PREDICTABILITY AND CREDIBILITY OF SPEED LIMITS

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The NZ Transport Agency

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Glossary of terms

CLoS	Customer Levels of Service
ECMT	
IRR	Infrastructure risk rating
KiwiRAP	The New Zealand joint agency Road Assessment Programme
MDS	multi-dimensional scaling
NZTA	NZ Transport Agency
Observed speed limit credibility	Calculated as the posted speed limit – speed driven in the simulator
OECD	Organisation for Economic Co-operation and Development
ONRC	One Network Road Classification
RPS	road protection scores
Safe and appropriate speed	determined by NZTA speed management tool
Safe speed	participants' perception of a safe speed to drive (from the road rating booklet)
Simulator speed	the speed participants chose to drive in the simulator
Speed choice	the speed participants' would choose to drive (from the road rating booklet)
Speed limit belief	participants' belief of the posted speed limit (for the roads in the booklet)

Executive Summary

The choice of inappropriate speeds by drivers is one of the oldest and most difficult problems in road safety and exceeding speed limits is common, a survey of OECD and ECMT member countries indicated that overall 40-50% of drivers (up to 80% in some jurisdictions) are driving above the posted speed limits (OECD/ECMT, 2006). One approach to improving drivers' speed choice and increasing safety is to differentiate the road hierarchy to make it clear to drivers what is an appropriate speed for the road. In New Zealand, one recent attempt to identify different categories of roads according to their functions has been the One Network Road Classification system (NZTA, 2013). This system has created six functional categories intended to establish different levels of service, and by implication, safe and appropriate speed ranges for the 94,000 km of roads in New Zealand.

In order for drivers to appreciate the different road functions, however, and differentiate their expectations and speed choices appropriately, the categories should be visually distinguishable. The focus of the present research was to investigate the relationship between the visual appearance of roads from the One Network Road Classification categories and drivers' subjective categorisation and speed choice for those roads. The subjective categories that drivers use to differentiate road types have been shown to influence the speeds they choose to drive but as yet we do not understand the road types that drivers use to differentiate their speeds. Identifying the subjective categories that drivers use, and the visual features they use in categorising roads can help inform road designs such that speed limits are more credible to drivers and safety margins are increased.

The study sought to answer the following research questions:

Question 1 – *How do drivers categorise roads from the ONRC functions?*

Question 2 - *What are drivers speed choices for roads from the ONRC categories?*

Question 3 – *Are there road categorisations or individual properties of roads that lead to better discriminability (speed limit credibility) and higher safety margins?*

To answer these questions, two studies were conducted. In the first study 78 participants were recruited to drive a video of urban roads in our laboratory and indicate what 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 chosen roads contained examples from the six ONRC categories with a range of speed limits (30-80 km/h) and infrastructure risk rating (IRR) categories. To find out how drivers categorise these roads, we asked the participants to complete a picture sort task with photos of the roads they had just driven, sorting them 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 perceived safe speed for the road, what they believed the speed limit to be (speed limit belief) as well as providing ratings of comfort, difficulty and familiarity.

To extend the findings regarding drivers' categorisation of roads and their speed choices, analysis of data from a previously completed study of rural roads was undertaken. In this study, participants (n = 64) completed essentially the same picture sort and rating tasks with photos of 34 rural roads, selected to include a range of road protection scores (RPS) and visual characteristics (intersections, road width, horizontal alignment, and roadside features). The road ratings for this study included the comfort, difficulty, monotony associated with driving each road, as well as the speed they would drive, the safe speed, and their speed limit belief for each road. It should be noted that this study was originally conducted for a different purpose and the roads were not systematically balanced across each ONRC category. Given this, the findings need to be interpreted with some degree of caution

With regards to the first research question (how do drivers categorise roads from the ONRC functions?), there was some degree of overlap between drivers' subjective categorisation of the roads and the ONRC groupings, primarily for the roads with the highest and lowest levels of service (National Strategic roads and Access roads respectively). In contrast, Arterial roads were not recognised as a distinct group or type of road by participants, perhaps partly because these roads have a great variety in function and use (e.g., they may have several urban villages along their length). Arterial roads were grouped with Primary Collectors and Secondary Collectors in the picture sort task, suggesting that drivers find it difficult to distinguish between roads across these categories. This highlights the need to make these roads more visually distinct, even in the context of varied use, to encourage appropriate and consistent driver behaviour.

Drivers did choose different speeds for roads in different ONRC categories – the highest speeds were chosen for National Strategic roads, followed by Arterials, Primary Collectors, Secondary Collectors and Regional roads, and the lowest for Access roads. The speed participants chose to drive was closely related to their belief about the speed limit for the road they were on. Interestingly though, on lower speed roads (less than 50 km/h) drivers would typically choose speed below their speed limit belief, whereas on higher speed roads, they chose speeds higher than their speed limit belief. Speed choices were also related to the objective risk (IRR or RPS) of the road. For urban roads, greater land use and roadside hazards were associated with decreased speeds; on rural roads higher RPS scores were associated with lower speed choices. Thus, drivers' speed choices in urban and rural environments appear to be related to the objective risk of the road.

Of particular concern, however, were roads with low speed limit credibility, where drivers choose speeds substantially higher than the legal speeds (expressed as the speed drivers choose subtracted from the posted speed limit). Notable among these were residential streets (primary collectors, secondary collectors or access roads) that had posted speed limits of 40 km/h that were well marked without additional traffic calming measures, and were very similar in visual appearance to roads with a posted speed limit of 50km/h. Speed limit credibility was also poor for wide roads that had few houses, with good visibility and painted medians. These roads had posted speed limits of 50 km/h but speed choices were up to 80km/h. These findings demonstrate the importance of the posted speed limit matching the visual appearance of the roads, in particular wide roads with extensive markings appear to suggest higher speeds to drivers. This occurrence of higher speeds on roads with more markings has been reported for both urban roads (Charlton et al., 2010) and rural roads (Charlton & Baas, 2006). The reasons for this effect are not certain but it may be because unpainted roads appear narrower to drivers or simply because highly delineated roads are more often associated with higher speed limits. In the present study, drivers were generally accurate with speed limit estimations for residential roads, apart from the lower speed zones (40 km/h), without any other modifications to alter the visual appearance of the roads.

Overall, drivers subjective categorisation of roads was informed by a number of factors including speed limit belief (on the higher speed roads), road features (horizontal alignment), road markings (including medians), width of the road, clear views, and presence of houses, driveways and footpaths. Together these findings provide some clear insights into how drivers view and categorise roads, and indicate specific areas that could be targeted to improve speed limit credibility, in particular highly marked wide roads in urban areas with low levels of adjacent land use appear to signal higher speed limits, and increased residential land use is linked to lower speeds. This could be taken into account when carrying out maintenance on NZ roads to improve the differentiation of the ONRC road hierarchy.

Predictability and Credibility of Speed Limits

1. Background

Speed choice plays a crucial role in road safety as it has been associated with increased risk of crashes and higher severity of injuries associated with crashes (Aarts & van Schagen, 2006; Elvik, 2013). In New Zealand, driving too fast for the conditions was cited as a contributing factor in 31% of all fatal crashes and 21% of serious injuries between the years 2013-2015 (Ministry of Transport, 2016).

Previous research has indicated roads that have high rates of speeding (i.e., drivers who exceed the speed limits) are the most dangerous (Lahausse, van Nes, Fildes, & Keall, 2010). Unfortunately exceeding speed limits is common; across all road types 40-50% of drivers reporting that they drive over the posted speed limit (Goldenbeld & van Schagen, 2007). It has been argued that a major factor in this low rate of compliance is posted speed limits that are not credible to drivers. A credible speed limit is defined as one that matches drivers' expectations as evoked by the road and the traffic situation (Goldenbeld & van Schagen, 2007). If the look and feel of the road does not match drivers' expectations, drivers will be more inclined to choose their own speed, leading to greater speed variation and potential for conflict among road users (e.g., more overtaking).

Drivers choose their speed moment to moment, and the speed they choose appears to be a consequence of a range of interacting factors (conscious and unconscious) that include their momentary perception of risk, the look and feel of the road and roadside environment, expectations and habits formed from prior exposure to similar roads, the purpose of their trip, their implicit perception of speed, and simple preference (Ahie, Charlton & Starkey, 2015). Ahie et al (2015) interviewed 193 drivers about speeds on the roads they had just travelled when driving for different reasons (saving money on fuel, driving safely, driving for fun, driving as usual, and the speed they had just driven). Overall, drivers reported choosing the lowest speeds when driving economically and the highest speeds when driving for fun. Drivers' usual speeds were 2-3 km/h faster than their perceptions of the safe speed. Usual speed was the best predictor of the speed they had just been travelling, suggest that habit plays an important role in drivers' speed choices. Measures of on-road speed, of drivers on the same road across multiple days showed little variation in speed, providing further support for the influence of habitual behaviour in determining speed on familiar roads. There was a high degree of variability in drivers' preferred speeds, with some drivers reporting that their usual speeds were over 10% above their speed limit belief (close to their fun speed; fast movers), and at the opposite end of the spectrum some drivers' (slow movers) usual speeds were over 10% lower than their speed limit belief, and often slower than their reported safe speeds. Such a wide variability in preferred speeds has negative consequences, including increased travel times and a higher likelihood of dangerous driving manoeuvres (such as overtaking and tail gating). These findings highlight the need to explore ways, other than the posting and enforcement of speed limits, to encourage drivers to choose safe, appropriate and homogenous speeds.

To explore factors influencing drivers' speeds on rural roads, 574 drivers were given a series of photographs of 80 km/h roads and asked to rate both the speed they would prefer to drive there and what they would consider a safe speed limit (Goldenbeld & van Schagen, 2007). The drivers had not been informed of the actual speed limit and their answers showed large differences between preferred speeds and safe speeds for some roads but not others. The size of the difference between the preferred speed or safe limit and the actual limit was taken as indication of the credibility of the speed limit for each road. The finding that these differences existed for some 80 km/h roads but not others showed that the credibility of the speed limit for a rural road is influenced by specific features of the road and the environment. The researchers concluded that this means that it is possible to improve the credibility of the speed limit by either modifying the look and feel of the road or better tuning of the speed limit to the road environment.

In another recent study of how features of the road environment that contribute to speed choice, 29 drivers were presented with a series of photographs of roads with speed limits from 40 km/h to 110 km/h from highways around Malaysia, with the actual speed limit erased from the sign (Lee, Chong, Goonting & Sheppard, 2017). Participants were asked to indicate the 'appropriate' speed for each road. Overall, the average appropriate speed was significantly higher than the average speed limit of the roads, but this differed depending on the actual speed limit of the road. For roads with 40, 50, 70 and 80 km/h speed limits, the appropriate speeds reported by participants were significantly higher compared with the speed limit. There was no significant difference between participants' choice of appropriate speed and the posted speed limit for 90 km/h roads, but for roads with a speed limit of 110 km/h the appropriate speed was judged to be significantly lower (88.76 km/h). Photos of narrower roads, curves, roads with decreased line of sight, fewer lanes, intersections and the presence of street lighting resulted in significantly lower judgements of an appropriate speed.

The presence of buildings, trees, vegetation and amount of traffic did not appear to alter drivers' judgements of appropriate speeds. These researchers also reported that speed limits closer to drivers' judgements of an appropriate speed for a road were likely to result in better credibility. These findings suggest that both the speed limit and road features contribute to drivers' judgements of appropriate speed, and drivers are unlikely to comply with posted speed limits that dramatically differ from this.

One method of promoting speed choices that are both safe and consistent across drivers is the articulation of a road hierarchy with readily visible differences between different road types and speed limits. The clear and consistent signalling of different road types (and associated speed limits) through road and roadside design helps to establish mental representations (called schemata) and expectations leading to correct driver behaviour (Theewes & Godthelp, 1992). These schemata then afford correct behaviour automatically, even when drivers are not paying attention (Charlton et al., 2010). In an experiment in which the features of urban roads were systematically altered to make roads of two different types more visually distinguishable, we were able to improve the consistency of drivers' speed choices significantly and produce a 30% reduction in crashes and a 86% reduction in crash costs over a five-year period (Charlton et al., 2010; Mackie, Charlton, Baas, & Villasenor, 2013). Part of the reason for the safety increase of the self-explaining roads treatments was due to the greater speed homogeneity, which has long been known to lower the risk and severity of crashes (van Nes, Brandenburg & Twisk, 2010). Making roads with different functions appear visually distinct to drivers is a key component to producing both homogenous speeds and credible speed limits (Goldenbeld & van Schagen, 2007).

New Zealand has recently adopted the One Network Road Classification (ONRC) system to categorise roads according to their function (NZTA, 2013). The ONRC divides roads into six main categories (National (including high volume sub-category), Arterial, Regional, Primary collector, Secondary Collector and Access (including low volume access sub-category), based on traffic and freight volumes, numbers of pedestrians and cyclists, destination, and availability of alternate routes. As shown in Figure 1, national routes link main population centres and transport hubs (e.g., ferry terminals, airports), arterial roads link regionally significant locations and industries, regional roads provide links within and between regions, primary collectors link local populations and industries, secondary collectors link local areas of population (and may be the only route to some places), and access roads are typically smaller roads often used on journeys to and from home (NZTA, 2013). The ONRC classification allows comparisons to be made across roads of a similar type throughout the country as well as informing investment decisions to ensure that road maintenance and improvement is targeted appropriately. The classification system takes into account the needs of all road users, but is predominantly focused on traffic volumes; infrastructure and road design features are not taken into consideration. Roads within each ONRC category are maintained to a specific Customer Level of Service (CLoS), which includes Mobility (travel time reliability, resilience of the route), Safety (including Kiwirap and IRR scores), Amenity (travel quality and aesthetics) and accessibility (land access and road network connectivity). Higher levels of CLoS are defined for roads with the highest traffic volumes, for example, National high volume routes should have the highest KiwiRap star ratings (5*) and/or the lowest IRR scores. Over time, with consistent investment and adherence to defined customer levels of service for each ONRC group, the look and feel of the roads within each group should become more consistent, which will help drivers recognise the type of road they are on, the appropriate speed to drive and the types of traffic they are likely to encounter, on all roads whether local roads or state highways.

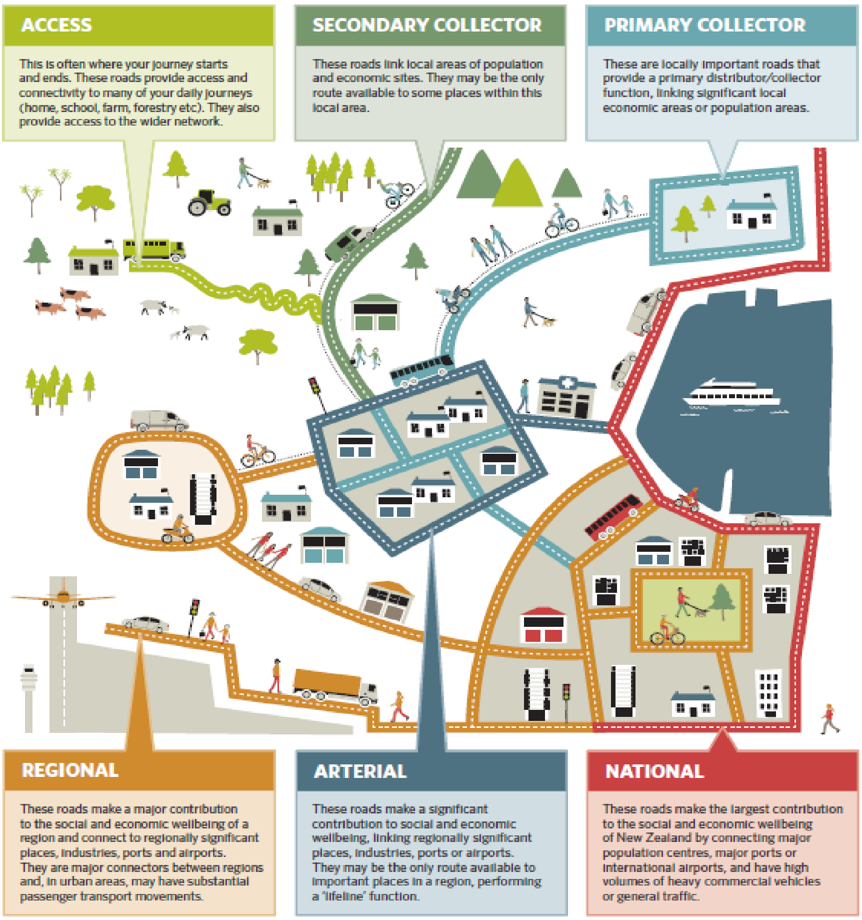


Figure 1. The One Network Road Classification (reproduced from NZTA 2013).

