Ageing and driver behaviour at rural T-intersections

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Eighty drivers in four groups of 20 (10 males; 10 females), respectively aged under 30 years, 40-59, 60-69 and 70 years and over, participated in research to identify factors contributing to older driver's rural T-intersection accidents.

Participants estimated safe gaps and speeds for traffic approaching from their right from a test vehicle parked at a right-angle to the highway, simulating a T-intersection. Safe gaps for a right turn onto the highway were estimated using threshold (last possible moment) and single judgement procedures (go/not go). A laser device recorded traffic speed and distance. Each participant's speed at turning right across the road also was tested. Drivers aged over 59 years had most visual defects and the poorest neck articulation.

All participants judged speed poorly, over-estimating slower, and under-estimating faster, traffic. They used distance rather than speed in gap estimation. While those under 30 years allowed the smallest gaps, those over 59 years were the least consistent judges and were slower to clear the next lane when turning right. Older drivers may be at higher risk at intersections, especially when approaching traffic exceeds 100km/h, through failure to detect approaching vehicles, poor speed and gap estimation once vehicles are detected, and slower lane clearance when turning.

Road safety research data identify intersections as major road crash sites. The rate of urban accidents is higher but the sequelae are more serious in rural settings because of higher speeds. Older drivers are over represented in the intersection crash statistics and 67% of older drivers who have crashes do so at these sites (Bernhoft, 1990; Evans, 1991; Frith, 1991). Typically, those accidents are multi-vehicle and side-on, frequently, they are fatal (Evans, 1988). Older drivers have more physical and sensory deficits, affecting their detection, perception and response to approaching vehicles. For example, their peripheral and monocular vision is more likely to be impaired and their ability to make compensatory head and/or body movements often is limited, so that early detection of, and response to, approaching vehicles is greatly reduced (Isler, Parsonson & Hansson, 1997; Klein, 1991; Owsley, Ball, Sloane, Roenker & Bruni, 1991). They often underestimate both the speed of approaching vehicles and the time needed to complete the turn safely (Hills, 1980).

Major-minor road intersections present drivers with complex information-processing and motor tasks, as they have to identify and respond to signs, lane markings, and approaching traffic as well as slow down and stop, give signals, and make directional changes, all in an appropriate sequence. Concern over a pattern of fatal crashes involving older drivers at rural T-intersections in New Zealand under otherwise good driving conditions led Transit New Zealand (now known as Transfund New Zealand), the statutory body with responsibility for the country's major road system, to contract the present authors to investigate driver behaviour, especially gap estimation, at these junctions (for full sample description and detailed data analysis see Parsonson, Isler & Hansson, 1996)

Method

Eighty drivers participated, comprising 10 males and 10 females in each of four age groups, 'young' (under 30 years, mean age M= 23.4), 'middle aged' (40 to 59 years, M= 49.9); 'older' (60 to 69 years, M=65.3); 'oldest' (and 70 years and over, M=76.1). Pretests included a driving history questionnaire, a range of vision tests, including monocular visual acuity, stereovision, and horizontal peripheral vision (using a Keystone VS-II Vision Screener and perimetry), reaction time, degrees of head rotation, short-term memory, and a practical test of lane clearance in a right turn from a stopped position.

Judgements of safe gaps and traffic approach speeds were made at a roadside site, simulating a T-intersection on a rural two-lane major road, by drivers seated in the research vehicle as if preparing to turn right onto the major road. Judgements were made only for traffic approaching from the right. Two gap estimation procedures (20 trials of each) and a speed judgement procedure were applied.

