Road user perception of safety at Safe System intersections

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Key Findings

- Survey respondents perceive roundabout controlled intersections to be safer than stop or give way controlled intersections in both rural and metro scenarios.
- Survey respondents perceive plateau (raised platform) intersections to be less safe than stop or give way controlled intersections in metro scenarios.
- Study findings suggest that public perception of the benefits of increasingly Safe System aligned intersection designs are tied to their familiarity to the public.

Abstract

This study examined driver perceptions of safety at metro and regional intersections with different types of control. Data were collected using an on-line survey with 696 participants drawn from the Royal Automobile Association of South Australia's Member Panel. Results demonstrate a greater perception of safety associated with the use of roundabouts, yet a reduced perception of safety associated with a lesser known Safe System aligned design of raised plateaus, suggesting a need for greater public awareness of the benefits of less well-known treatments.

Keywords

Intersection, control, Safe System, roundabout

Introduction

In South Australia, 508 of the 1,211 right angle fatal and serious injury (FSI) crashes that occurred in the 10 years between 2007 and 2016 were at intersections where stop or give way control was applied. An additional 479 right angle FSI crashes occurred where no control was employed (i.e. where no control device such as a give way/stop sign or traffic signal was present at the intersection). Together, these represent over 11% of all FSI crashes on South Australian roads. These statistics are based on South Australian police crash data.

The design of non-signalised intersections in Australia has traditionally relied on stop and give way controls. In some jurisdictions, the T-junction rule has been employed in-lieu of stop or give way control in certain situations. At these intersections, safe operation is predicated on road user attention and decision-making; road users must identify the intersection, comply with any controls and make the right decisions to avoid conflicts with other vehicles (Austroads 2018). Research has found that the increased cognitive workload induced by complex traffic environments can lead to delayed response times and reduced driving performance (e.g., lane keeping, speed choice, response to safety critical events, etc.). Such findings suggest complex driving environments, including intersections, may increase the likelihood of driving errors, particularly for inexperienced or older drivers (Austroads, 2016; Cantin et al., 2009; Edquist et al., 2012; Patten et al., 2006; Ross et al., 2014).

A study undertaken by Andersson (1982) concluded a 44% reduction in all crashes and a 65% reduction in right angle crashes at 4-leg intersections where give way control was replaced with stop control. Other research has also shown crash reductions where stop control was installed at intersections with no previous control (Elvik et al. 2009, Frith and Harte 1986). In light of such research, the use of stop control in-place of give way control based on safety related concerns may be appropriate: in Australia, stop control is allowed in-place of give way control where there is insufficient sight distance at an intersection (Standards Australia 2009). Stop control is also used as a means of treating intersections with a poor safety record, though this is not formally acknowledged in either the Australian Standards or Austroads Guides. However, a substantial number of FSI crashes occur at stop-controlled intersections in South Australia, giving rise to concern that such a method of improving safety at intersections is not well-aligned to the Safe System objective of eliminating serious injuries and death on our roads.

While the increase in control by using stop control may reduce crash likelihood, it will not reduce the severity of a crash should it occur. Safe System aligned designs that are aimed at reducing the severity of crash outcomes through the control of impact speed and impact angle, such as roundabouts and raised plateaus (Austroads 2015, 2018), have historically been employed on a less common basis but are becoming more widely used throughout Australia.

While there is a large professional body of knowledge related to the safety benefits of Safe System aligned designs (e.g., Austroads, 2018), little is known about public perception of these designs.

Research shows that the provision of treatments on roads and at intersections can alter cyclists' and pedestrians' perceptions of safety at those sites (e.g., Emo et al., 2011; Ng et al., 2017; Perdomo et al., 2014; Wang & Akar, 2018). While no research regarding driver perceptions of intersection safety was identified however, investigations of some treatments, including road delineation and perceptual countermeasures have been found to influence driver behaviour via driver perceptions of comfort and risk (e.g., Elvik et al., 2009; Horberry et al., 2006; Walton et al., 2011). Other elements of the road network, including intersection complexity, traffic volume, and vehicle travelling speeds can also influence the perceived safety of intersections (Wang et al., 2002). As such, the aim of this study is to identify road user perception of safety at non-signalised intersections where different types of control are employed, including approaches aligned with Safe System.