We already know that the subjective categories that drivers use to differentiate road types influence their speed choice (e.g., physical cues of the road environment; Oxley, 2006) but there is a need to identify specific individual characteristics of the roads that drivers use to differentiate their speeds. Identifying the subjective categories that drivers use, and the visual features they use in categorising roads can help inform road designs that improve speed limit credibility and promote higher safety margins. The current research aims to examine whether peoples' subjective categorizations of a range of NZ roads (urban and rural) match the ONRC categories and to identify whether there are unique categorizations that lead to improved speed credibility.

Considering that roads in the same functional category might not always look the same (particularly given the very recent introduction of the ONRC categories which focus primarily on traffic volumes), the goal of the research was to investigate the relationship between the visual appearance of roads from the One Network Road Classification categories and drivers' subjective categorisation and speed choice for those roads.

2. Research goal and approach

The report describes two studies. The first study carried out a systematic comparison of urban roads (as defined by Stats NZ http://www.stats.govt.nz, and as used in the NZTA Speed Management Guide) from each of the six ONRC functional classifications to examine how drivers' subjective categorisation and speed choices for these roads were influenced by the visual appearance of these roads and how they aligned with the ONRC classification. An overview of the research approach is shown in Figure 2. Participants drove a representative selection of urban roads in the simulator, and then completed a picture sort and rating task. After this smaller-groups of these participants returned to the laboratory to take part in focus groups discuss their impressions and expectations regarding various types of roads. The second study reported here extended this analysis to drivers' categorisation of rural roads by examining data from a previous experiment that used a similar picture sort and rating task for 34 rural roads.

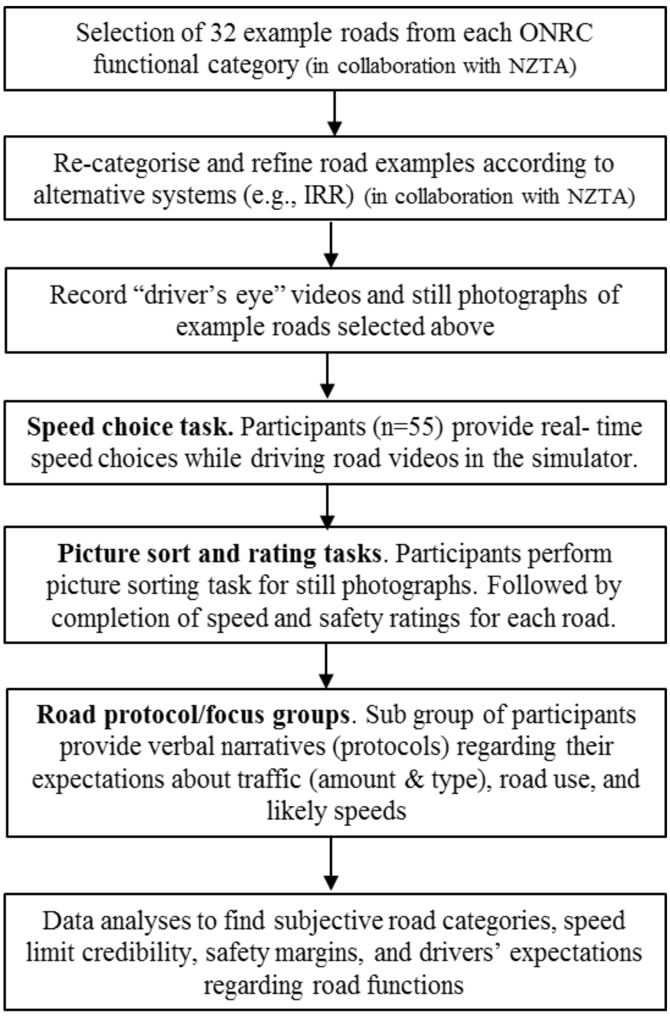


Figure 2. An overview of the research approach for Study 1.

In order to address the underlying research goal of understanding the relationship between how the visual characteristics of roads give rise to drivers' subjective categorisations of roads and how they influence speed choice, the following research questions were formulated:

Question 1 – *How do drivers categorise roads from the ONRC functions?*

Question 2 - *What are drivers speed choices for roads from the ONRC categories?*

Question 3 – *Are there road categorisations or individual properties of roads that lead to better discriminability (speed limit credibility) and higher safety margins?*

3. Study 1 – Urban Roads

As described above, Study 1 focussed on the comparison of urban roads. The example roads were selected from each of the six ONRC functional classifications to represent a range of speed limits and infrastructure risk ratings.

3.1. Method

3.1.1. Participants

Seventy eight participants with a full New Zealand driver's license were recruited for the study via community noticeboards and electronically via the University communication channels. Of these fifty five individuals 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 an average 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, out of which 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 follow-up study, 13 participants were randomly selected and invited to participate in one of three focus groups (7 female, 6 male) approximately a month after completion of the first part of the study.

Ethical approval for the recruitment and test protocols was received for both stages of the study from the School of Psychology Research Ethics Committee at the University of Waikato. Each of the participants received a $20 gift voucher for participating in each session.

3.1.2. Apparatus

Participants completed the driving task in the Applied Cognitive/Transport Research Group driving simulator consisting of a complete automobile (2010 Toyota Prius plug-in) positioned in front of three angled projection surfaces (see Figure 3). Full details of the simulator specifications can be found in Charlton & Starkey (2016). For the present experiment, only a single, central projection screen was used (located 2.32m from the driver and angled back away from the driver at 4.3 degrees). The image projected on the screen measured 2.6 m wide by 1.47 m high (at a resolution of 1920 by 1200 pixels). Participants' control actions (accelerator, brake, and steering wheel position) were recorded continuously via the vehicle CAN bus. Moving the steering wheel produced a sensation of apparent steering by adjusting the position of the central part of the scene (i.e., the road) on the centre projection screen in real time. The accelerator and brake pedals increased or decreased the speed of the video, and the equivalent vehicle speed (in km/h) was displayed on the digital dashboard speedometer. Unobtrusive cameras were mounted between the passenger and driver's seats and on the rear-view mirror of the vehicle to monitor and record the participants' behaviour during the experimental sessions.

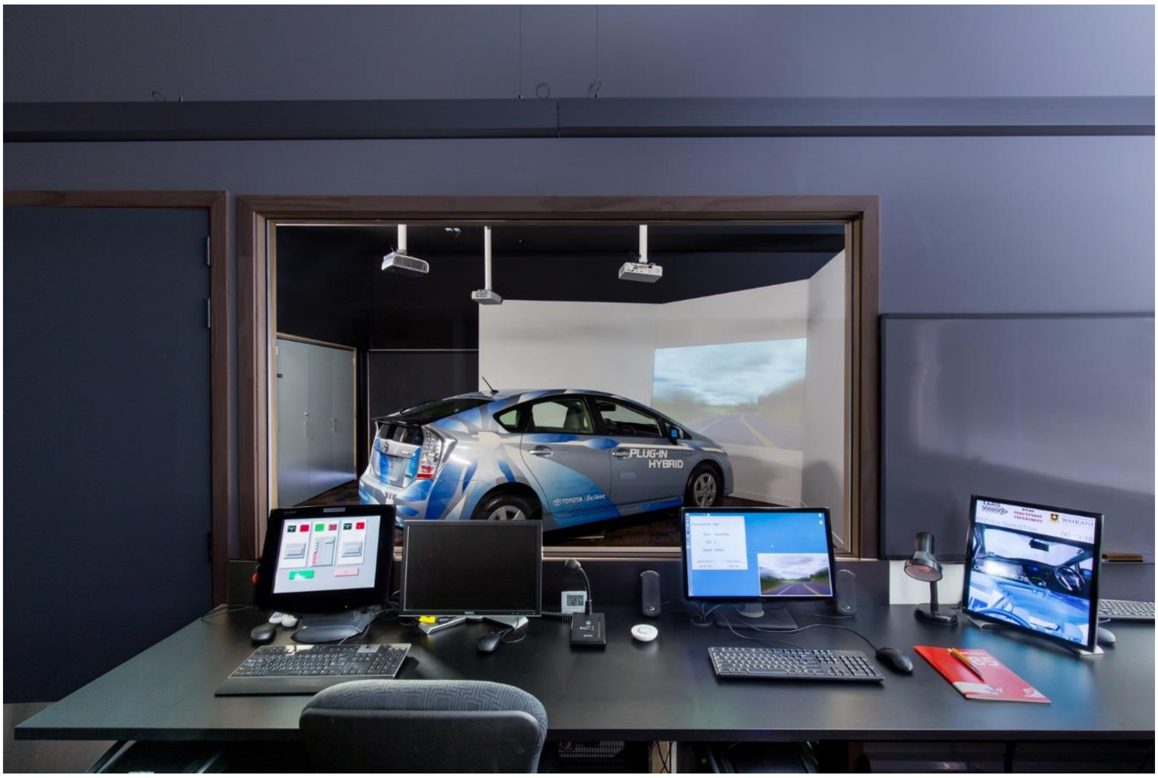


Figure 3. The AC/TRG driving simulator as viewed from the experimenter's station.

3.1.3. Road selection

A total of 32 urban roads in the Waikato region were identified after discussion with NZTA representatives. The roads were selected to include examples from each of the six ONRC categories, ensuring that there were a range of speeds limits (30-80km/h), safe and appropriate speed designations (30-80 km/h) (as defined in the NZTA Speed Management guide) and infrastructure risk ratings (IRR). The IRR system provides a composite rating of risk of a section of road based on eight key features: road stereotype (e.g., two lane undivided, multi-lane undivided), alignment (e.g., winding, straight), carriageway width, shoulder width, roadside hazard, land use, intersection and access density, and traffic volumes, with higher scores indicating greater levels of risk. The final selection of roads, and their ONRC classification, posted speed limit, safe and appropriate speed and IRR are summarised in Table 1. As can be seen in the Table, the final selection included 5 national roads (mean IRR = 1.73; the range is provided in Table 1), 5 regional roads (mean IRR = 2.18), 9 arterial roads (mean IRR = 2.18), 5 primary collector roads (mean IRR = 2.26), 4 secondary collector roads (mean IRR = 2.05) and 4 access roads (mean IRR = 2.07). Still photographs of each of the roads can be found in Appendix 1 and details of the IRR scoring are in Appendix 2.

Table 1. The ONRC category, posted speed limit, safe and appropriate speed and infrastructure risk rating for each of the 32 roads.

ONRC Category	Road Number	Posted Speed Limit (km/h)	Safe and Appropriate Speed (km/h)	IRR
1. National Strategic	R1, R2	80	80	2
	R5	80	60	1
	R6, R7	60	60	2
2. Regional Strategic	R8	50	60	1
	R15	50	40	4
	R13	50	40	3.5
	R14, R16	50	40	3
3. Arterial	R3	80	80	1
	R4	80	80	2
	R9, R10, R11, R12	50	50	3
	R26	50	40	3.5
	R28	50	40	3
	R25	30	30	3.5
4. Primary collector	R18, R20	50	40	4
	R17, R27	50	40	3
	R19	40	40	2
5. Secondary collector	R22, R23, R24	50	40	3
	R21	40	40	2
6. Access	R29	50	40	3
	R31	50	40	4
	R32	40	40	3
	R30	40	40	2

3.1.4 Driving simulator task

High-definition video (HD resolution, 100 Hz frame rate) of the roads were collected from a video capture vehicle driven at or just below the posted speed limits in a safe (i.e., non-aggressive) driving style by an experienced driver. The roads were filmed multiple times in order to capture each of the locations in dry weather, with average levels of oncoming traffic and to avoid any unusual or distracting events (e.g., hazards created by other vehicles, pedestrians, cats / dogs running into the road etc.). Situations where the speed of the video capture vehicle was impeded due to heading traffic were discarded. The videos, with accompanying car and road sounds, were edited into a series of 1 min test stimuli or “clips”. Two 35 min test videos were created, each beginning with the same warm-up clip followed by the 32 clips of interest in different random orders (simply designated order A and B). In the videos, each clip was separated by from adjacent clips by a 1 sec interval which dissolved from the clip to black and then to the next clip. The resulting video contained a total of approximately 27.5 km of driving with a mean vehicle speed (prior to adjustment by the participants) of 43.01 km/h and a modal speed of 50 km/h. A 3 min training video containing three clips not used in the test stimuli was created and used during participant familiarisation. During the simulator task participants could alter their speed using the accelerator and brake pedals to select the speed they would choose to drive each road as if they were in their own car. Participants’ speed (henceforth referred to as observed speed) was recorded as they drove each clip.

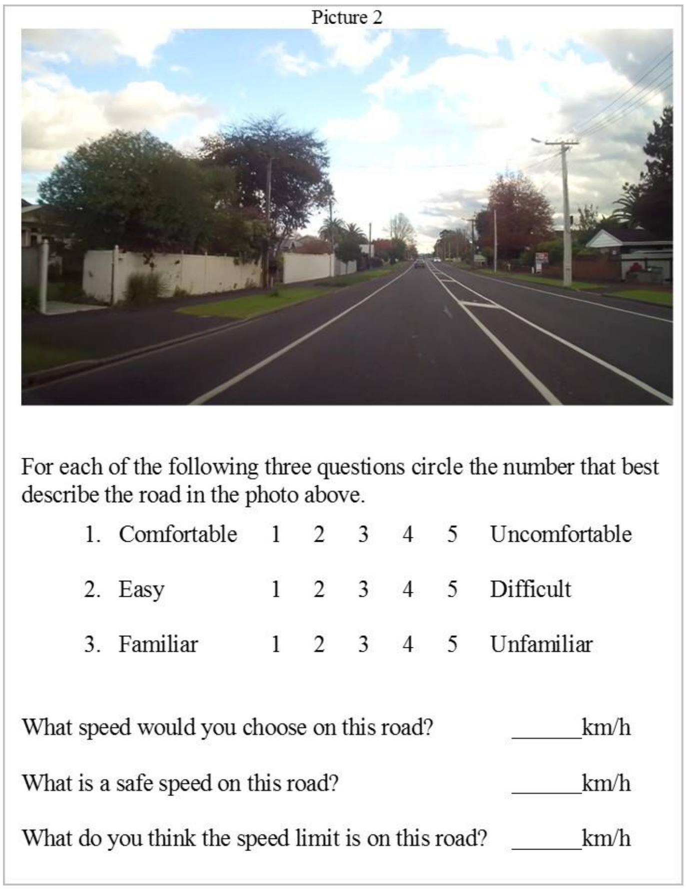
3.1.5. Picture sort task

A high-resolution colour photo was taken from the mid-point of each of the 32 video clips for use in the picture sort and road rating tasks. The colour photos were printed individually on A5 paper (210mm wide x 148mm) and laminated. Participants were provided with the photos in a randomly-ordered stack (the same random order for all participants) and were asked to sort them into more than two piles so that their driving would be the same on all roads in a pile, and would be different from their driving behaviour on roads in the other piles. Participants were given 5 minutes to complete this task and were then asked to provide a brief written description of each pile. The number of times each picture was grouped with each other picture was recorded for each participant and then calculated for the group as a whole (a similarity matrix).

3.1.6 Road rating booklet

A road rating booklet was created for each participant to complete, containing several short background questionnaires and a road rating task. The questions included demographic information (e.g., age, gender) and driving history (e.g., driving experience, driving exposure), the 12 item Adelaide Driving Self-Efficacy questionnaire (George, Clark, and Crotty, 2007) and the eight item Brief Sensation Seeking scale (Hoyle et al., 2001) (please note the findings from the latter two questionnaires are not included in this report).

For the road rating task the photographs of the 32 roads were accompanied by six short questions and formatted to fit in an A5 booklet format (see Figure 4). The first three questions asked participants to rate how comfortable, difficult and familiar the road was on a scale of 1 to 5. They were then asked to indicate what speed they would choose to drive on this road (speed choice), what they thought was a safe speed (safe speed) and what they thought was the speed limit (speed limit belief). Two versions of the booklet were produced, each with the photographs in one of two orders, the same two orders used for the two versions of the driving simulator videos.


Picture 2

For each of the following three questions circle the number that best describe the road in the photo above.

