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Do cyclists make better drivers? Associations between cycling experience and change detection in road scenes

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ABSTRACT

Efficient processing of visual information is crucial to safe driving. Previous research has demonstrated that driving experience strongly affects attentional allocation, with large differences between novice and experienced drivers. Expanding on this, we explored the influence of non-driving experiences on attentional allocation by comparing drivers with and without cycling experience. Based on situation awareness field studies, we predicted cyclist-drivers would demonstrate superior performance. Participants were 42 experienced drivers (17 female, 25 male) aged 30–50 years (M = 39.8): 20 drivers and 22 cyclist-drivers. The experiment used a change detection flicker task, in which participants must determine whether two alternating images are identical (change-absent) or differ in a single detail (change-present). The changed object was either a road sign, car, pedestrian, or bicycle. Change target significantly affected both accuracy and response time: all participants were slower and less accurate at detecting changes to road signs, compared with when the change was a moving road user (i.e., car, pedestrian, bicycle). Accuracy did not differ significantly between groups, but cyclist-drivers were significantly faster than drivers at identifying changes, with the effect being largest for bicycle and sign changes. The results suggest that cycling experience is associated with more efficient attentional processing for road scenes.

1. Introduction

Driving is a visually demanding task (Lee, 2005; Sivak, 1996). In order to drive safely we must efficiently process a range of visual cues, which alert us to attributes such as where we need to go, how fast we should travel, and whether hazards are present. Failure to search for and/or detect hazards has been identified as a contributing factor in 9–12% of serious injury crashes (Beanland et al., 2013) and hazard perception ability is negatively correlated with crash involvement (Boufous et al., 2011; Horswill et al., 2010, 2015). As such, it is vital to identify factors that are associated with superior processing of visual information when driving.

There is considerable evidence demonstrating that our experiences and pre-existing knowledge shape the way we process visual information. Even under basic experimental conditions, visual search performance in a given trial is likely to be influenced by experience on previous trials (Chun and Jiang, 1998; Chun and Wolfe, 1996). Within the driving context, research findings from a diverse range of methods, from naturalistic field observations to controlled laboratory experiments, have supported the notion that drivers' schema (i.e., mental models of the world) shape what they search for and notice, and ultimately how they interact with others on the road (Bellet et al., 2009). These schema are formed iteratively through experience: situations we have encountered in the past determine what we expect to see and therefore what we will look for, which in turn influences the information we pick up, which is then fed back to update relevant schema (Neisser, 1976).

Research examining the effects of experience on visual information processing has predominantly focused on comparing novice drivers (i.e., < 2–3 years' driving experience) with more experienced drivers (Underwood, 2007). Novice drivers primarily focus on the road directly in front of their vehicle, whereas experienced drivers demonstrate more extensive horizontal scanning and better adapt their scanning strategies when the environment changes (Chapman and Underwood, 1998; Crundall et al., 2003; Falkmer and Gregersen, 2005; Underwood, 2007; Underwood et al., 2002). Consequently, novice drivers are less likely to notice peripheral events, such as vehicles approaching an intersection (Underwood et al., 2003). Similarly, a recent study found that frequent cyclists anticipate and detect more hazards than infrequent cyclists when viewing videos of bicycle paths and sidewalks (Lehtonen et al.,

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2016); however, the same study found that frequent cyclists rode at faster speeds, meaning they may genuinely encounter more hazards (i.e., it is more dangerous if a pedestrian suddenly steps out in front of a bicycle that is travelling faster vs. slower).

Differences between novice and experienced drivers have been observed during passive viewing of traffic scenes (Underwood et al., 2002), driving-related video games (Ciceri and Ruscio, 2014) and real driving (Crundall and Underwood, 1998; Falkmer and Gregersen, 2005). This suggests differences between novice and experienced drivers are not simply the result of novices finding the driving task more demanding; rather, it implies accumulated driving experience fundamentally alters the manner in which drivers allocate their visual attention.

Although there is considerable evidence exploring how one's *level* of experience influences visual attention, there is relatively little research examining whether relevant *cross-modal* experiences also play a role. All drivers experience the road using other transport modes, such as walking, cycling or motorcycling. Several recent studies have compared real-world behavior of drivers, pedestrians, cyclists and motorcyclists, and have demonstrated fundamental differences in how and where road users allocate their attention (e.g., Salmon et al., 2013, 2014; Walker et al., 2011). When negotiating an urban intersection, for example, car drivers mostly focus on traffic lights and areas where other cars might appear, whereas motorcyclists search for a broader range of potential hazards, and cyclists focus on seeking safe travel routes (Salmon et al., 2013, 2014). These studies were undertaken in the field, while participants were using the specified transport mode, which meant participants in different modalities experienced varying goals and task demands that influenced their behavior (Cornelissen et al., 2012, 2013; Salmon et al., 2013, 2014; Walker et al., 2011). This raises the question of whether differences in attentional allocation between road users persist when they are given identical tasks. If this were the case, then experience using multiple transportation modes could potentially improve hazard perception. Previous research has revealed that drivers' tendency to focus on searching for other cars can lead them to overlook other hazards, such as cyclists (Summala et al., 1996), highlighting the need to broaden drivers' expectations of what they will encounter on the road.

