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Driving on urban roads: How we come to expect the 'correct' speed

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ABSTRACT

The subjective categories that drivers use to distinguish between different road types have been shown to influence the speeds they choose to drive but as yet we do not understand the road features that drivers use to make their discriminations. To better understand how drivers describe and categorise the roads they drive, 55 participants were recruited to drive a video of familiar urban roads in a driving simulator at the speed they would drive these roads in their own cars (using the accelerator and brake pedal in the driving simulator to adjust their speed). The participants were then asked to sort photos of the roads they had just driven into piles so that their driving would be the same on all roads in one pile but different to the other piles. Finally, they answered a series of questions about each road to indicate what speed they would drive, the safe speed for the road, their speed limit belief as well as providing ratings of comfort, difficulty and familiarity. Overall, drivers' categorisation of roads was informed by a number of factors including speed limit belief, road features and markings (including medians), road width, and presence of houses, driveways and footpaths. The participants' categories were congruent with what they thought the speed limits were, but not necessarily the actual speed limits. Mismatches between actual speed limits and speed limit beliefs appeared to result from category-level expectations about speed limits that took precedence over recent experience in the simulator. Roads that historically had a 50 km/h speed limit but had been reduced to 40 km/h were still regarded as 50 km/h roads by the participants, underscoring the point that simply posting a sign with a lower speed limit is not enough to overcome drivers' expectations and habits associated with the visual appearance of a road. The findings provided insights into how drivers view and categorise roads, and identify specific areas that could be used to improve speed limit credibility.

1. Research aims

Previous research has suggested that drivers develop mental representations of road types that guide their expectations regarding the characteristics of the roads they are driving on, including the appropriate speed. In this context, it has been argued that when these expectations are inconsistent with the official road category or speed designation, drivers will be more inclined to choose their own preferred speed, leading to greater speed variation and potential for conflict among road users. Although there have been experiments with findings supporting this argument, nearly all of them have examined drivers' speed choices based on ratings and judgements of still photographs rather than moment-to-moment speeds selected while driving. The aims of the present experiment were first to examine the correspondence between the subjective categories that drivers apply to roads and the official road categories determined by the road controlling authority. A second aim was to determine the speed limit beliefs and speed choices associated with drivers' subjective categories and the road characteristics that drivers use to differentiate those categories.

2. Introduction

Speed choice plays an important role in road safety because inappropriately high speeds have been associated with increased risk of crashes and higher severity of injuries associated with crashes (Aarts and Van Schagen, 2006; Elvik, 2013). Unfortunately, exceeding speed limits is common; across all road types 40–50% of drivers speed to some degree (OECD/ECMT, 2006). Drivers choose their speed moment to moment, and the speed they choose appears to be a consequence of several interacting factors including the look and feel of the road and roadside, the purpose of their trip, their momentary perception of risk, expectations and habits formed from prior experience, and simple preference (Ahie et al., 2015).

Ahie et al. (2015) interviewed 193 drivers about their speeds on the roads they had just travelled and found a high degree of variability in drivers' preferred speeds, with some drivers reporting that their usual

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speeds were more than 10% above what they believed the speed limit to be, and other drivers reporting that their usual speeds were at least 10% lower than their speed limit belief. Such wide variability in speed choices has negative consequences, including increased travel times and a higher likelihood of dangerous driving manoeuvres (such as overtaking and tailgating). The drivers' speed choices were highly influenced by the speeds they usually drove, more so than their beliefs regarding what constituted a safe speed for a particular road.

It appears that a driver's momentary choice of speed is often based on habit rather than resulting from an explicit decision (Charlton and Starkey, 2013, 2017). These habitual speed choices may be an inevitable consequence of repeated exposure to particular road and traffic conditions that result in the formation of schemata containing proceduralised or automatic ways of perceiving and driving on familiar roads and road environments (Charlton and Starkey, 2013; Groeger, 1999; Theeuwes and Godthelp, 1995). Understanding how these schemata are organised and what they contain offers us an opportunity to create roads with credible speed limits, where drivers' expectations on the road lead to speed choices that more closely match the posted speed limits (Goldenbeld and van Schagen, 2007).

In an early attempt at revealing the structure of drivers' schemata for roads, Gundy (1994) conducted a series of studies in which participants were asked to sort photographs of rural roads into piles of similar roads, label the piles, and estimate a safe driving speed for the roads. The results of the sorting task were used to identify homogeneous road categories using Multi-Dimensional Scaling (MDS). The results indicated that the road categories were differentiated by the width of the carriageway and the presence of intersections or curves. The results also indicated that these subjective road groupings were quite different from the official road categories based on engineering and regulatory definitions.