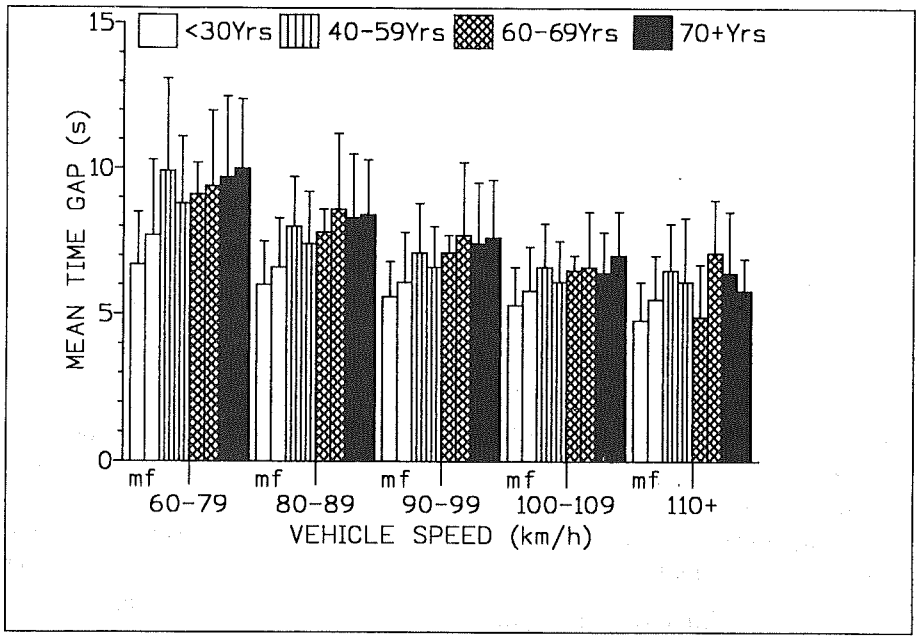
The first was a threshold procedure, in which the driver watched approaching traffic and repeatedly said "yes" until the target vehicle reached the point at which the gap was no longer acceptable, at which point they said "no". The

researcher measured the speed and distance of the vehicle at each "yes" and recorded those at the final "yes".

Single judgement trials followed. In these the driver looked straight ahead and was instructed to look at an approaching car when told to do so by the researcher and to quickly decide and announce the decision to go ("Yes") or not to go ("No"). Whatever the decision, the researcher recorded the speed and distance of the target vehicle at the time of announcing the decision.

Finally, speed judgements (20 trials) were made by the driver giving their estimate of the speed of an approaching vehicle, its speed being recorded by the researcher.