1. Comfortable 1 2 3 4 5 Uncomfortable
2. Easy 1 2 3 4 5 Difficult
3. Familiar 1 2 3 4 5 Unfamiliar

What speed would you choose on this road? ______km/h

What is a safe speed on this road? ______km/h

What do you think the speed limit is on this road? ______km/h

Figure 4. An example page from the urban road rating booklet.

3.1.7. Procedure

When participants arrived at the laboratory the purpose of the study was explained to them, any questions they had about the study were answered and they provided written informed consent. Participants were then seated in the car and were given standardized instructions on how to operate the driving simulator; to use the accelerator to speed up, the brake to slow down, and to gently steer to match the speed they would usually drive on these types of roads in their own car (as indicated by the digital speedometer). The participants then drove the short practice video (containing 3 clips) to familiarise themselves with the driving simulator task; this took approximately 5 mins. Participants were free to repeat the extra practice video if they wished. This was followed by the video containing the 32 test stimuli (and one warm-up clip) in one of the two orders (counterbalanced across participants). At the end of the drive, participants were given the road rating booklet containing the questionnaires, the instructions for the picture sort task, and the road rating task. The booklet version given to the participants presented the 32 photographs in the alternate order to the one they had driven in the simulator (i.e., if they had driven the video in order A, they received the booklet containing the photographs in order B). At the end of the study participants were thanked and given a $20 gift voucher and asked whether they would be interested in participating in a follow-up study.

The focus groups sessions (3-5 people in each) were held approximately a month after the experimental session and led by two moderators. The sessions were video and audio-recorded for subsequent transcription and analysis. On arrival, participants provided written informed consent form and were briefed about the format of the session. Participants were then shown five sets of road photographs, grouped according to the results of the picture sort task (see section 32.1 below). The photographs were presented, one group at a time, on a projection screen and on an A3 sheet of paper for each participant (see Appendix 1 for the photos). The following questions were used as prompts to generate discussion about each group of roads: 1) How often would you drive on these types of roads? 2) What do you think the main purpose of these roads are/ what would you use them for (what would be the purpose of your trip)? 3) What time of day would you be most likely to use the roads in this group? 4) What speed would you choose on these roads? 5) What is a safe speed on these roads? 6) What do you think the speed limit is on these roads? 7) What would you expect to see on these roads (e.g., type and amount of traffic, other road users, pedestrian etc. 8) What are the common features of these roads that standout and make them different from other types of road? 9) Do you think any of these roads definitely don't belong in this group and why? If so, which other group might these roads belong to and why? At the end of the session, participants were invited to offer any further comments about the roads or the experiment and ask any other questions they had. They were thanked for participating and given a $20 gift voucher.

3.1.8. Data Analysis

The first part of the data analysis focused on identifying how the participants grouped the photos in the picture sort task, so we could determine how they categorised urban roads. Two analysis techniques were used. Multi-dimensional scaling (MDS) was used to produce a graph showing the similarities between the roads, based on how frequently they were sorted into the same piles (Fig 5). Roads that were frequently sorted into the same piles are closer together on the graph, whereas those that were rarely placed in the same pile are further away from each other. We then conducted a hierarchical cluster analysis based on the MDS data to determine which roads should be grouped together (shown as the large circles on Figure 5), so that we could identify six 'categories' from the participants picture sorts. (In statistical terms, a similarity matrix was produced from the participants picture sorts and was used to calculate a multi-dimensional scaling solution (SPSS/PROXSCAL) mapping the participants' pattern of choices into two-dimensional space (normalised raw stress = .020, dispersion accounted for .98, Tucker's coefficient .99). The proximity matrix was then used as an input for a hierarchical categorical cluster analysis to identify boundaries for a six-cluster solution (as an alternative to the 6 ONRC categories). The cluster analysis produced a non-overlapping six cluster solution, shown superimposed on the MDS in Figure 5, to indicate the typical categories identified by the participants.

The next analysis determined whether the participants' observed speeds in the simulator and speed choice ratings from the rating booklet were significantly different for the ONRC categories, using a mixed design Anova. A series of Pearson's correlations were then conducted to explore factors that influenced speed choice (including speed limit belief, discomfort, safe speed, difficulty and unfamiliarity). Further descriptive analyses examined participants' speed limit belief as compared to the posted speed limit for roads within each of the ONRC categories. The speed participants drove in the simulator was used to calculate the observed credibility of the speed limit (posted speed limit – speed driven in the simulator), to identify roads that had poor speed limit credibility.

The focus group recordings were transcribed verbatim and the researchers used the transcripts to identify what features and functions of the ONRC hierarchy drivers commented on as well as what expectations they reported having for different ONRC and subjective road categories. Finally, a series of correlations were conducted to examine the associations between drivers speed choices (in the simulator and from the booklet), and specific components of the IRR.

3.2. Results

3.2.1. How do participants categorise roads from the ONRC functions?

As described above, data from the picture sort task were subjected to multidimensional scaling and hierarchical cluster analyses to identify six road categories representing the participants' subjective road categorisations as shown in Figure 5. The figure shows the 'psychological distance' between the 32 roads based on how often they were grouped together by the participants. More specifically, the roads that are closer together were sorted into the same pile more frequently by participants, whereas the roads that are further apart in Figure 5, were rarely (or never) grouped together. As can be seen from the figure, two of the categories contained eight roads each (C and E), the remaining categories contained six (A), five (D), four (B) and one road each.

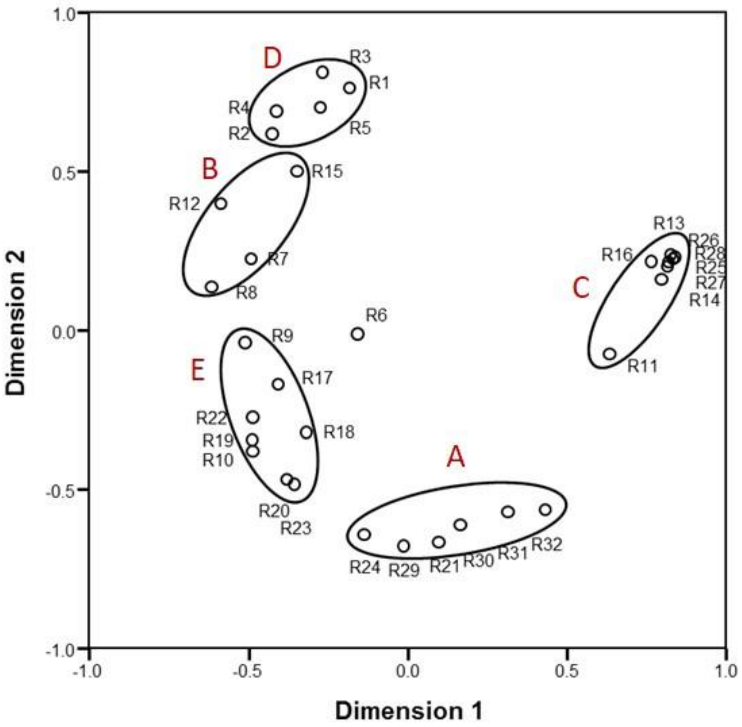


Figure 5. Multi-dimensional scaling solution (MDS) for the participants' picture sort of 32 urban roads (small circles). The results of the hierarchical cluster analysis were superimposed on the MDS to indicate the categories identified by the participants (large ovals labelled A-E).

The correspondence between these six subjective road categories and the ONRC functional classifications can be seen in Figure 6. As shown, the ONRC classifications and participant categories are not particularly well-matched. Two of the categories, A and D, are comprised of roads from two different ONRC classifications, whilst the other three clusters contain roads from three ONRC classifications. Cluster A showed the greatest overlap between the participants' categorisation and ONRC, as it contained all of the access roads and two secondary collectors. Looking at the dispersion of ONRC classifications across the participants' road categories reveals that the National roads (no 1 in Figure 6) appeared in two of the participants' categories (B and D, in addition to the single road, R6). Regional roads (no 2), primary collectors (no 4) and secondary collectors (no 5) were also distributed across two of the participants' categories (B and C, C and E, and, A and E, respectively). All access roads (no 6) were grouped together in cluster A. The Arterial roads (no 3) were distributed across four of the participants' categories (B, C, D and E), suggesting that this group of roads will not elicit similar or consistent driving behaviour.

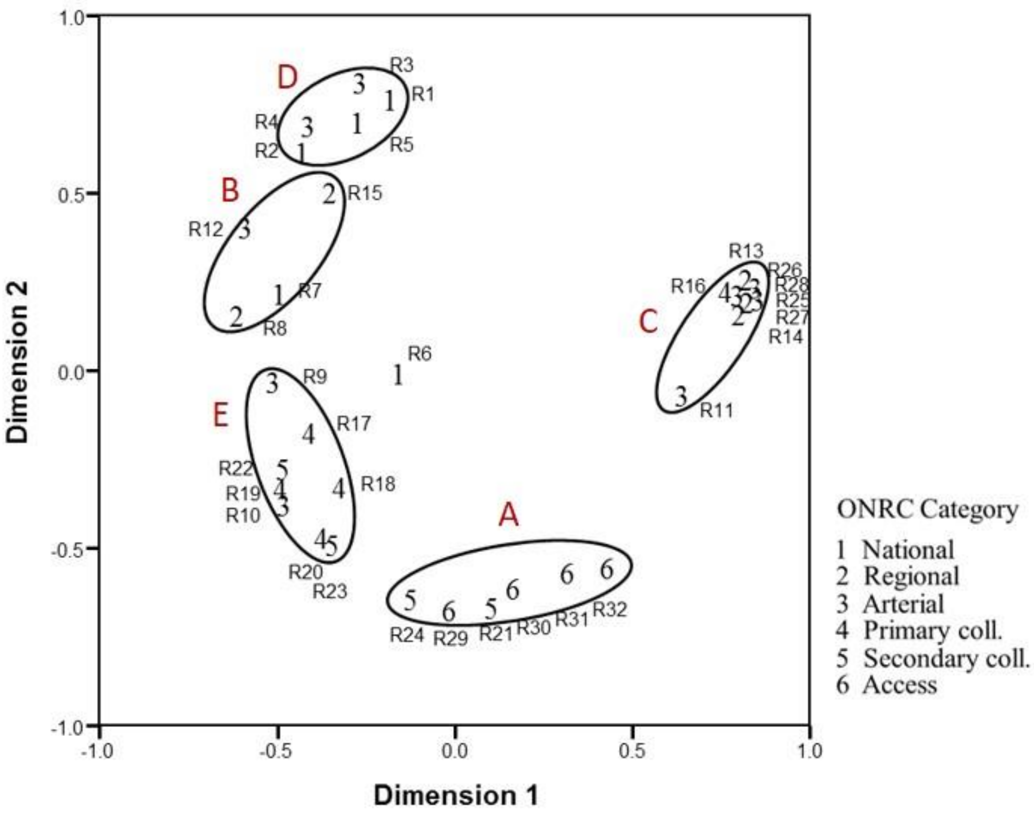


Figure 6. The ONRC classifications (nos 1-6) of the roads within the participants' six road categories (ovals A-E).

As the participants' road groupings did not match the ONRC classifications, we also examined the posted speed limits of the roads within each group (Figure 7). As can be seen in the Figure, all the roads in cluster D had a posted speed of 80 km/h, whilst all the other clusters contained roads with two different speed limits. Cluster B contained roads with 60 km/h and 50 km/h speed limits, clusters A and E contained roads with 50 km/h and 40 km/h limits (but note that half of the roads in cluster A had a speed limit of 40 km/h whereas only one road in cluster E had a speed limit of 40 km/h), and cluster C contained 50km/h roads and the only road with a 30km/h speed limit. These findings suggest that the posted speed limit does relate to how drivers categorise roads, particularly between the higher speed roads (80 km/h) and those with a lower speed limit (30-60 km/h). For the lower speed roads, these findings suggest that either the posted speed limit does not lead to major differences in driver behaviour, or that drivers find it difficult to distinguish between roads with 30 km/h, 40 km/h, 50 km/h and 60 km/h speed limits.

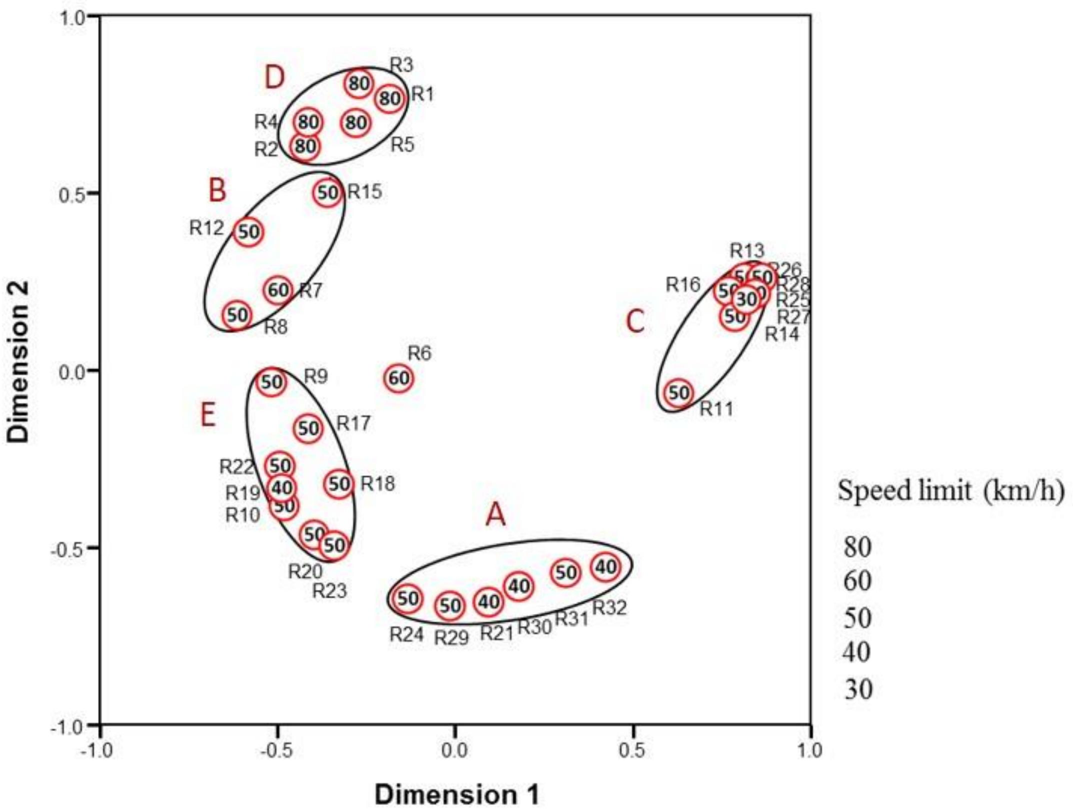


Figure 7. The posted speed limits of the roads within each of the participants' categories (ovals A-E).

3.2.2. What are drivers speed choices for roads from the ONRC categories?

The next set of analyses examined drivers speed choice for roads across the six ONRC functional classifications. Figure 8 presents the participants' average speed choice ratings (from the booklet), the average speeds they drove the same roads in the simulator, and the average posted speed limit for each ONRC category. As can be seen in the Figure, speeds were highest for National roads, followed by Arterials, Primary collectors, Regional roads, Secondary collectors and lowest for Access roads. For four of the six ONRC categories (National, Regional, Arterial and Access roads), the participants' speed choice (rated speed) and simulator speed (observed speed) were lower than the average posted speed limit of the groups of roads (the posted speed limits for roads within each category can be found in Table 1). In contrast, participants' speed choice and simulator speeds were both higher than the average posted speed limit for Primary collectors; for secondary collectors, their speed choice was higher than the speed limit but their simulator speed was lower. In addition, the speeds drivers chose in the simulator were slower compared with their reported speed choice.