Methods

The data presented in this study were collected through an online survey that was commissioned as part of a larger research project undertaken for the Department of Planning, Transport and Infrastructure (DPTI) in South Australia. The larger research project was framed around identifying whether an increase in control translates into improved safety. This study focusses on the results of the survey and not the wider research project for which it was commissioned.

Survey distribution

The survey was developed and distributed with the assistance of the Royal Automobile Association of South Australia (RAA). This method was chosen as:

- A greater number of responses were likely compared to other feasible methods (e.g. recruitment through the Centre for Automotive Safety Research [CASR] website, recruitment of university students).
- CASR has a longstanding relationship with the RAA who were receptive to the idea of collaboration.
- All other methods displayed bias that may be equal to or greater than that of the selected method.

The RAA elected to recruit respondents through their Members Panel. The Members Panel consists of subscripted RAA members who elect to respond to regular surveys. At the time of the survey, the RAA had more than 685,000 members able to participate in Member Panel surveys, though only a small proportion were registered to receive the surveys. The survey was completed online through the RAA Member Panel website and was available for one week. Multiple attempts were not allowed. The survey was restricted to respondents who were at least 18 years of age, were residents of South Australia, and had a full driver's licence. A total of 846 people attempted the survey, of which 696 completed and submitted their responses. Incomplete surveys were excluded from analysis.

Questions

The survey consisted of four general themes of inquiry organised in four sections. Only the questions related to the aim of this study are discussed. These are the general profiling questions and "perception of personal safety at intersections" questions. The other two themes ("negotiating rural T-junction intersections" and "understanding of intersection warning signs") are not discussed in this study.

General profile questions

This consisted of questions regarding demographic, driving practices and behaviour, and general perception of risk. The purposes of these questions were to establish the profile of respondents, their general driving practices and behaviour, as well as establishing the respondents' perception of personal safety in terms of the general task of driving and from where this risk (i.e. sources of risk such as one's own behaviour, the behaviour of others, or the road environment) arises.

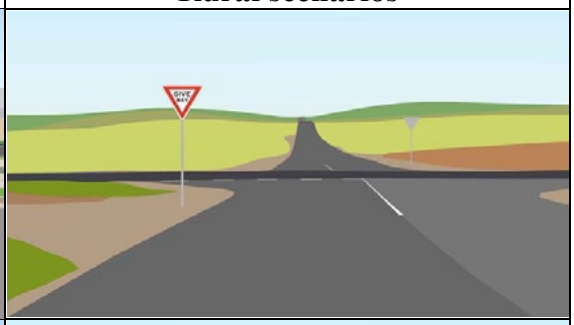
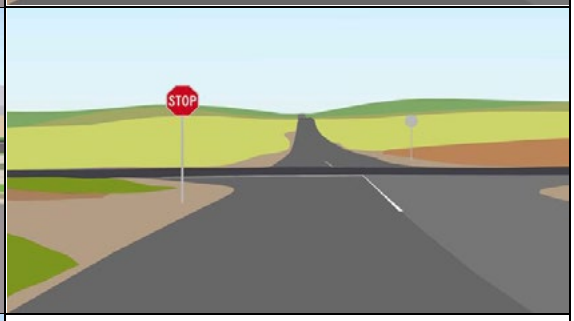
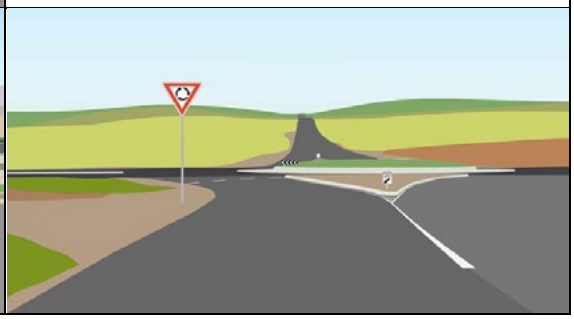
For one general profile question in the survey ("Considering all factors [e.g. the road environment, other drivers, your own driving ability], how safe do you perceive the task of driving to be?"), respondents were asked to select an answer from a rating scale (very safe; moderately safe; neither safe nor dangerous; moderately dangerous; very dangerous). This same rating scale was used for the "perception of personal safety" questions (below). The terms "safe" and "dangerous" were not defined to the survey respondents.