One experimental method that can be used to explore attentional allocation is change detection paradigms, in which observers must report whether two temporally-separated displays are identical or different. If visual input is interrupted during the change period, then the observer may experience *change blindness* and fail to detect the change (Rensink et al., 1997). Visual interruptions can result from an eye blink or saccade (Grimes, 1996; O'Regan et al., 2000; Velichkovsky et al., 2002), or from an artificial disruption such as a blank screen or scene cut (Rensink et al., 1997; Simons and Levin, 1997; Velichkovsky et al., 2002), occlusion of the change target (Simons and Levin, 1998), or occlusion of nearby regions (Bahrami, 2003; O'Regan et al., 1999). Change blindness is strongly influenced by top-down processes: observers are more likely to detect changes to objects that have greater task relevance (Galpin et al., 2009; Lee et al., 2007; Pearson and Schaefer, 2005; Shinoda et al., 2001; Velichkovsky et al., 2002), personal relevance (Jones et al., 2003; Humphreys et al., 2005; Marchetti et al., 2006), or are central to understanding the scene (Rensink et al., 1997). Observers with domain expertise are more efficient than domain-novices at detecting changes, but only when the changes are relevant to their expertise (Feil and Mestre, 2010; Reingold et al., 2001; Werner and Thies, 2000). In contrast, bottom-up salience and physical size do not influence change detection in real-world contexts, including driving-related tasks (Caird et al., 2005; Mueller and Trick, 2013; Richard et al., 2002; Stirk and Underwood, 2007).

Change detection paradigms have demonstrated utility for revealing which aspects of the scene attract drivers' attention. Drivers are more efficient at detecting changes with greater safety relevance, such as vehicles changing position, compared with changes that have less safety relevance or changes that are irrelevant to driving (Beanland et al., 2017; Galpin et al., 2009; Lee et al., 2007; Mueller and Trick, 2013; Shinoda et al., 2001; Zhao et al., 2014). Drivers are comparatively poor at detecting changes to road signs (Beanland et al., 2017; Metz and Krüger, 2014) and increasing familiarity with the driving route further exacerbates change blindness to road signs (Charlton and Starkey, 2011, 2013; Harms and Brookhuis, 2016; Martens, 2011; Martens and Fox, 2007). Research examining change blindness during simulated driving has found a correlation with safe decision-making: drivers who accurately detect changes are more likely to make safe decisions at road intersections (Caird et al., 2005).

Building on previous research, the current study used a driving-related change detection task to explore the effect of cycling experience on drivers' attentional allocation. All participants were experienced drivers, but half also cycled regularly on public roads. Past research has found that drivers who also hold a motorcycle license are more efficient at detecting and responding to motorcycles (Crundall et al., 2012) and less likely to collide with motorcycles when driving a car (Magazzù et al., 2006), compared with drivers who hold only a car license. These studies demonstrate multi-modal experience can benefit aspects of hazard perception directly related to the other transport mode. Similarly, cyclist-drivers self-reported safer driving behavior around cyclists, compared with drivers who never or rarely ride a bicycle; however, these behavioral differences could be attributable to the fact that cyclist-drivers hold more positive attitudes towards cyclists (Johnson et al., 2014). The current study therefore assessed whether cyclist-drivers differ from non-cycling drivers in terms of their attentional allocation, and whether any observed differences are mode-specific (i.e., an attentional bias towards other cyclists) or more general (i.e., generic hazard perception benefits arising from multi-modal experience).

We systematically manipulated the change target so that it was either a road sign, car, pedestrian, or bicycle. This allowed us to compare both overall driving-related change detection ability and ability to detect specific targets between drivers and cyclist-drivers. If cyclist-drivers experience similar multi-modal benefits to motorcyclist-drivers, then cyclist-drivers should be more efficient at change detection when the change target is a bicycle rider. This result would be consistent with change blindness research on expertise and personal relevance (e.g., Feil and Mestre, 2010; Jones et al., 2003; Marchetti et al., 2006; Reingold et al., 2001; Werner and Thies, 2000). In other words, target-specific effects would show simply that cycling experience makes drivers more attentive to bicycles, just as motorcycling experience makes drivers more attentive to motorcycles. If the effects generalize more broadly then we would predict an overall effect whereby cyclist-drivers are more efficient at change detection than drivers without cycling experience, which would imply that cycling experience helps drivers develop better situation awareness in general, consistent with findings from field studies which suggest that travelling in different transport modes differentially develops situation awareness (Salmon et al., 2013, 2014; Walker et al., 2011).

2. Method

2.1. Participants

Forty-two fully-licensed drivers (17 female, 25 male) aged 30–50 years (M = 39.8, SD = 5.3) provided written informed consent and were offered AUD$10 compensation. All drove at least weekly and had normal or corrected-to-normal visual acuity as measured using a near vision chart. Twenty-two participants were *cyclist-drivers* who rode a bicycle on public roads at least weekly, and twenty were *drivers* who did not use any other road vehicles (e.g., bicycles or powered two-wheelers). Participants in the cyclist-driver group were recruited through ads seeking individuals who regularly used both road bicycles and cars, whereas participants in the driver group were recruited for a "driver attention study" and were asked to report which transport