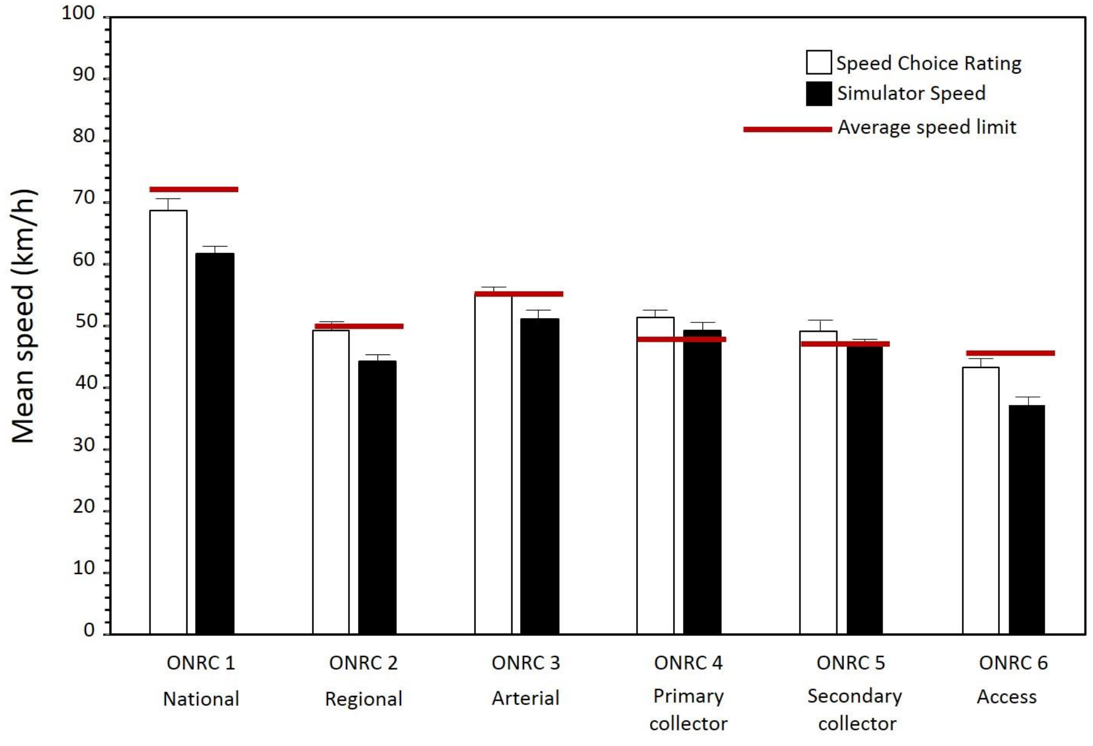


Figure 8. Drivers' average speed choice ratings, average simulator speeds and the average posted speed limit for roads within each of the six ONRC categories. Data are presented as means ± 95% confidence intervals.

A repeated-measures ANOVA confirmed that there were significant differences between the six ONRC classifications for speed choice (rated speed), $F(5,270) = 335.29$, $p < .001$, $\eta_p^2 = .861$ and simulator speed (observed speed), $F(5,270) = 755.82$, $p < .001$, $\eta_p^2 = .933$. Bonferroni adjusted post-hoc pairwise comparisons revealed that Speed choice differed significantly across all ONRC categories ($p < .01$) except between Regional roads (ONRC 2) and Secondary collectors (ONRC 5). For Simulator Speed, there were significant differences between all six ONRC categories (all *p's* < .001. Finally, although speed choice was significantly higher compared to simulator speed across all 32 roads, $F(1,50) = 63.33$, $p < .001$, $\eta_p^2 = .559$, there was a strong positive correlation between the speed choice ratings and simulator speeds (r (32) = .89, $p< .001$; $R^2 = .784$).

Repeated measures Anova were also undertaken to determine if participants' subjective ratings of comfort and difficulty differed across the six ONRC categories. There were significant differences in ratings of comfort ($F(5,270) = 21.70$, $p < .001$, $\eta_p^2 = .287$) and difficulty ($F(5,270) = 25.91$, $p < .001$, $\eta_p^2 = .324$) across the six ONRC categories (Figure 9). Bonferroni corrected pairwise comparisons revealed that National roads had significantly higher comfort ratings compared to all other road categories (all *p*'s <.05) except Secondary collectors (note that lower scores indicate greater comfort). Regional roads had significantly lower comfort ratings compared to all other road categories (all *p*'s <.01). The ratings of difficulty followed a similar pattern, with National roads rated as being significantly lower in difficulty compared with Regional, Arterial, Secondary Collectors and Access roads (all *p*'s <.01). Regional roads received significantly higher difficulty ratings than any other group of roads (all *p*'s <.01).

Further analyses aimed to explore factors that influenced the participants' speed choice ratings. As well as asking participants the speed they would choose to drive on each road, we also asked what they thought the posted speed limit was, what was a safe speed, and to provide ratings for comfort, difficulty and familiarity. A series of Pearson's correlations were conducted to explore the association between each of these variables and participants' speed choices (see Figures 10 and 11).

As shown in Figure 10, there was strong positive correlation between participants' speed limit belief and speed choice rating across the 32 roads, r (32) = .98, $p <.001$. Interestingly, at lower speeds (less than 50km/h), participants chose a speed just under the mean speed limit belief, at higher speeds, they chose speeds higher than speed limit belief.

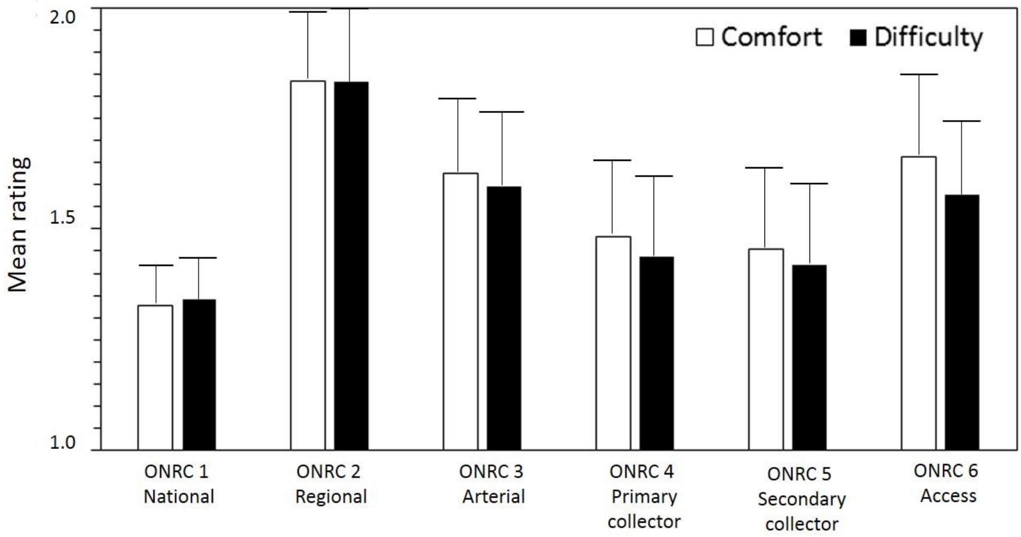


Figure 9. Mean ratings of comfort and difficulty for roads within each of the six ONRC categories (higher ratings indicate greater discomfort / difficulty). Data are presented as means ± 95% confidence intervals.

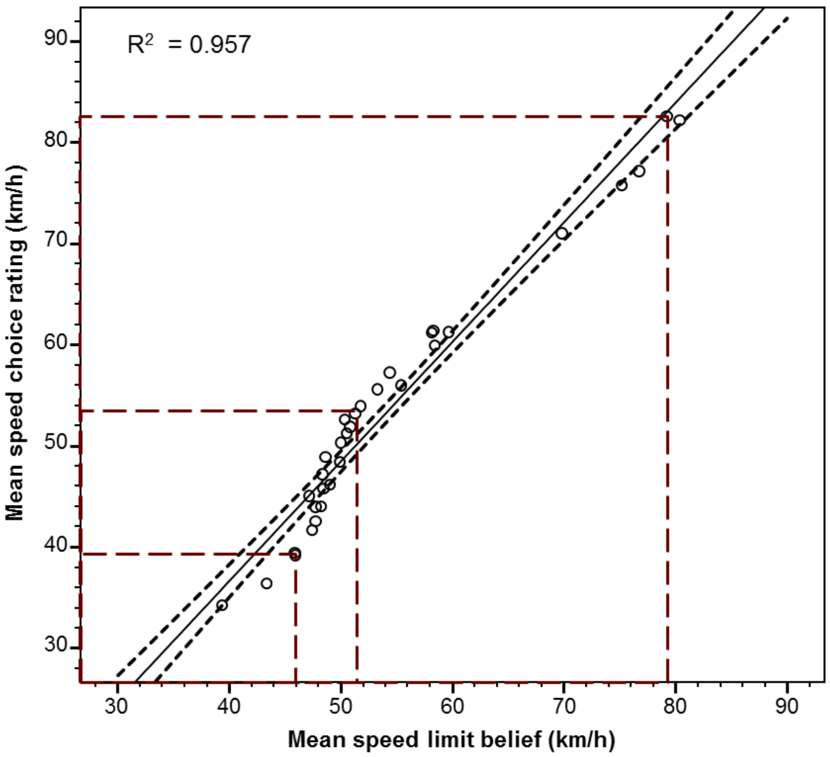


Figure 10. The association between participants' speed choice and speed limit belief. The solid black line shows the linear regression, the dashed black lines are the 95% confidence intervals.

Speed choice ratings also showed a strong positive correlation with safe speed ratings, *r* (32) = .99, p < .001 (Figure 11b), and moderate negative correlations with discomfort, r (32) = -.81, p < .001 (Figure 11a), difficulty, r (32) = -.77, p <.001 (Figure 11c) and unfamiliarity, r (32) = -.58, p <.001 (Figure 11d) indicating that lower speeds were chosen when roads were rated as less comfortable, more difficult and unfamiliar.

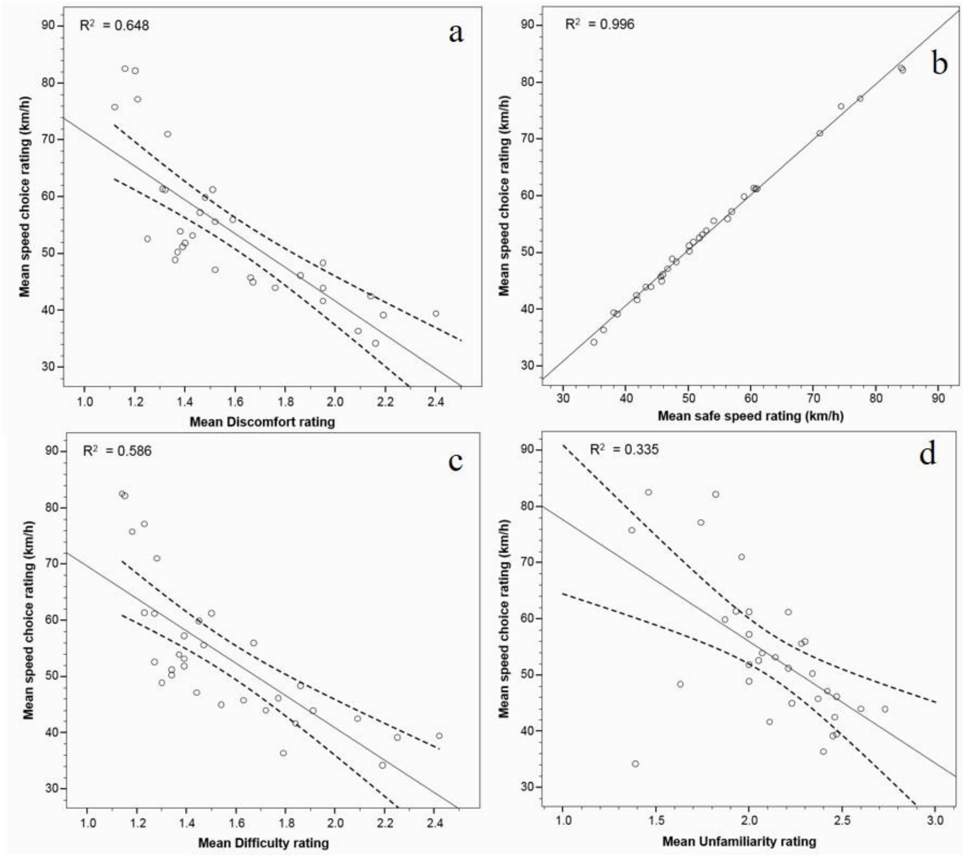


Figure 11. The association between participants speed choice, and ratings of discomfort (a), safe speed (b), difficulty (c) and unfamiliarity (d). The solid black line shows the line of best fit from the linear regression, dashed black lines are 95% confidence intervals.

Although there was a strong correlation between drivers' speed choice rating and speed limit belief, their estimation of the speed limit was not always accurate. Figure 12 presents the mean and range of speed limit beliefs, as well as the posted speed limits for the 32 roads grouped by ONRC category. For the National Roads (ONRC 1), the mean speed limit belief was below or equal to the posted speed limit for all of the roads however for three of the roads (R1, R6, R7), the highest speed limit belief was actually 20km/h higher than the posted speed limit.

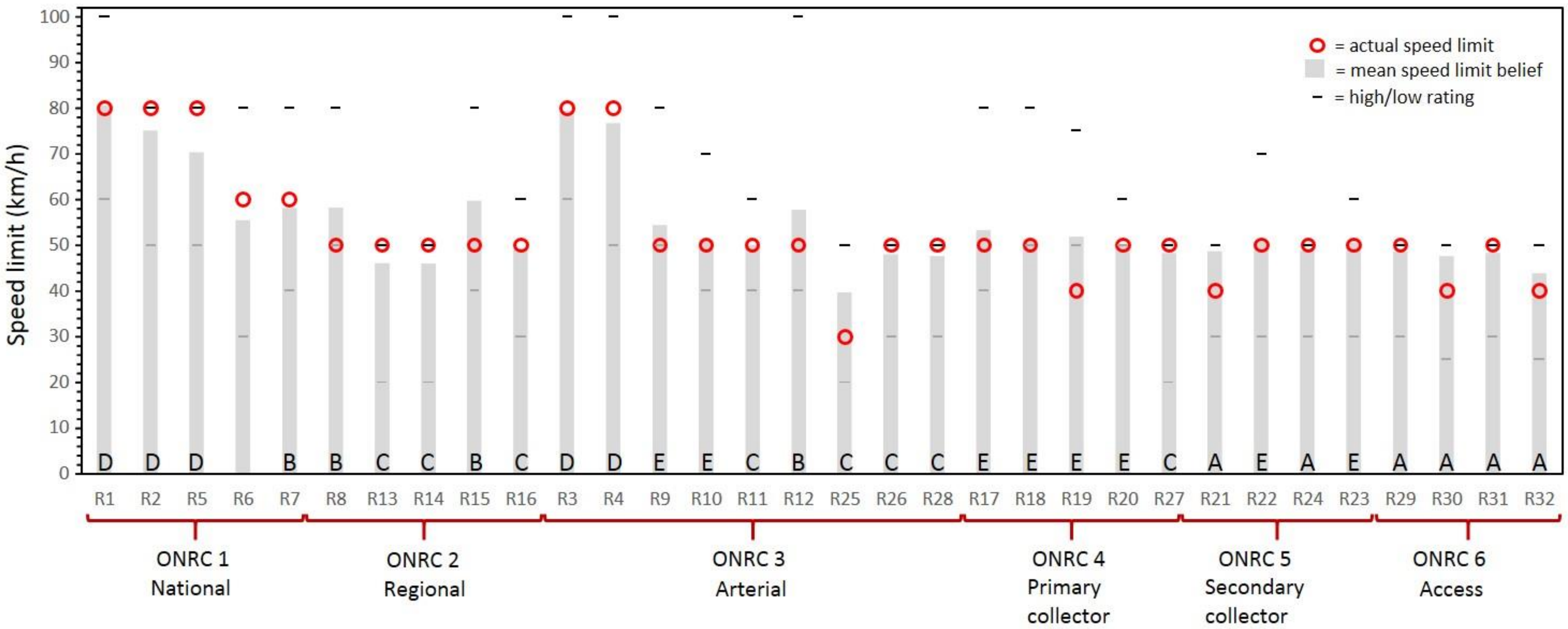


Figure 12. The mean (and range) of speed limit beliefs, the posted speed limit and the participants' sort group for the 32 roads.

The regional roads (ONRC 2) showed a somewhat different pattern; for two roads (R8 and R15) the mean speed limit belief was higher than the posted speed limit (50 km/h), and in both cases the highest speed limit belief reported by participants was 80 km/h suggesting that the speed limits on these roads have poor credibility. In contrast, for R13 and R14, the mean speed limit belief was below the posted speed limit, and the highest speed limit belief rating for each road was the posted speed limit, indicating highly credible speed limits (Figure 13). Interestingly, the roads with poor speed limit credibility (R8 and R15) were grouped together in the picture sort task (participant category B), but separately from the other roads in this category (the 3 other roads were in category C).