Perception of personal safety at intersections questions

These questions were related to the core objective of the project and consisted of questions regarding respondents' perceptions of risk when faced with a specific scenario of turning right at a two-lane/two-way cross road intersection. The respondents were presented with an image from a driver's point of view on the approach to the intersection along the minor road. The wording for each question was identical ("You are driving a passenger vehicle and approaching a "cross road" intersection along a [metro/rural] road. How safe do you perceive performing a right turn to be?").

Seven scenarios were presented: four at a metro intersection and three at a rural intersection (Table 1). Each scenario differed by the type of control used to control the movements of minor road vehicles. Four types of control were presented: give way (single sign, control line), stop (single sign, control line), raised plateau (raised intersection footprint, single give way sign, control line) and roundabout (roundabout intersection footprint, single roundabout sign, control line). All four scenarios were presented for both metro and rural locations, with the exception of no raised plateau scenario

Table 1. Images presented to respondents for each scenario of the perception of personal safety at intersections questions

	Image presented to respondents	
	Metro scenarios	**Rural scenarios**
Give way control		
Stop control		
Plateau		Not presented
Roundabout		

for the rural location due to the treatment's relative scarcity in rural areas. Respondents were not informed about the differences between each intersection, instead relying solely on what was visually presented to them with each image. The intention behind including these intersections was to assess road user perception of safety at intersections that are objectively safer (roundabout and raised plateau) than that of traditional cross road designs (Austroads, 2015, 2018).

Results

General profile questions

Demographic questions identified most respondents (78.9%) as residing in the Adelaide metropolitan area (5000 – 5199 postcode area) (see Table 2). A further 17.5% resided in the inner rural areas of South Australia (5200 – 5499 postcode area) and 3.6% resided in the outer rural areas of South Australia (> 5500 postcode area), including one from Broken Hill, NSW (2880 postcode).

Table 2. Residential postcode of survey respondents

Residential postcode	N	%
5000 – 5199 (metro)	549	78.9
5200 – 5499 (inner rural)	122	17.5
5000 and above (outer rural)	24	3.5
2880 (Broken Hill)	1	0.1

Most respondents were aged 45 years and over (90.9%) with 11.2% being 75 years and over (see Table 3). The majority of respondents had held an unrestricted driver's licence for 20 or more years (93.7%) (see Table 4).

Table 3. Age range of survey respondents

Age range	N	%
18 – 24 years old	2	0.3
25 – 34 years old	21	3.0
35 – 44 years old	40	5.7
45 – 54 years old	108	15.5
55 – 64 years old	174	25.0
65 – 74 years old	273	39.2
75 – 84 years old	72	10.3
85 years old and above	6	0.9

Table 4. Time having held an unrestricted drivers licence of survey respondents

Time holding unrestricted license	N	%
Less than 1 year	2	0.3
1 – 2 years	2	0.3
3 – 4 years	2	0.3
5 – 9 years	8	1.1
10 – 14 years	12	1.7
15 – 19 years	18	2.6
20 years or more	652	93.7

Almost all respondents had driven a passenger vehicle in the past six months (99.0%) (see Table 5). Less had ridden a bicycle (26.6%), motorcycle (11.5%), or had driven a heavy vehicle (14.8%) in the past six months. Five respondents had not driven/ridden any of these vehicles in the past six months.

Table 5. Vehicles having been driven by survey respondents in past six months

Vehicles driven/ridden in past 6 months	N	%
Bicycle	185	26.6
Motorcycle	80	11.5
Passenger vehicle (e.g. car, van)	689	99.0
Heavy vehicle (e.g. truck, bus)	103	14.8
None of the above	5	0.7

Most respondents reported that in the past six months, they had driven on metro roads most days (65.9%) (see Table 6). Only 4.0% reported having rarely or never driven on metro roads. In comparison, the minority of respondents reported having driven on rural roads most days (19.8%), with nearly half reporting having driven sometimes, rarely or never on rural roads (48.8%).