Kaptein and Claessens (1998) used a similar picture sorting task (using computer generated images of prototypical roads with no sharp curves) and MDS and hierarchical cluster analysis and found that participants' subjective categories of roads correctly reflected the road classifications if they were designed according to self-explaining roads (SER) principles rather that the mixed design methods typically used. More recently, Stelling-Konczak et al. (2011) found that participants readily discriminated between different types of rural roads (and identified the correct speed limits) when those roads were consistently delineated using the presence/absence of edge-lines, coloured median treatments, and physical separation between lanes.

Applying a somewhat different experimental technique (the Repertory Grid Technique), Riemersma (1988) obtained similar results with factor analysis, MDS, and hierarchical clustering analyses indicating that drivers did form differentiated road categories, categories that were more often based on the physical characteristics of the roads rather than the official road categories. Weller et al. (2008) conducted a study in which participants were asked to rate 21 photographs of rural roads across a range of attributes. Factor analysis of the ratings indicated that participants' ratings could be characterised in terms of three factors: monotony, comfort, and demand. Based on these factors, the researchers found that rural roads could be clustered into three broad types based on lane width, road surface, curvature (and hence forward sight distance), and presence of a marked centre line. Interestingly, roads with high factor values for comfort and monotony also resulted in judgements of faster speeds as being appropriate for those roads.

Recently, we found that drivers categorised familiar rural roads according to a few geometric features that were associated with participants' subsequent ratings of driving difficulty and comfort for the roads individually (Charlton and Starkey, 2017). Similar to findings of some of the previous studies, the participants differentiated the roads based on features such as curves, intersections, lane separation, and road width. Importantly, the road categories identified by the participants showed significant differences in the participants' subsequent judgements of the speed they would choose to drive on each road and what they thought was a safe speed for each road. Although the familiar rural roads included a broad range of road types and situations, visually they were relatively undifferentiated as regards to road markings and other forms of formal delineation (as is typical in rural New Zealand). Nonetheless, the participants sorted them into distinct and non-overlapping categories, categories that correctly predicted significant differences in subsequent judgements about speed, difficulty, physical comfort, and safety. We concluded that the participants' based their categorisations on their experience with the roads and that the categories reflected underlying mental representations or schemata for these familiar roads based on the type of driving required for each.

The goal of many of the earlier studies was to determine how well participants' road categorisations corresponded to official road classifications or proposed design and delineation schemes. It has been argued that when drivers' expectations regarding the characteristics of a road (including appropriate speed) are inconsistent with the official category or road designation, drivers will be more inclined to choose their own preferred speed, leading to greater speed variation and potential for conflict among road users (Ahie et al., 2015; Goldenbeld and van Schagen, 2007; Kosztolanyi-Ivan et al., 2016a,b). However, in these experiments participants' speed choices have been collected from ratings and judgements of still photographs rather than the actual moment-to-moment speeds selected while driving on these roads.

Because choosing speeds based on static images is not the same as choosing speeds while moving, the approach of the present research was to have participants "drive" video images of familiar urban roads in a driving simulator, followed by picture sort and rating tasks to support the identification of drivers' subjective categories for these roads. The urban roads chosen as stimuli were selected from six categories comprising the One Network Road Classification (ONRC) system (NZTA, 2013). The ONRC divides roads into six types (National, Arterial, Regional, Primary collector, Secondary Collector and Access), based on traffic and freight volumes, numbers of pedestrians and cyclists, destination, and availability of alternate routes.

The goals of the present experiment were first to examine the correspondence between the subjective categories that drivers apply to roads and the official road categories determined by the road controlling authority. Second, we wanted to determine the speed limit beliefs and speed choices associated with drivers' subjective categories and the road characteristics that drivers use to differentiate those categories. To accomplish these goals we measured drivers' speed choices in the simulator, their speed limit beliefs and judgements of the safe speeds, comfort, and driving difficulty familiarity, as well as analysing their categorisation of familiar roads and conducting focus group discussions about the categories.

3. Method

3.1. Participants

Fifty-five individuals with a full New Zealand driver's license completed the study (28 males, 27 females) with a mean age of 35.49 years (*SD* = 13.33, range 18–59 years). Participants reported having their driver's license for a period of 17.76 years (*SD* = 12.94, range 1–42 years). The participants reported driving on average 180.65 km per week (*SD* = 186.63, range 5–1000 km per week). In terms of driving history, 25 participants reported being involved in a crash at some point during their driving history; of these, 12 reported being involved in 1 crash, 7 reported being in 2 crashes and 5 people reported being in 3 or more crashes. All participants were asked if they would be willing to be contacted about a follow up focus group. Of those who expressed interest in participating in the focus groups 13 participants (7 female, 6 male) were randomly selected and invited to participate in one of three focus group sessions approximately a month after completion of the first part of the study.

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