Figure 13. Roads classified as ONRC 2 (Regional Strategic) with poor speed limit credibility (R8, R15, left hand side) and good speed limit credibility (R13, R14, right hand side). The letter in the bottom left corner indicates the participants' sort category.

For roads in the next ONRC group (Arterial roads. ONRC 3), the majority of roads (R3, R4, R9, R10, R11, R26 and R28) had good speed limit credibility with the average speed limit belief close to, or below, the posted speed limit. However, for R3, R4, R9 and R10, the highest speed limit belief was 20km/h above the posted speed limit. The remaining two roads in this category (R12 and R25) had speed limit belief ratings that were higher than the posted speed limit (albeit the speed limit on R25 was 30km/h) and for R12, the highest speed limit belief rating was 100 km/h, double the actual speed limit for the road. Figure 14 shows R12, with poor speed limit credibility alongside R10, (a road from the same ONRC group) where the speed limit belief was more accurate. In the participants’ picture sort, R12 was typically categorised with R7, R8 and R15 (the latter two roads can be seen in Figure 13).

Figure 14. Roads classified as ONRC 3 (Arterial) with poor speed limit credibility (R12, left hand side) and good speed limit credibility (R10, right hand side). The letter in the bottom left corner indicates the participants’ sort category.

Of the five primary collector roads (ONRC 4), four had posted speed limits similar to the participants’ speed limit belief (R17, R18, R20 and R27). For two of these roads (R17 and R18), the highest speed limit belief ratings were 30 km/h higher than the posted speed limit. In contrast, the highest speed limit belief rating for R27 was the same as the posted speed limit. The other road in this category, R19, had an average speed limit belief rating that was 10 km/h higher than the posted speed limit (40km/h), in addition, the lowest speed limit belief rating was also 10km/h over the posted speed limit suggesting that drivers’ were unsure of the appropriate speed to drive on this road. Figure 15 shows R19 with two roads with more accurate speed limit beliefs, R18 and R20. These three roads were typically grouped together in the picture sort task.

Of the secondary collector roads (ONRC 5), R21 had an average speed limit belief rating that was higher than the posted speed limit of 40km/h, whereas the speed limit belief for the other two roads (R22, R24) in this category were similar to the speed limit (Figure 16).

Figure 15. Roads classified as ONRC 4 (Primary Collectors) with poor speed limit credibility (R19, left hand side) and good speed limit credibility (R18 and R20). The letter in the bottom left corner indicates the participants' sort category.

Figure 16. Roads classified as ONRC 5 (Primary Collectors) with poor speed limit credibility (R21, left hand side) and good speed limit credibility (R22 and R24). The letter in the bottom left corner indicates the participants' sort category.

The last group of roads, (Access, ONRC 6), contained one road (R30) that had a speed limit (40 km/h), that was markedly lower than the average speed limit belief rating. Interestingly, R32, the other 40km/h road in this group, had relatively good speed limit credibility as the mean speed limit belief rating was similar to the speed limit. These roads are shown in Figure 17.

Figure 17. Roads classified as ONRC 6 roads (Access) with poor speed limit credibility (R30, left hand side) and good speed limit credibility (R32). The letter in the bottom left corner indicates the participants' sort category.

To determine the effect of participants' speed limit belief on actual driving speed, we also calculated the observed speed limit credibility (posted speed limit – speed driven in the simulator) for each of the 32 roads (Figure 19). A value of zero (on the red line), indicates a good match between drivers' actual speeds in the simulator and the speed limit, positive values (above the red line) occur when drivers actual speeds were lower than the posted speed limit, and negative values indicate that the roads were driven faster than the speed limit (i.e., poor speed limit credibility). As can be seen in the figure, four of the six 'problematic' roads identified in the previous analyses (R8, R15, R12 and R19) had low observed speed limit credibility, with R19 producing the poorest rating. Two other roads (R3 and R22) also had relatively poor ratings (typically driven at ≥ -5km/h above the posted speed limit), and are pictured below (Figure 18). Both of these roads showed a large range of speed limit belief ratings (Figure 12), suggesting drivers were unsure of the posted speed limits on these roads.

Figure 18. Two roads with poor observed speed limit credibility (typically driven at ≥ 5km/h above the posted speed limit).

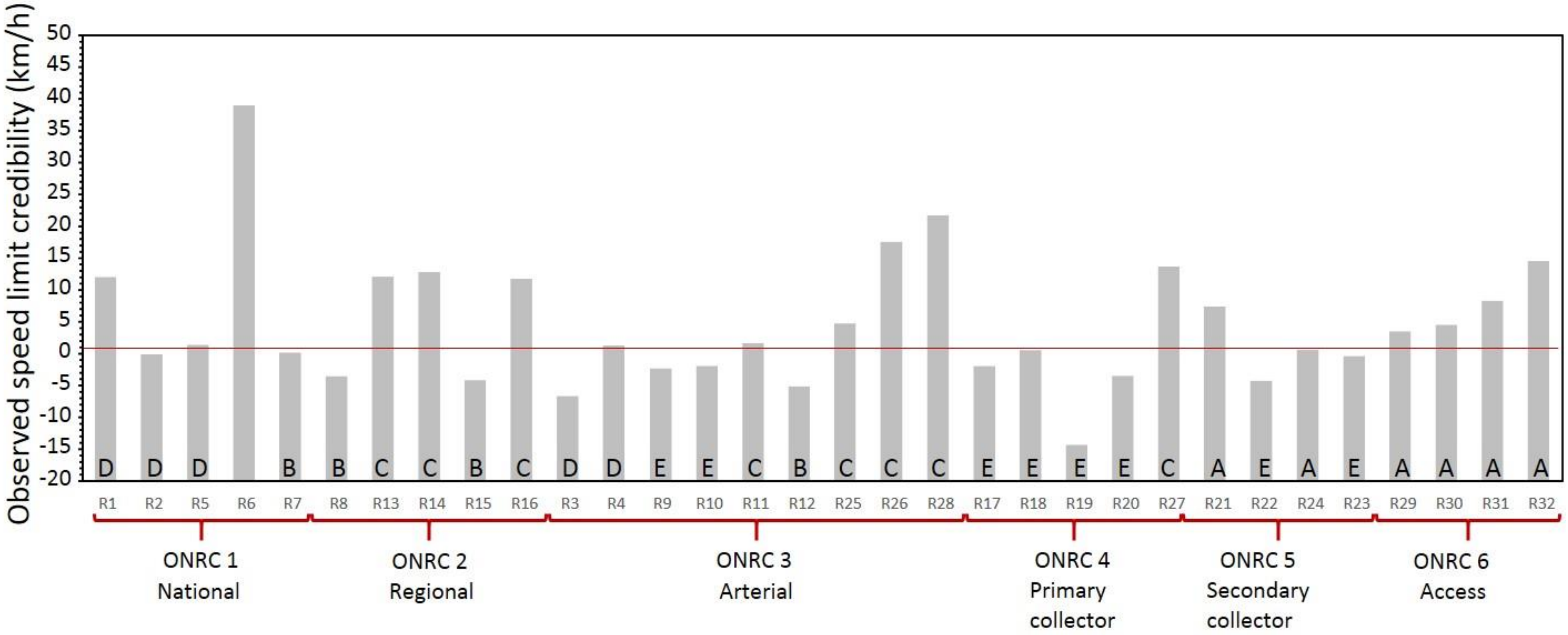


Figure 19. The observed speed limit credibility (speed limit –speed in simulator) for the 32 roads by ONRC classification. The letter indicates the participants' sort category. Note that R6 was not included in any of the other categories identified by participants.

3.2.3 Are there road categorisations or individual properties of roads that lead to better discriminability (speed limit credibility) and higher safety margins?

The last research question was explored primarily through the focus group discussions. Participants described the roads in sort group C (mean IRR score = 2.36, mean land use score = 4.625) as “town centres”, “city centres”, “central business district” and the “inner city” (shown in Figure 20). These roads would usually be used when “going shopping, going out to dinner and socialising” and they were viewed as destinations rather than part of a route. Participants expected to see lots of pedestrians as well as slowly-moving cars looking for parking. They thought the speed limit on these roads, and the speed they would drive (unless looking for parking) would be 40 or 50 km/h, and a perceived safe speed would be 30-50km/h depending on traffic (although several participants indicated they may drive slightly faster on R11 as it looked a little different to the others). As can be seen in Figure 20, participants’ estimates of the speed limits and the perceived safe speeds were largely accurate, apart from R25 which has a speed limit, and safe and appropriate speed of 30km/h. Even though participants viewed these roads as destinations rather than through routes, three of them (R13, R14 and R16) are Regional Strategic routes which connect regionally significant places and industries.

Figure 20. The roads in sort group C from the participants’ picture sort (mean land use score = 4.625, mean IRR = 2.36).

Roads in group A (mean IRR score = 2.023, mean land use score = 3, see Figure 21) were described as “residential roads” by the focus group participants. They would use these roads when going home or visiting friends or families, and similar to the roads in group C, they viewed these roads as leading to a destination, rather than a through route. They thought the speed limit would be 50km/h, they would chose to drive between 40 – 60 km/h and a perceived safe speed would be the same, although this would be lower in the afternoon, because of children coming home from school. Figure 21 shows that three of the roads had posted speed limits of 40 km/h, while the others had a posted speed limit of 50km/h. Participants’ description of the roads were largely accurate, with four in this group being designated as Access roads, where journeys frequently start and finish. In general the roads in this group look similar with minimal paint on the roads, well developed roadsides with numerous driveways, houses and pavements. The speed limit credibility for R21 and R30 was poor, perhaps due to the similar visual appearance of these and the 50 km/h roads. Interestingly, the speed limit for the other 40 km/h road (R32) was more credible, perhaps as a result of the traffic calming measures and road humps.

Figure 21. The roads in group A from the participants’ picture sort (mean IRR score = 2.023, mean Land use score = 3).

The roads in group D (mean IRR score = 1.64, mean Land use score = 2, see Figure 22) were described as “bypass/through roads, boundary roads or highways”. They would typically be used for going to work and to get to other parts of the city. They were described as “wide, well maintained, with medians, generally fast routes”. The speed limit was thought to be 80 km/h, they would drive between 80-100km/h, which was also perceived to be a safe speed (although driving speed may be affected by direction of travel, with slower speeds heading into town and faster speeds on the way out). As shown in Figure 22, participants' estimation of the speed limit was correct with all roads having a posted speed limit of 80 km/h, although they reported that they would choose to drive up to 100 km/h on these roads. Their description of , when and how they would use the roads were in keeping with the ONRC functional classifications, National Strategic and Arterial, which provide links between population centres and regionally significant places.

Figure 22. The roads in group D, from the picture sort task (mean IRR score = 1.64, mean Land use score = 2).

Group B (mean IRR score = 2.01, mean land use score = 3.25, see Figure 23) contained roads that were "arterial/linking roads, connector roads", used to go to other parts of town for shopping or work. They were described as well marked and wide, and speeds would be slower than highways but faster than town routes (particularly on the roads without houses). The speed limit was thought to be 60 km/h, participants reported they would choose to drive between 60-70km/h, which was also thought to be a safe speed for these roads. Participants expected to encounter a reasonable amount of traffic including large vehicles, as well as runners and people out walking. Figure 23 shows that the speed limits for these roads were generally over-estimated, with three of the four roads having a posted speed limit of 50 km/h. Three of the roads are classed as National or Regional Strategic, and R12 is an Arterial road even though the visual appearance of the roads are very similar. Three of these roads (R8, R12 and R15) had poor speed limit credibility (Figure 18). For R12 and R15 this may be due to the median which provides good separation from on-coming traffic, giving the illusion of greater safety, encouraging faster speeds. In contrast, R8 has a speed limit of 50 km/h but a safe and appropriate speed of 60 km/h suggesting that the posted speed limit may be too low.

Figure 23. The roads in group B, from the picture sort task (mean IRR score = 2.01, mean land use score = 3.25).

The final group of roads, group E (mean IRR score = 2.25, mean land use score = 3, see Figure 24), were described as “main suburban or main residential and bus routes”. Participants said that these roads didn’t really fit together, but after some discussion agreed that they were used to “cut through to other areas and going to work”, they were the type of roads that you had to use to go anywhere. They were described as generally being well painted, with cycle lines and wide views, and some participants interpreted these features as indicating it was safe to drive at higher speeds (in comparison to group A). The speed limit was thought to be 50 km/h, speed choices ranged from 40-70 km/h, as did the safe speed. The actual speed limit was 50 km/h for each road (except R19 which was 40 km/h), even though all but two of the roads (R9 and R10) had safe and appropriate speeds of 40 km/h. The lower speed limit on R19 may explain its’ poor speed limit credibility (Figure 18). The roads in this group are from three ONRC categories (Arterials, Primary Collectors and Secondary Collectors), suggesting that drivers find it difficult to distinguish between roads across these categories. Unlike the previous clusters, the road markings differed on the roads in this group, with cycle lanes (R10 and R17), painted medians (R9, R19 and R22) dashed white centre lines (R20 and R23). This may explain why participants thought these roads did not really fit well together.

Figure 24. The roads in group E, from the picture sort task (mean IRR score = 2.25, mean land use score = 3).

To further explore the factors involved in drivers' speed choices, the relationships between specific components of the infrastructure risk rating score (IRR) and participants' speed choice ratings and simulator speeds were explored. A comparison of the means of the participants' speeds (both speed choice ratings and observed speeds in the simulator) to the road characteristics showed a strong association with adjacent land use but not the characteristics of the road itself. Intersection score, and access score (nearly the same except it also includes driveways) also showed strong negative correlations with speed choices and together with the land use scores contributed to a strong negative correlation between mean speed choices and Infrastructure Risk Rating score. Table 2 shows the Pearson correlations between the participants' mean speed choices (ratings and simulator) and the IRR component scores, and the total IRR Score for each of the 32 roads.

Table 2. The correlations (Pearson's *r*) between mean speed choice rating, mean simulator speed, the IRR component scores and the total IRR scores for the 32 roads.

	Speed choice rating n = 32	Simulator speed n = 32
Land use	-.72**	-.60**
Road stereotype	-.29	-.19
Alignment	.13	.17
Carriageway	-.16	-.09
Roadside hazard	-.78**	-.57**
Intersection	-.61**	-.58**
Access	-.67**	-.50**
Traffic volume	.36	.31
Total IRR	-.61**	-.45*

* p<.05, ** p<.001

4. Study 2 - Rural Roads

As mentioned at the outset, Study 2 extended the comparison of ONRC functional classifications to drivers' subjective categorisation and speed choices to the analysis of rural roads. It should be noted that the roads selected for this study formed part of an earlier investigation that used similar methods but was conducted before the current project was planned (Charlton & Starkey, 2017). The rural roads were selected for a study with a different purpose (an examination of risk) and were not systematically balanced across each ONRC category, and for two of the ONRC categories (National and Secondary collector) all the photos were from the same roads. In spite of this limitation, the analysis of these roads has been incorporated into this report to provide a fuller perspective about participants' speed choices for different types of roads. Given the differences in the way the roads were selected for the two studies, however, the findings need to be interpreted with some degree of caution.

4.1. Method

4.1.1. Participants

Sixty-four participants (23 male, 41 female) were recruited from the local community via posters, email and social media for this part of the study. Their ages ranged from 19 to 70 years of age (*M* = 39.1, *SD* =14.15) with all but two having a full (unrestricted) New Zealand driving license (exceptions held a restricted licence and a learner's license). Just over half of the participants (*n* = 33) had been involved in a vehicle crash during their driving history. Most of these participants (*n* = 22) reported having been in one crash; seven others reported two crashes. Four other participants reported having experienced either three, four, five, or eight crashes (one participant each). The weekly amount of driving reported by participants averaged 230 km, but varied considerably across participants, ranging from 15 to 1000 km per week (*SD* = 212 km, *MDN* = 180 km). The recruitment and test procedures were approved by the School of Psychology Research and Ethics review committee.