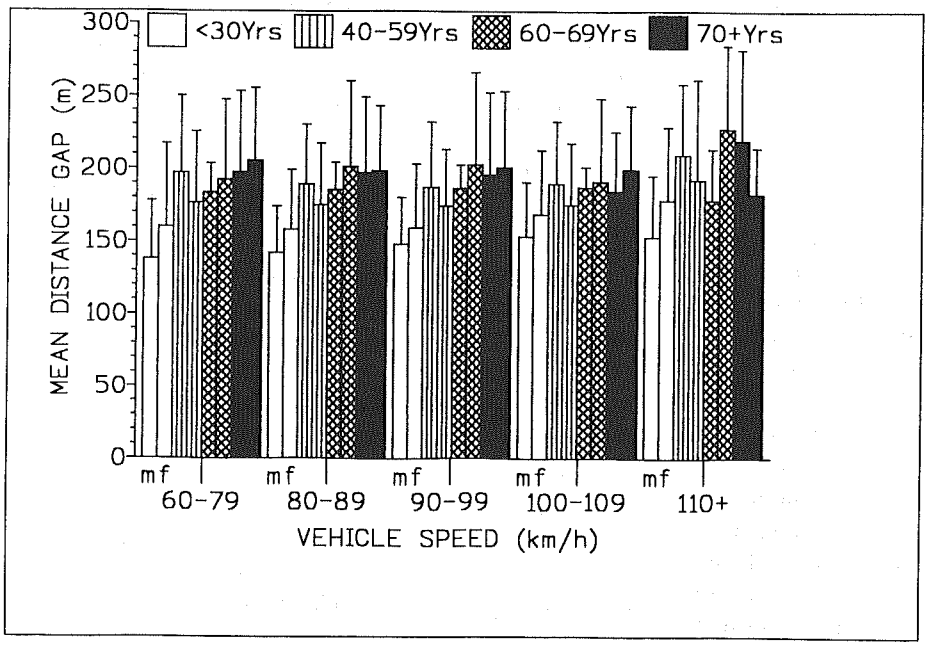
Figure 1



Results and Discussion

Pre-tests revealed that drivers under 30 years (particularly males) reported most accidents and infringements. On average, older drivers (over 59 years) drove fewer kilometers per year and mostly in urban areas, had slightly longer reaction times, more visual defects, more restricted head movement, and were almost 0.4s slower on average in completing the lane-clearance test than their youngest counterparts. For example, the vision test data were instructive. On monocular visual acuity tests, 12 drivers had severe visual impairment on one eye. Of these, 11 were aged 60 or more. Four of the seven impaired drivers aged over 70 years were functionally monocular. On tests of depth perception, 16 participants had scores in the "unacceptable" or "most unacceptable" range, of these 10 were in the over 70 years age group. On tests of neck articulation, the two oldest groups (60-69years, 70+years) had, respectively, 19 degrees and 27 degrees less rotation than the under 30 years group. Thus it is not surprising that age was a more significant variable than gender on ANOVAs on various pre-test data sets. In terms of driving ability, all drivers rated themselves as at least "average", most males self rated as "above average".

Figure 2



Findings from driver judgements were as follows:

Gap estimation using the threshold judgement procedure (see Figures 1 and 2) revealed the following with respect to accepted time gaps for vehicle approach speeds over five categories (60-79, 80-89, 90-99, 100-109, 110+ kph): First, the time gaps accepted as safe, with very few exceptions, reduced as the vehicle approach speed increased, the means ranging between about 6.7s and 10.0s at 60-79 kph and lowering to between 4.8 and 7.0 seconds at 110+ kph; Second, the youngest drivers (<30 years) consistently accepted the shortest gaps, with young males always allowing less time than young females; Third, that only the 40-59 year-old males consistently allowed longer time gaps than their female counterparts,

otherwise men generally allowed less (except for 70+ years males at 110+ kph). ANOVA revealed significant main effects for age ($p<0.05$) and speed ($p<0.01$), but not for gender. The data for distance gaps accepted over the same five speed categories revealed that distance gaps varied little as vehicle approach speeds increased, with means consistently ranging between 140 and 230m and remaining stable across the speed range, and ANOVA revealed a significant ($p<0.05$) main effect for age. These findings suggest that distance, rather than speed, was the primary means for determining safe gaps for right turns at T-intersections under the threshold method.

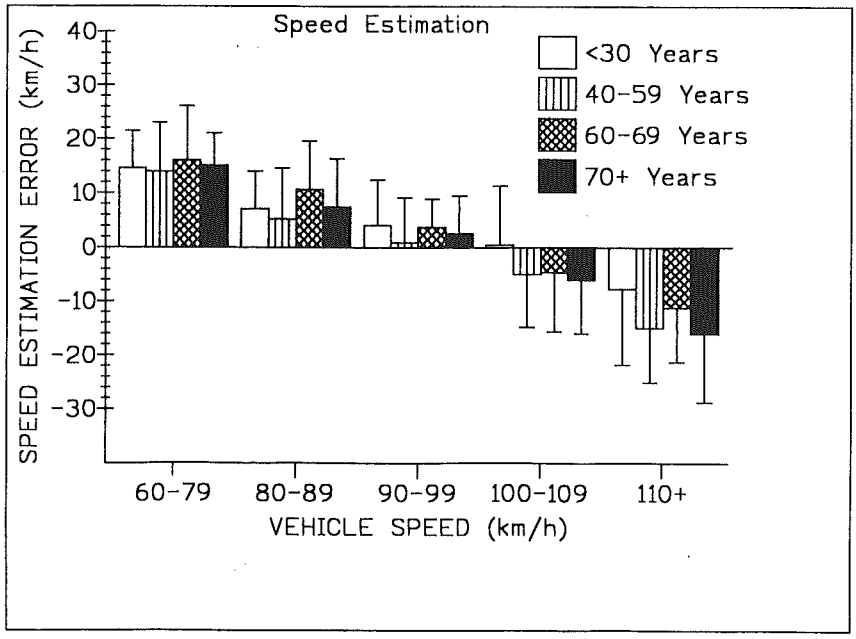
The single judgement data revealed that drivers were not consistent judges, especially when the distances of approaching vehicles were just above or below the typical thresholds revealed in the previous gap estimation trials. Most drivers took longer to decide "No" than "Yes", and men tended to both make "Yes" decisions more quickly (in the 40-59 years group the men were slower) and be more consistent in their judgements than similarly aged women. These results suggest that "Yes" decisions may be easier to make if the target car is beyond the threshold distance and that males may be more practised, given higher annual driving distances, or less cautious than equivalent age females. As was evident in the threshold trials, young drivers (<30 years) tended to accept the smallest time and distance gaps in single judgement trials, with most males accepting gaps within 4-7s of impact (distance 90-160m) and females accepting gaps within the same time band but a broader distance (70-200m).

