2. Apparatus

A fixed-based medium-fidelity driving simulator equipped with the necessary vehicle control systems and 3D sound system (5.1-channel) was used to conduct the experiment. On three plasma displays (size: 42″; the front screen resolution: 1920 × 1080 dpi, the side screens' resolution: 1360 × 768 dpi, 150° horizontal and 40° vertical perspective) scenarios were presented at a rate of 60 frames per second. Speedometer, rear- and side-view mirror information was visible on the centre and side screens. The real-time simulation and scenarios were developed with SCANeR Studio (OKTAL) software.

Eye movements were recorded with Tobii Pro Glasses 2 eye tracker (a sampling frequency of 50 Hz). Tobii I-VT Fixation Filter (minimum fixation duration = 60 ms, velocity threshold = 30°/s, and max angle between fixations = 0.5°) fixation classification algorithm was used (Tobii Technology, 2012).

2.3. Scenarios

The driving environment was designed to match the typical urban setting of a Danish urban street with speed limit of 50 hm/h and contained buildings, parked cars and street furniture. The drive was three kilometres long and included six pedestrian-related hazard situations. The participants encountered each situation in two conditions, hidden and visible, and with two types of pedestrians, adult and child, 24 situations altogether.

The present study analysed each participant's driving behaviour and eye movements in one of the six hazard situations, both with an adult pedestrian and with a child pedestrian in the visible and hidden condition. The selected situation was a potential street-crossing situation and was chosen as it is the most common accident situation among child pedestrians in Denmark. In the situation, a pedestrian (adult or child, see Fig. 1) was standing on the pavement on the left side of the street. Children were dressed in clothes in bright colours, while adults were wearing grey clothes to make differences of pedestrian types more noticeable and realistic.

Fifty meters before the participant reached the pedestrian, the pedestrian ran towards a ball lying at the opposite side of the street, thereby indicating to the participant that the pedestrian might cross the street. The pedestrian entered the street, but stopped after two meters without entering the path of the driver. In the visible condition, the driver could see the pedestrian the whole time (Fig. 2a). In the hidden condition, the running pedestrian disappeared behind a parked car and