4.1.2. Road selection

The 34 colour photos used in this study were taken from high-definition video recorded from the driver's point of view on rural roads in the local area (within a 40 km radius of the University of Waikato). The rural road video recordings were created for a study of drivers' perceptions of risk (Charlton, Starkey, Perrone, & Isler, 2014) and included a range of objective driving risk as quantified by road protection scores (RPS) from KiwiRAP (the New

Zealand Road Assessment Programme) (Waibl, Tate, & Brodie, 2012). (Please note IRR scores were not available when this study was conducted). RPS scores are used to determine a Star Rating for each 5km stretch of road and range from 1-star (high risk) to 5 star (low risk). The photos used in the current study (see Table 3 and Appendix 4) were selected to depict a representative range of rural roads in the area, balancing both RPS scores (which ranged from 1.71 to 46.05, M = 10.91, SD = 9.58) and visual characteristics such as intersections, road width, horizontal alignment, and roadside features (e.g., power poles, barriers, and vegetation). For example, two different sections of road could both have high RPS scores, indicating a relatively high degree of objective risk, but for quite different reasons (e.g., the horizontal alignment in one case and the presence of an intersection in another). As shown in Table 3, the roads covered a range of ONRC categories with six pictures of roads in ONRC class 1 (National Strategic), 16 were classed as Regional Strategic (ONRC 2), five were Arterials (ONRC 3), and seven were Primary collectors (ONRC 5). The posted speed limit for all of the locations shown in the photos was 100 km/h. The photos were also chosen such that there were few or no other vehicles seen in the pictures, in order that the roads would be the focus rather than other road users. The weather in all of the photographs was dry and clear with good visibility. For the picture sort task, the colour photos were individually printed on A5 paper and laminated.

4.1.3. Road rating booklet

The pictures also were placed into a booklet for participants to complete a rating task for each of the 34 pictures (as in study 1, Figure 4) along with several demographic questions. Participants were asked to rate the comfort, difficulty and monotony of each road on a scale of 1 to 5 as well as indicating what speed they would drive, what would be a safe speed, and the speed limit. They were also asked to rate how safe (from 1 to 10) they would feel if they were driving this road (note: the risk ratings are not included in this report).

4.1.4. Procedure

As in Study 1, participants were given the pile of pictures (in a random order) and asked to sort them into more than two piles so that their behaviour would be the same on all roads in one pile but different to the roads in the other piles. Participants were then asked to give a descriptive label to each pile. After this, participants completed the road rating booklet and demographic questionnaire. At the end of the study participants were given a $10 gift voucher in thanks for their participation.

Table 3. The ONRC category, RPS score, Kiwirap Star Rating and location of each of the 34 rural roads.

ONRC classification and location	Road Number	Road Protection Score[a]	KiwiRap Star Rating
National Strategic (High volume)			
Waikato Expressway, Rangiriri	P2	2.90	4.60
	P14	2.68	4.10
	P30	2.90	4.41
Waikato Expressway, Mercer	P6	1.71	4.20
	P20	2.24	4.20
	P25	2.24	4.2
Regional Strategic			
Taylor Rd, Gordonton	P3	4.64	2.90
Gordonton Rd, Taupiri	P4	6.57	3.00
Kakaramea Rd, Ngahinapouri	P1	7.92	2.73
	P11	6.34	2.70
	P15	9.32	2.90
Kakaramea Rd, Pirongia	P24	6.30	2.68
Kakaramea Rd, Whatawhata	P27	12.24	2.8
Ormsby Rd, Pirongia	P18	8.82	2.9
	P33	8.82	2.90
Ormsby Rd, Puketotara	P28	5.74	2.73
Otorohanga Rd, Tokanui	P5	7.96	3.10
	P21	5.47	3.10
	P29	27.21	3.1
Otorohanga Rd, Otorohanga	P13	12.09	3.00
	P16	6.06	3.00
Kawhia Rd, Tihiroa	P12	46.05	2.77
Arterial			
Thermal Explorer Hwy, Ngaruawahia	P7	6.68	2.90
	P9	29.27	2.90
	P31	8.23	2.90
	P34	30.60	2.90
Collins Rd, Hamilton	P23	8.80	2.90
Secondary Collector			
Kawhia Rd, Honikiwi	P8	12.02	2.70
	P10	18.69	2.69
	P17	9.18	2.73
	P19	18.35	2.73
	P26	9.18	2.73
Kawhai Rd, Te Rauamoa	P22	10.60	2.8
	P32	12.94	2.80

[a]The RPS score is for the 100m section that includes the location shown in the picture

4.1.4 Data analysis

The data from picture sort task was analysed in the same way as Study 1. That is, from the tally of photographs placed in each pile by all of the participants a similarity matrix was created. This was used to calculate a multidimensional scaling solution (normalised raw stress = .056, dispersion accounted for = .944) representing the psychological distance between the photographs in two dimensions. A hierarchical cluster analysis was then conducted using the similarity matrix and superimposed on the MDS output to identify boundaries for non-overlapping clusters of roads. Analyses (one-way Anovas) were conducted to determine if there were differences in the speed related measures (speed choice, safe speed and speed limit belief) across the ONRC categories. The influence of other factors (speed limit belief, safe speed, comfort, difficulty and monotony) on participants' speed choice were explored using Pearson's correlations. The last part of the analyses examined the characteristics of the roads within each of the 6 clusters based on the picture sort. Repeated measures Manova was used to explore differences in comfort, difficulty, monotony and speed choice ratings across the six clusters. Finally, Pearson's correlations were also conducted to examine the relationship between speed choice and the RPS score of each road.

4.2. Results

4.2.1. How do participants categorise roads from the ONRC functions?

The participants sorted the photos into an average of 4.72 piles (SD = 1.77, MDN = 4.0), ranging from two to nine piles. Figure 25 shows the psychological "distance" between the 34 road scenes based on how often they were grouped together by the participants. As can be seen in the Figure, the analysis identified six non-overlapping road categories, one cluster (C1) contained three roads, three clusters (C2, C3, and C5) contained four roads, one cluster (C6) contained five roads and the other (C4) contained 8 roads. Six roads remained unclustered (because they were not reliably grouped with other photos).

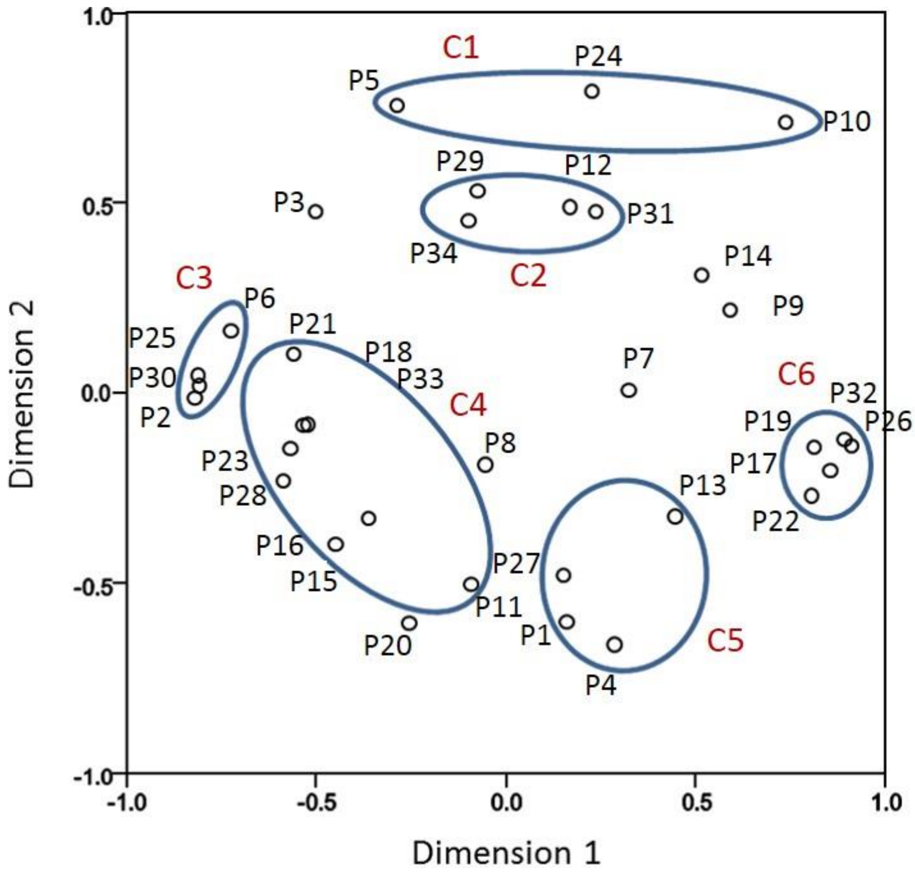


Figure 25 Multi-dimensional scaling solution for the participants' picture sort of 34 rural roads (small circles). The results of the hierarchical cluster analysis (large ovals labelled C1-C5) were superimposed on the MDS to indicate the non-overlapping boundaries for the categories identified by the participants.

To determine if the participants' road categorisation was similar to the ONRC groupings, the ONRC category of each road was superimposed on the MDS solution (Figure 26). Three of the clusters (C1, C2, and C4) contained roads from two ONRC categories whilst C3, C5 and C6 contained only National strategic roads, Regional strategic roads or Secondary collectors respectively (but no cluster contained all the roads for that ONRC category). Of the unclustered roads, two were National strategic roads, one was classified as Regional strategic and two were Secondary collectors. At first glance these findings suggest that participants' sort categories were a reasonable match with the ONRC classifications, but as the roads in Clusters 3 and 6 all came from the same two roads (Waikato Expressway and Kawhia Road, respectively), it is possible that these pictures were grouped together because they were from the same road and therefore looked similar, rather than it being related to the ONRC classifications. In contrast, the Arterial roads (ONRC 3) were spread across different clusters even though four of these roads were also photos of the same road (Thermal Explorer Highway).

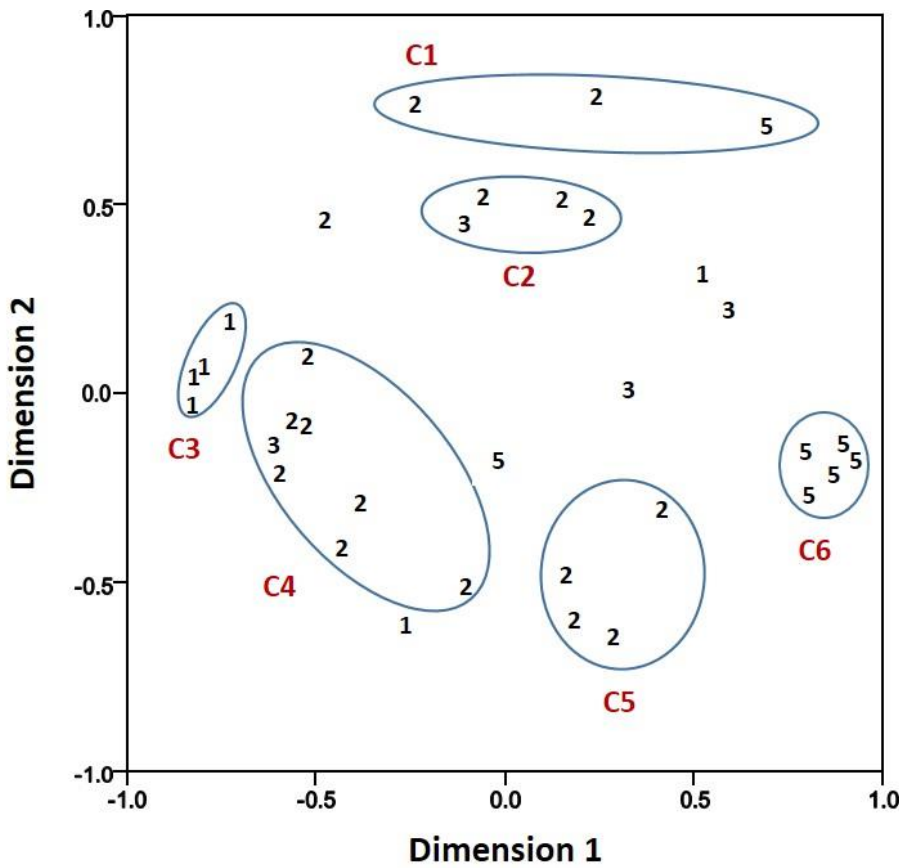


Figure 26. The ONRC classifications (1 = National strategic, 2 = Regional strategic, 3 = Arterial, 5 = Secondary collector) of the roads within the participants' six clusters (ovals C1-C6).

4.2.2 What are drivers speed choices for roads from the ONRC categories?

A series of one way ANOVAs were conducted to explore differences in speed choice, safe speed, and speed limit belief for across the four ONRC classifications (Figure 27). As can be seen in the figure, the speed related ratings for the higher category roads (ONRC 1, 2 and 3) were between 95 – 100 km/h, whereas the ratings for roads in ONRC 5 were somewhat lower, around 80 km/h. Of note, a small but significant proportion of participants rated their speed choice and safe speed as higher than their speed limit belief for roads in ONRC 1. The roads in the other ONRC classifications showed a different pattern whereby speed choices and safe speeds were rated as lower compared with the speed limit belief. There were statistically reliable differences across the ONRC classifications for each of these measures; Speed choice, F (3,30) = 17.38, p<.001 η_p^2 = .635, Safe speed, F (3,30) = 16.83, p<.001, η_p^2 = .627, and Speed limit belief, F (3,29) = 7.55, p<.001, η_p^2 = .430. Bonferroni corrected post-hoc tests revealed that each of these measures were significantly lower for ONRC 5 (secondary collectors) compared to the each of the other three groups. There were no significant differences between the speed measures for roads in ONRC classifications 1, 2 and 3.

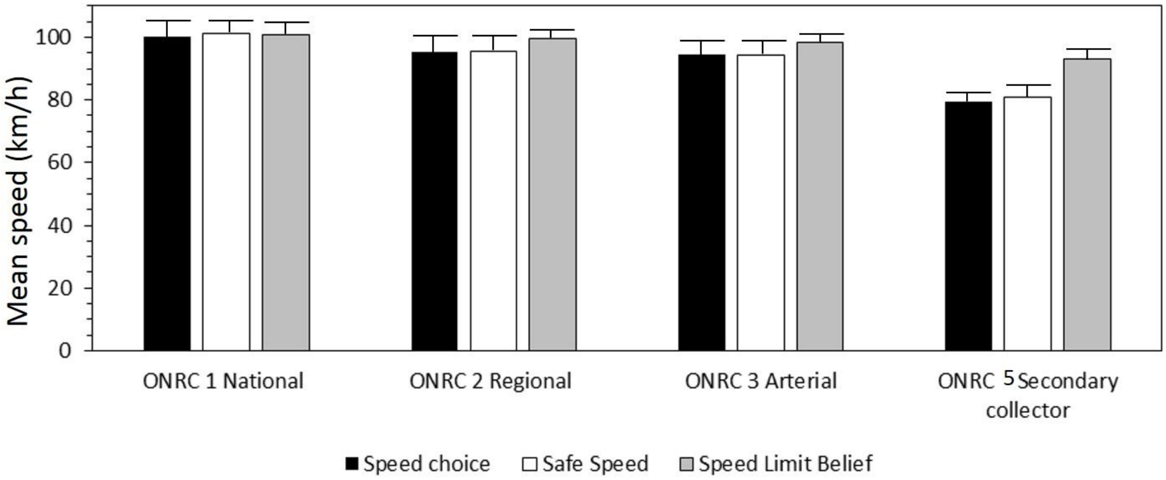


Figure 27. Drivers’ average speed choice, safe speed and speed limit belief for the rural roads in each of the four ONRC classifications. Data are presented as means ± 95 confidence intervals.

To explore other factors that influenced drivers speed choice on rural roads, a series of Pearson’s correlations were conducted (Figure 28). Participants’ speed limit belief, (*r* (34) = .958, *p*<.001, (Figure 27a) and estimates of safe speeds, *r* (34) = .995, *p* <.001, showed strong positive correlations with speed choice (Figure 28b). Of interest is the finding that, in a manner reminiscent of speed choices for urban roads (Study 1) at lower end of the range of speeds participants chose a speed under the mean of speed limit belief, at higher speeds, they chose speeds higher than speed limit belief.

In addition, as ratings of discomfort, *r* (34) = -.915, *p* <.001 (Figure 28c), difficulty, *r* (34) = -.925, *p*<.001 (Figure 27d) and variety, *r* (34) = -.896, *p* <.001 (Figure 28e) increased, speed choice ratings showed a significant decrease. The partial correlations (unique contribution of the variable in predicting speed choice) for these variables were -.137 (discomfort), -.202 (difficulty) and -.125 (variety).