Surprisingly, more young females than males made extremely risky acceptances (1-4s; <80m) with vehicle approach speeds in the 80-99 kph range, which may reflect less driving experience and/or less skill in judging distance and speed. In all, younger drivers appeared to be prepared to take greater risks in gap acceptance than drivers over 30 years old, but women aged 60-69 years and men aged over 70 years were the least safe judges. As with the threshold method, the speed of the approaching vehicle did not have as much control over decisions as distance. Although "No" decisions were slightly more probable for vehicles exceeding 110 kph if within 150-200m, drivers were more likely to accept vehicles beyond 150m and reject a gap of less than 100m.

The results of the speed estimation trials (see Figure 3) clearly show that drivers of all ages overestimated the speed of vehicles travelling below 100 kph and underestimated those travelling over 99 kph, the extent of over- or under-estimation was directly related to the speed, so that the slower the vehicle, the greater the over-estimation error and the faster the vehicle, the greater the underestimation. The data suggest a tendency to assume traffic will be travelling at the open road speed limit (100 kph), regardless of its actual speed. The data suggest a tendency to assume traffic will be travelling at the open road speed limit (100kph), regardless of its actual speed. At approach speeds of less than 100 kph, women in the 60-69 years group more seriously overestimated approach speeds than similarly aged men, whereas in the 70 years and over group, men and women produced similar degrees of overestimation. At speeds of 100-109 kph, the 70 years and over women underestimated significantly compared with equivalent males, but speeds over 110 kph, both sexes fared badly, even by comparison with 60-69 year-olds. This pattern suggests increasingly poor speed judgement occurs with ageing which, combined with more evident vision and head movement restrictions, can lead to late detection and underestimation of speed of fast approaching vehicles thus increased probability of intersection crashes.

Overall, these results indicate that all drivers are likely to have some difficulty in making gap estimation judgements at T-intersections because they tend to rely much more on judging the distance of approaching vehicles than on estimating their speed, the older drivers have additional handicaps affecting judgement. The data on approaching vehicle speed estimation reveal that slower vehicles' speeds are likely to be overestimated, while those of faster vehicles will be underestimated. Drivers may learn to rely more on distance judgement because they experience difficulty with speed, so try to set "safe" distance gaps to accommodate for this. Underestimation of faster vehicles is more dangerous when distance is relied upon, so drivers may need to be taught to accept larger distance gaps (say 200m) to increase the buffer effect. Younger drivers appear to be more at risk from regularly accepting small gaps, whereas drivers aged over 59 years are more likely to be at risk through failure to detect and respond to approaching vehicles due to deteriorating vision and physical deficits that restrict compensatory heads

Figure 3



movements.

Safety at rural major-minor road T-intersections can be enhanced by reducing approach speeds on the major road and by providing clear view from the minor road at the intersection of over 300m. For older drivers, there is a need for better vision and head movement assessment during relicensing (see also Isler, Parsonson & Hansson, 1997), training in setting longer distance gap acceptance thresholds, and, where appropriate, issuing licenses to restricted urban, off-peak, and/or daytime driving to allow mobility but reduce risk.

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Notes:

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