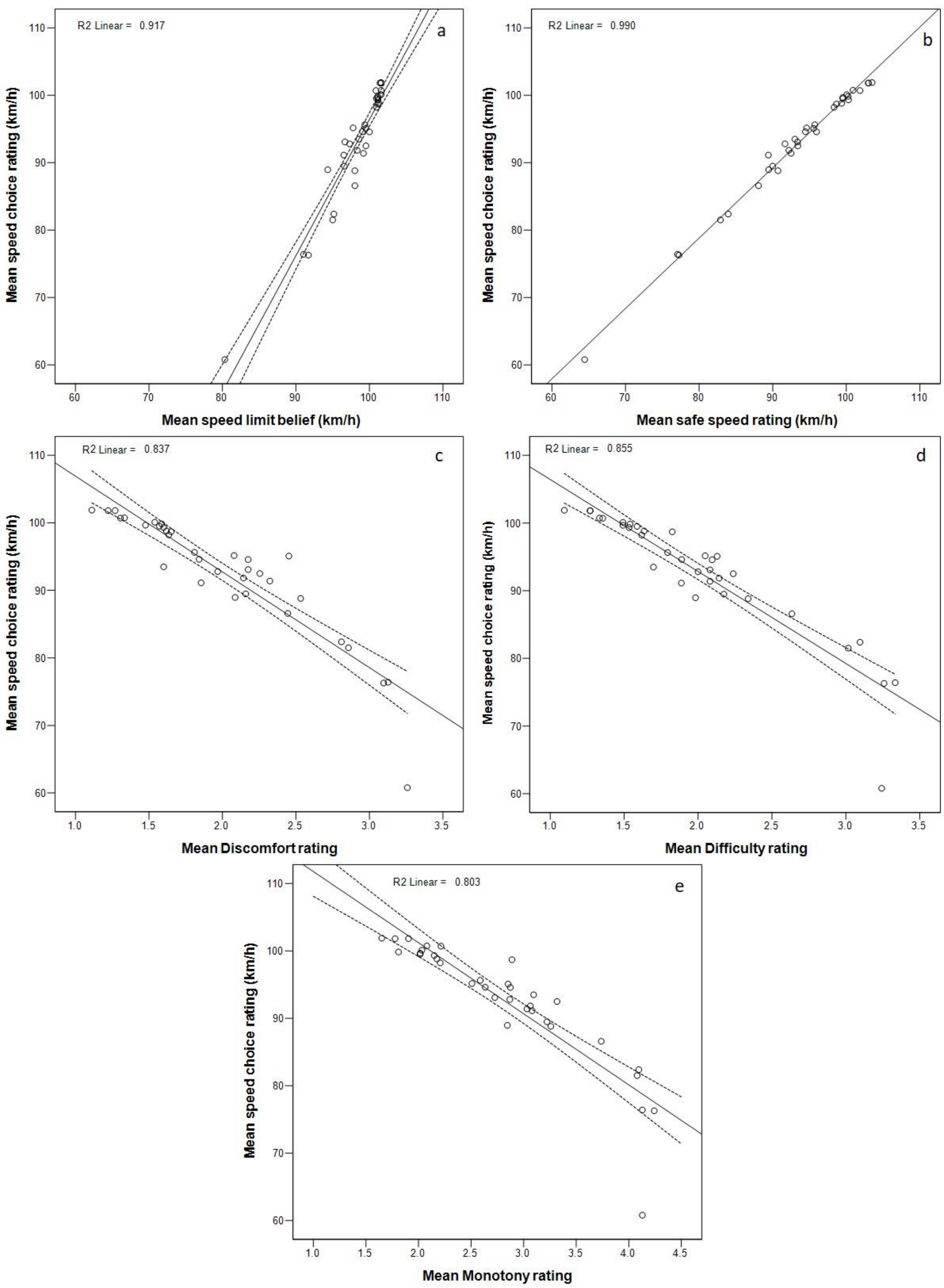


Figure 28. The association between participants' speed choice, and ratings of speed limit belief (a), safe speed (b), discomfort (c), difficulty (d) and monotony (e). The solid black line is the line of best fit from the linear regression, dashed black lines are 95% confidence intervals.

4.2.3. Are there road categorisations or individual properties of roads that lead to better discriminability (speed limit credibility) and higher safety margins?

In the picture sort task, the labels participants gave their piles were short descriptions such as, “straight roads”, “bridges with rails”, “narrow roads”, “intersections coming up”, “curves you can’t see through”, “gentle curves”. The most frequent attributes the participants referred to in their labels were horizontal curves, forward visibility, road and shoulder width, presence of intersections, bridge rails, and divided medians.

By examining the roads included in each cluster, and taking into account the descriptive labels the participants gave their piles in the picture sort, we were able to give a descriptive label to the roads in each cluster: C1 included P5, P10 and P24, depicting bridges (Figure 29), and C2 included P12, P29, P31 and P34 which were merge lanes and intersections (Figure 30).

Figure 29. The rural roads in Cluster 1 (bridges).

Figure 30. The rural roads in Cluster 2 (merge lanes and intersections).

Cluster 3 incorporated P2, P6, P25 and P30, all roads with a divided median and part of the Waikato Expressway (Figure 31), and C4 was the largest group (P11, P15, P16, P18, P20, P21, P23, P28, P33) depicting two-lane straight roads (Figure 32),

Figure 31. The rural roads in Cluster 3 (divided median).

Figure 32. The rural roads in Cluster 4 (two lane straight roads).

Cluster 5 included roads with gentle horizontal curves (P1, P4, P13, P27) (Figure 33) and C6 was made up of roads with severe curves (P17, P19, P22, P26, P32) (Figure 34), all from the same road (Kawhia Rd).

Figure 33. The rural roads in Cluster 5 (gentle horizontal curves).

Figure 34. The rural roads in Cluster 6 (severe curves).

Six roads (P3, P7, P8, P9, P14, P20) shown in Figure 35, depicting a double-yellow centre line, a wire rope median barrier, a steel guardrail, an overtaking lane, high earthen banks on the side, and a dual carriageway where the opposing traffic was not visible in the photo remained unclustered.

Figure 35. The rural roads that did not form part of a cluster as a result of the MDS and hierarchical cluster analysis.

To explore differences in drivers' speed choice and ratings of comfort, difficulty and monotony for the roads in each of the six participant sort based clusters, a repeated measures Manova was conducted (speed limit belief and safe speed were excluded from this analysis because of the high correlation with speed choice). There was a significant difference in the ratings across the six clusters (Wilks' Lambda = .058, F (20, 44) = 35.44, p < .001, η_p^2 = .942), and significant differences for each measure across the categories (all p <.001). As seen in Figure 36, the slowest speeds were chosen for bridges, and severe curves, whilst faster speeds were selected for two lane roads and those with a divided median. In keeping with the correlations reported earlier, the clusters with lower speed choice (i.e., bridges and severe curves) also had higher ratings of difficulty, discomfort and variety.

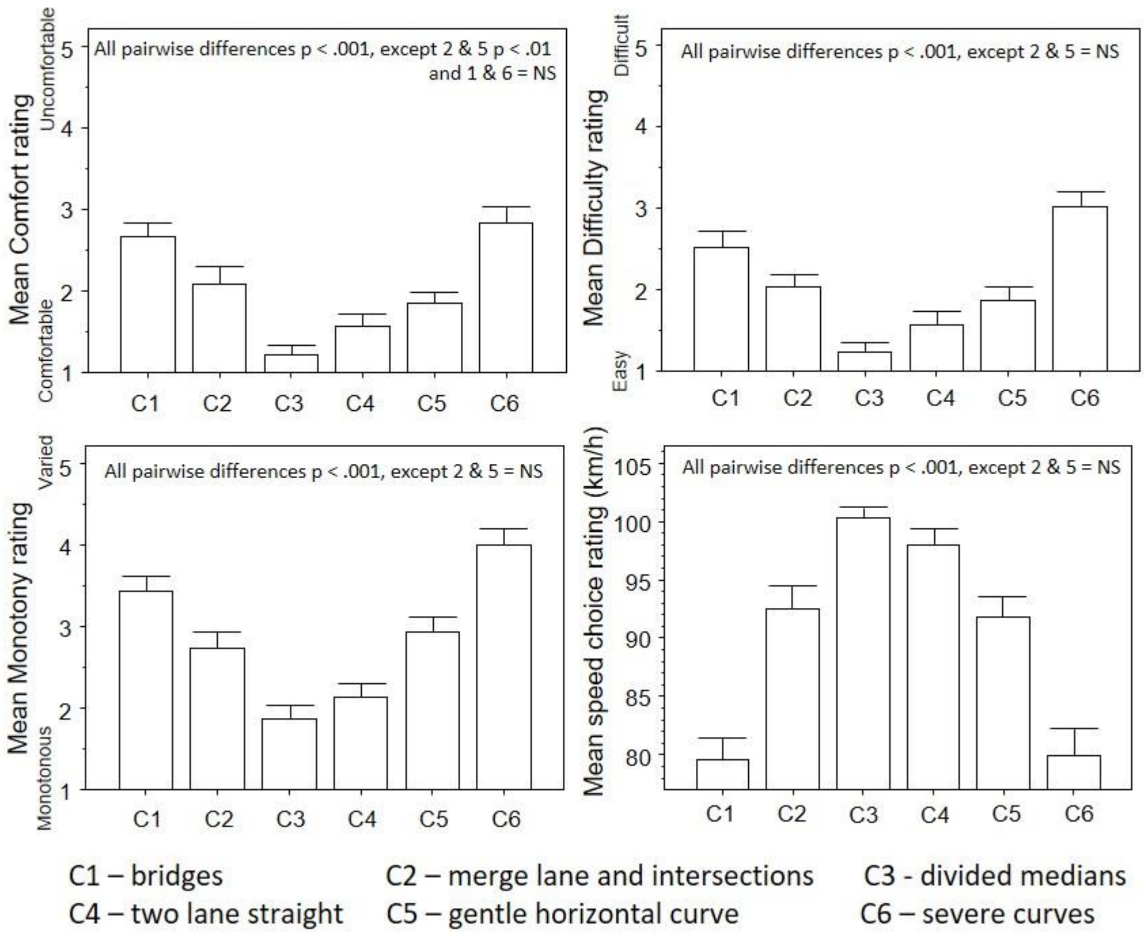


Figure 36. The mean comfort, difficulty, monotony, and speed choice ratings for the six road categories. Lines show 95% confidence intervals. Note that the rating scales for comfort and monotony have reversed polarity such that low numbers indicate high comfort and high monotony.

Finally, the relationship between speed choice and the objective risk rating for each road was also explored. Participants speed choice also showed a moderate significant correlation with the RPS score for the rural roads, r (34) = -.346, p = .045. A scatterplot of the RPS scores indicated 4 outliers, all of which were intersection with very high RPS scores (P9, P12, P29 and P34). When these were excluded from the analysis, the correlation between speed choice and RPS score increased to -.724 (n = 30, p <.001) indicating that as levels of objective risk increased, participants speed choice decreased (Figure 37). This was a pattern similar to the findings for the urban roads in Study 1, where speed choice ratings showed a significant negative correlation (r = -.61, p <.001) with RPS scores.

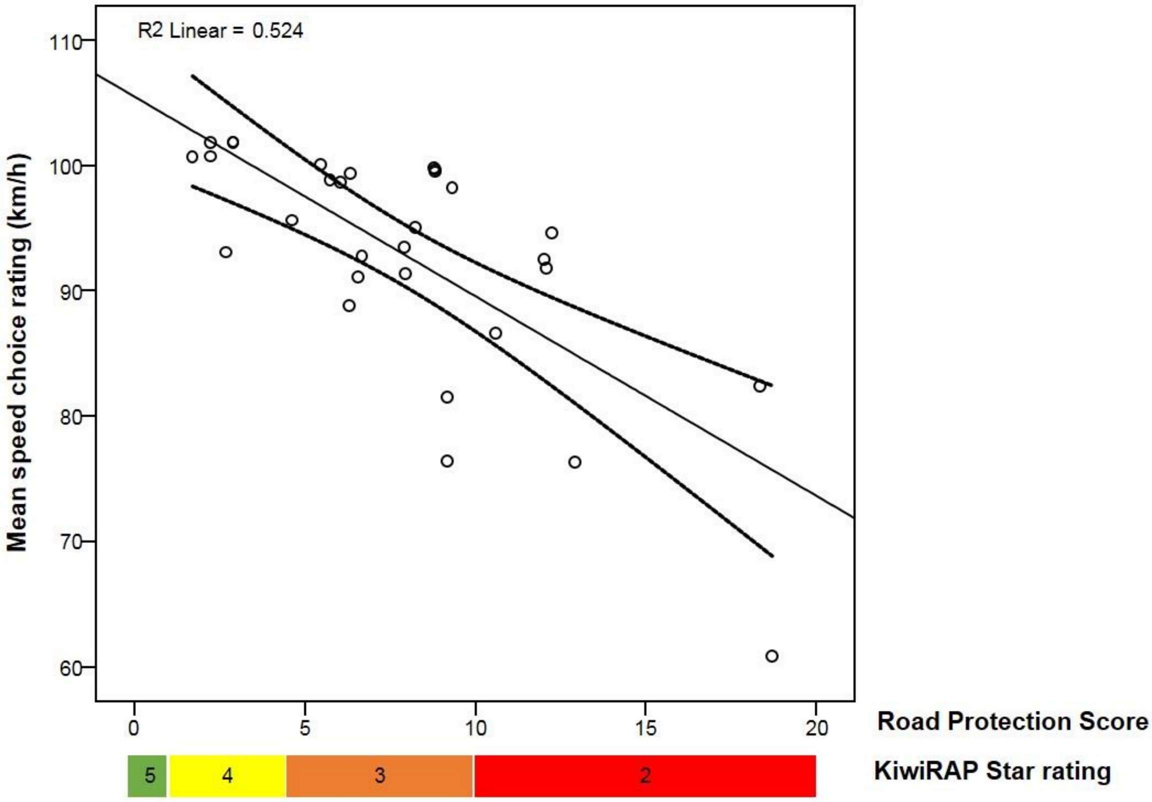


Figure 37. The association between participants speed choice and the RPS score (and KiwiRAP star rating) for 30 rural roads (intersections were excluded).

5. Discussion

The present research investigated how the visual appearance of roads from across a range of ONRC classifications was related to drivers' subjective categorisation and speed choices for those roads. To do this we posed three research questions:

Question 1 – *How do drivers categorise roads from the ONRC functions?*

Question 2 - *What are drivers speed choices for roads from the ONRC categories?*

Question 3 – *Are there road categorisations or individual properties of roads that lead to better discriminability (speed limit credibility) and higher safety margins?*

To answer the first question we identified drivers' subjective categorisation of roads based on the picture sort tasks. There was some degree of overlap between drivers' subjective categorisation of the roads and the ONRC classifications, primarily for the roads with the highest and lowest levels of service (National Strategic roads and Access roads respectively). In contrast, Arterial roads were not recognised as a distinct group or type of road by participants, suggesting that these roads need to be made more visually distinct to encourage appropriate and consistent driver behaviour.

To answer the second question we used both speeds in the driving simulator and speed choice ratings. Drivers did choose different speeds for roads with different ONRC classifications – the highest speeds were chosen for National Strategic roads, followed by Arterials, Primary Collectors, Secondary Collectors and Regional roads, and the lowest for Access roads. The speed participants chose to drive was closely related to their belief about the speed limit. Interestingly though, on lower speed urban roads (less than 50 km/h) drivers would typically choose speed below their speed limit belief, whereas on higher speed roads, they chose speeds higher than their speed limit belief. This same pattern was observed for rural roads, at the lower end of the speed range drivers chose speeds substantially lower than their speed limit belief, whereas they chose speeds higher than what they believed the speed limit to be at the upper end of the speed range. Drivers' speed choices were also related to the objective risk (IRR or RPS) of the road. For urban roads, greater land use and roadside hazards were associated with decreased speeds; on rural roads higher RPS scores were associated with lower speed choices. Thus, drivers' speed choices in urban and rural environments appear to be related to the objective risk of the road.

As regards the third question, drivers appear to be very sensitive to what they believe the speed limit to be, and they base these beliefs on the visual appearance of the roads, particularly the road markings, the adjacent land use, and their previous experience. Their subjective categories thus reflect a number of different factors including their speed limit belief (particularly on the higher speed roads), road geometry (particularly horizontal alignment), road markings (including medians), the width of the road, forward visibility, and the presence of houses, driveways and footpaths adjacent to the roadway. Drivers' subjective categories then are major contributors to the speeds they choose to drive.

When drivers' speed choices are in alignment with the posted speed limit for a particular road there is less opportunity for conflict as speeds are more likely to be homogeneous and risks are limited to other aspects of the road and roadside environment. When the speed choices are not aligned with the posted speed limit there is a higher likelihood for lower speed limit credibility and reduced safety margins. In the present study, drivers were fairly accurate in their estimation of the speed limit, particularly for National strategic and rural roads (with 100 km/h speed limits). Some roads though had poor speed limit credibility, particularly residential streets (primary collectors, secondary collectors or access roads) that had posted speed limits of 40 km/h that were well marked without additional traffic calming measures, and were very similar in visual appearance to roads with a posted speed limit of 50km/h. Speed limit credibility was also poor for wide roads that had few houses, with good visibility and painted medians. These roads had posted speed limits of 50 km/h but speed choices were up to 80km/h. These findings demonstrate the importance of the posted speed limit matching the visual appearance of the roads, in particular wide roads with extensive markings appear to suggest higher speeds to drivers. Drivers were generally accurate with speed limit estimations for residential roads, apart from the lower speed zones (40 km/h), without any other modifications to alter the visual appearance of the roads.

In summary these finding provide some clear insights into how drivers view and categorise roads, and indicate specific areas of practice that could be targeted to improve speed limit credibility. For example, roads with ample width and extensive road markings (cycle lanes, flush medians, etc) appear to signal higher speed limits to drivers, whereas conspicuous footpaths and the proximity of residential housing appear to be cues for lower speeds. In general, the cues for higher speeds appear to take precedence over those for lower speeds. For example, in both the present study and other on-road studies (Charlton et al., 2010) a residential street possessing a high level of delineation will occasion higher speeds, regardless of the prominence of footpaths, residential housing, or even speed signs. This phenomenon, higher speeds associated with more delineation, has also been noted (albeit to a lesser degree), on rural roads (Charlton & Baas, 2006). The reasons for this “delineation effect” are not certain but it may be because unpainted roads appear narrower to drivers or simply because highly delineated roads are more often associated with higher speed limits.

An interesting question to ask for both practitioners and researchers is what degree of remediation is needed when speed limits or ONRC classifications are changed. In the present study, lower speed limits (40 km/h) for some residential roads were not recognised by the participants and led to low speed limit credibility. At higher levels in the ONRC classifications, the road width and presence of road markings led drivers to believe the speed limit was higher than it actually was, and choose speeds even higher than those beliefs. For rural roads a similar relationship was found to exist, and research performed elsewhere has shown that simple reductions in speed limit (from 90 km/h to 70) do not produce a high level of compliance without other visible changes to the road infrastructure (Jongen, Brijs, Mollu, Brijs &Wets, 2011). Thus as changes to road classifications and speed limits occur as a result of changes to the road network (e.g., the introduction of new expressways or bypasses) some thought will need to be given to how to signal these changes to drivers in a way that is intuitive and leads to good speed limit credibility. Changes to higher road classifications and speed limits can be accomplished with increased delineation, changes downward will likely be more challenging (e.g., when a section of state highway is decommissioned as a result of the opening of new expressway). Over time, these changes will also need to be taken into account when carrying out maintenance on NZ roads to improve the differentiation of the ONRC road hierarchy.

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Appendix 1. Still Photographs of the roads used in Study 1. The road numbers are provided in the top left corner of each photo and the participants’ sort group is shown in the bottom left hand corner.


R13
Belmont Rd, Paeroa, 37°22'43.3"S 175°40'08.6"E
ONRC = Regional Strategic (2), IRR = Med - Med High
Personal risk = Low - Med
Posted = 50, S&A Speed = 40
C
R14
Maniapoto St, Otorohanga, 38°11'09.9"S 175°12'41.5"E
ONRC = Regional Strategic (2), IRR = Med
Personal risk = Med
Posted = 50, S&A Speed = 40
C
R15
Albert Park Dr, Te Awamutu, 38°00'34.7"S 175°19'44.9"E
ONRC = Regional Strategic (2), IRR = Med High
Personal risk = Low
Posted = 50, S&A Speed = 40
B
R16
Tongariro St, Taupo, 38°00'34.7"S 175°19'44.9"E
ONRC = Regional Strategic (2), IRR = Med
Personal risk = Med
Posted = 50, S&A Speed = 40
C
R17
Bankwood Rd, Hamilton, 37°45'15.1"S 175°16'31.9"E
ONRC = Primary Coll (4), IRR = Med
Personal risk = Med
Posted = 50, S&A Speed = 40
E
R18
Comries Rd, Hamilton, 37°45'14.6"S 175°16'10.4"E
ONRC = Primary Coll (4), IRR = Med High
Personal risk = Med
Posted = 50, S&A Speed = 40
E
R19
Naylor St, Hamilton, 37°47'53.6"S 175°18'07.3"E
ONRC = Primary Coll (4), IRR = Low Med
Personal risk = Med
Posted = 40, S&A Speed = 40
E
R20
Rotokauri Rd, Hamilton, 37°46'07.8"S 175°14'05.5"E
ONRC = Primary Coll (4), IRR = Med High
Personal risk = High
Posted = 50, S&A Speed = 40
E
R21
Brookfield St, Hamilton, 37°48'02.5"S 175°18'04.6"E
ONRC = Secondary Coll (5), IRR = Low Med
Personal risk = Med High
Posted = 40, S&A Speed = 40
A
R22
Ashurst Ave, Hamilton, 37°44'25.6"S 175°14'11.9"E
ONRC = Secondary Coll (5), IRR = Med
Personal risk = Med
Posted = 50, S&A Speed = 40
E
R23
Rototuna Rd, Hamilton, 37°44'05.1"S 175°15'58.3"E
ONRC = Secondary Coll (5), IRR = Med
Personal risk = Med
Posted = 50, S&A Speed = 40
E
R24
Chedworth Ave, Hamilton, 37°45'07.2"S 175°17'10.6"E
ONRC = Secondary Coll (5), IRR = Med
Personal risk = Med
Posted = 50, S&A Speed = 40
A


R25
Victoria St, Hamilton, 37°47'04.5"S 175°16'49.7"E
ONRC = Arterial (3), IRR = Med High/Med
Personal risk = Med/Med High
Posted = 30, S&A Speed = 30
C


R26
Alexandra St, Te Awamutu, 38°00'35.3"S 175°19'28.7"E
ONRC = Arterial (3), IRR = Med High/Med
Personal risk = Low
Posted = 50, S&A Speed = 40
C


R27
Bridge St, Tokoroa, 38°13'08.1"S 175°52'04.5"E
ONRC = Primary Collector (4), IRR = Med
Personal risk = Low/Med
Posted = 50, S&A Speed = 40
C


R28
Broadway, Matamata, 37°48'35.1"S 175°46'26.4"E
ONRC = Arterial (3), IRR = Med
Personal risk = Med/Low
Posted = 50, S&A Speed = 40
C


R29
Wiltshire Dr, Hamilton, 37°44'11.3"S 175°17'07.4"E
ONRC = Access (6), IRR = Med
Personal risk = Low
Posted = 50, S&A Speed = 40
A


R30
Alfred St, Hamilton, 37°46'19.2"S 175°17'09.5"E
ONRC = Access (6), IRR = Low Med
Personal risk = Med
Posted = 40, S&A Speed = 40
A


R31
Aurora Tce, Hamilton, 37°47'40.1"S 175°19'05.4"E
ONRC = Access (6), IRR = Med High
Personal risk = Med
Posted = 50, S&A Speed = 40
A


R32
Sayer St, Hamilton, 37°47'50.0"S 175°15'24.9"E
ONRC = Access (6), IRR = Med
Personal risk = Low
Posted = 40, S&A Speed = 40
25
A

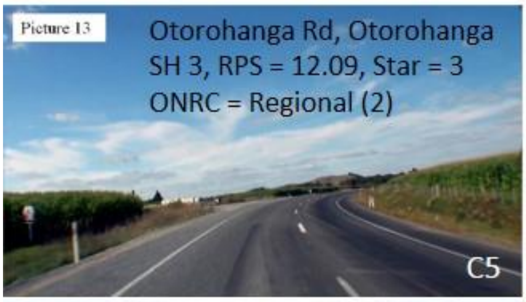
Appendix 2

Description and scoring for the key IRR components

IRR Component	Score
Land Use & Access	
Commercial Strip Shopping	5
Urban Residential	3
Commercial Big Box/Industrial	4
Rural Town	2.5
Controlled Access	2
Rural Residential	1.5
Remote Rural	1
No Access	1
Road Stereotype	
Unsealed	10
Two lane undivided	3.7
Multi-lane undivided	3.4
Divided - traversable	3
Divided - non-traversable or One Way	1
Roadside Hazard Risk Score	
High	2.28
Severe-Moderate	2.115
High-Moderate	1.855
Moderate	1.430
Minor	0.67
At-Grade Intersection Density	
10+ per km	5
5 to <10 per km	2.6
3 to <5 per km	1.5
2 to <3 per km	1.25
1 to <2 per km	1.15
<1 per km	1
Access Density	
20+ per km	1.3
10 to <20 per km	1.1
5 to <10 per km	1.06
2 to <5 per km	1.03
1 to <2 per km	1.01
<1 per km	1
Traffic Volume	
<1000	1
1000-6000	1.4
6000-12000	2.2
>12000	3

Appendix 3

Roads used in the Rural Road picture sort task


Picture 13
Otorohanga Rd, Otorohanga
SH 3, RPS = 12.09, Star = 3
ONRC = Regional (2)
C5

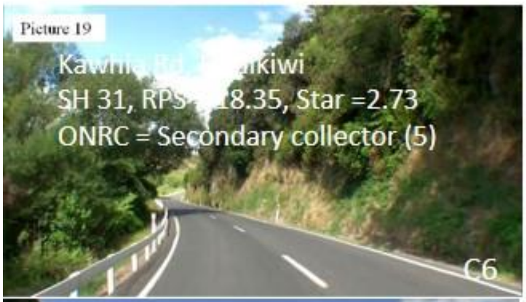

Picture 14
Waikato Expressway, Rangiriri
SH 1N, RPS = 2.68, Star = 4.1
ONRC = National (1)

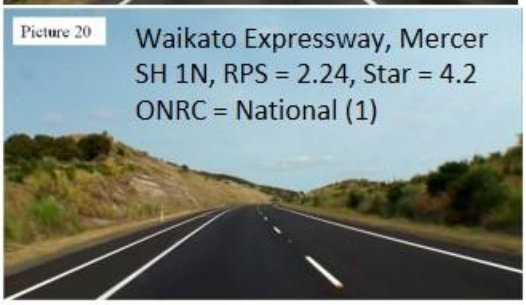

Picture 15
Karakaramea Rd, Ngahinapouri
SH 39, RPS 9.35, Star = 2.9
ONRC = Regional (2)
C4


Picture 16
Otorohanga Rd, Otorohanga
SH 3, RPS = 6.06, Star = 3
ONRC = Regional (2)
C4

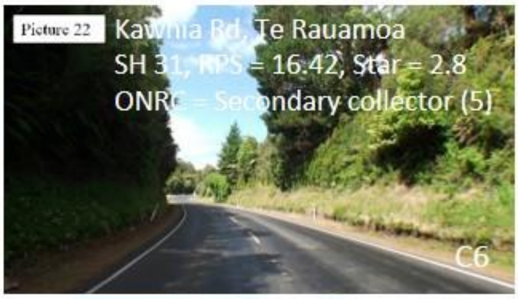

Picture 17
awhia Rd, Honikiwi
H 31, RPS = 18.35, Star = 2.73
ONRC = Secondary Collector (5)
C6


Picture 18
Ormsby Rd, Pirongia
SH 39, RPS = 8.82, Star = 2.9
ONRC = Regional (2)
C4

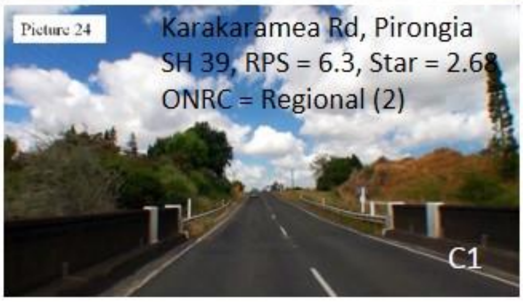

Picture 19
Star =2.73
ONRC = Secondary collector (5)
C6

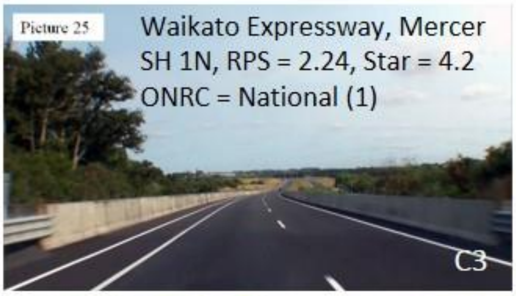

Picture 20
Waikato Expressway, Mercer
SH 1N, RPS = 2.24, Star = 4.2
ONRC = National (1)


Picture 21
Otorohanga Rd, Tokanui
SH 3, RPS = 5.47, Star = 3.1
ONRC = Regional (2)
C4

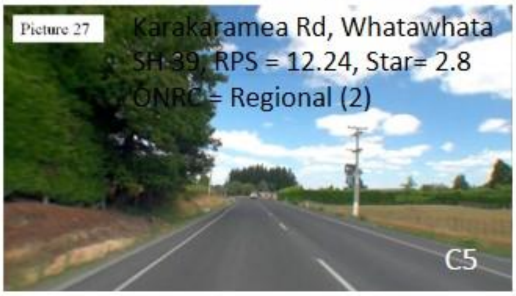

Picture 22
Te Rauamoa
16.42, Star = 2.8
C6


Picture 23
Collins Rd, Hamilton
ONRC = Arterial (3)
C4


Picture 24
Karakaramea Rd, Pirongia
SH 39, RPS = 6.3, Star = 2.68
ONRC = Regional (2)
C1

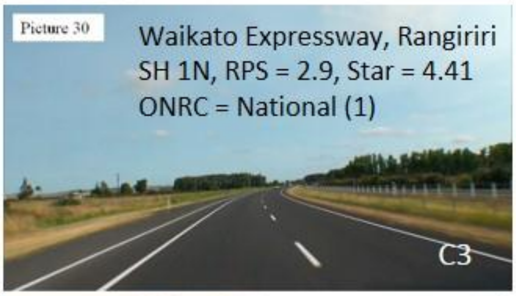

Picture 25
Waikato Expressway, Mercer
SH 1N, RPS = 2.24, Star = 4.2
ONRC = National (1)
C3

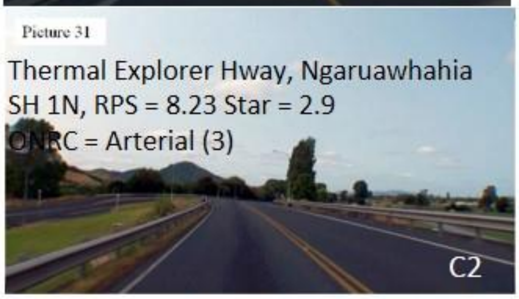

Picture 26
Kawhia Rd, Honikiwi
SH 31, RPS = 9.18, Star = 2.73
ONRC = Secondary collector (5)
C6


Picture 27
Karakaramea Rd, Whatawhata
SH 39, RPS = 12.24, Star= 2.8
ONRC = Regional (2)
C5


Picture 28
Ormsby Rd, Puketotara
SH 39, RPS 5.74, Star = 2.73
ONRC = Regional (2)
C4


Picture 29
Otorohanga Rd, Tokanui
SH 3, RPS = 12.94, Star = 3.1
ONRC = Regional (2)
C2


Picture 30
Waikato Expressway, Rangiriri
SH 1N, RPS = 2.9, Star = 4.41
ONRC = National (1)
C3


Picture 31
Thermal Explorer Hway, Ngaruawhahia
SH 1N, RPS = 8.23 Star = 2.9
ONRC = Arterial (3)
C2


Picture 32
Kawhia Rd
Star = 2.8
ONRC = Secondary collector (5)
C6


Picture 33
Ormsby Rd, Pirongia
SH 39, RPS =8.82, Star = 2.9
ONRC = Regional (2)
C4


Picture 34
SH 1N, RPS = 30.6, Star = 2.9
ONRC = Arterial (3)
C2