Table 6. Frequency of survey respondents driving on metropolitan and rural roads in past six months

	Metropolitan roads		Rural roads	
Frequency of driving in past 6 months	N	%	N	%
Never	5	0.7	12	1.7
Rarely	22	3.2	76	10.9
Sometimes	88	12.6	252	36.2
Often	122	17.5	218	31.3
Most days	459	65.9	138	19.8

The majority of respondents reported driving for two or less hours per day (87.1%) (see Table 7). Only 2.9% reported driving for five or more hours per day.

Table 7. Average hours per day driven by survey respondents

Average number of hours driving per day	N	%
Less than 1 hour	286	41.1
1 – 2 hours	320	46.0
3 – 4 hours	70	10.1
5 or more hours	20	2.9

The majority of respondents perceived themselves as driving at about the same speed as other traffic around them (80.5%) (see Table 8). A small proportion perceived themselves as generally driving slower (11.9%) or faster (7.6%) compared to other traffic around them.

Table 8. Self-reported driving speed of survey respondents compared to other traffic

Driving speed respective to other traffic	N	%
Slower than most	83	11.9
About the same speed as those around me	560	80.5
Faster than most	53	7.6

Regarding perceptions of the general task of driving (see Figure 1), the majority of respondents regarded driving to be moderately safe (50.3%). A substantial proportion regarded it as being very safe (14.9%), while a minority regarded it as being very dangerous (1.7%).

When asked about their perception of the greatest risk to their own safety as a road user, most respondents nominated the action of other road users (82.2%), while few nominated their own actions (7.8%) or the road environment in which they drive (10.1%).

Perception of personal safety at intersections questions

For each intersection scenario, the respondents were asked to rank their perception of their own personal safety if they were to perform a right turn from a minor road at a non-signalised intersection, as per the four metro and three rural scenarios described above.

The results for the metro scenarios were broadly similar, with a near majority of respondents perceiving each scenario as "moderately safe" (see Figure 2). The results for the give way control and stop control scenarios showed no statistically significant different at a 95% confidence level ($p = 0.58$) (see Table 9). A similar proportion of respondents perceived the give way control and stop control to be moderately or very dangerous (22.3% and 21.7%, respectively) (see Table 10). The results for the plateau scenario showed a near statistically significant difference compared to the give way control scenario ($p = 0.09$) with a greater proportion of respondents perceiving the plateau scenario to be moderately or very dangerous (24.4% versus 22.3%). The results for the roundabout scenario showed a statistically significant difference compared to the give way control scenario ($p = 0.00$) with a lesser proportion of respondents perceiving the roundabout scenario to be moderately or very dangerous (17.0% versus 22.3%).

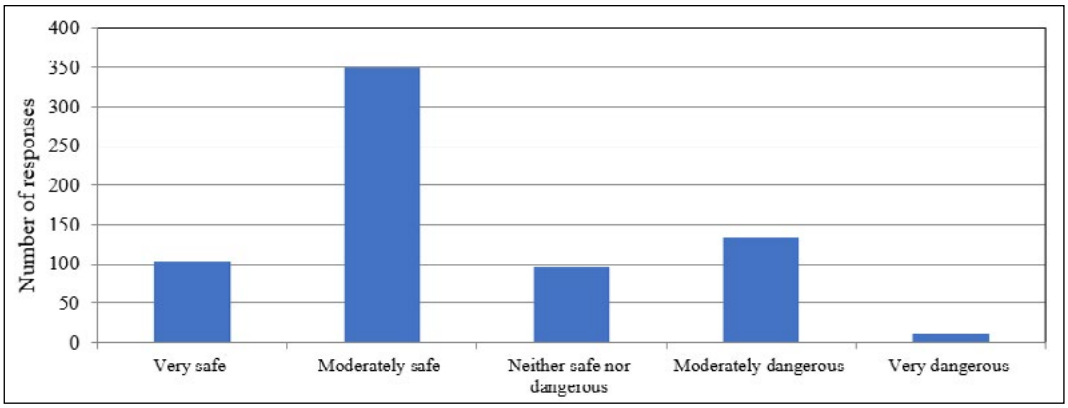


Figure 1. Results of perception of personal safety for the general task of driving

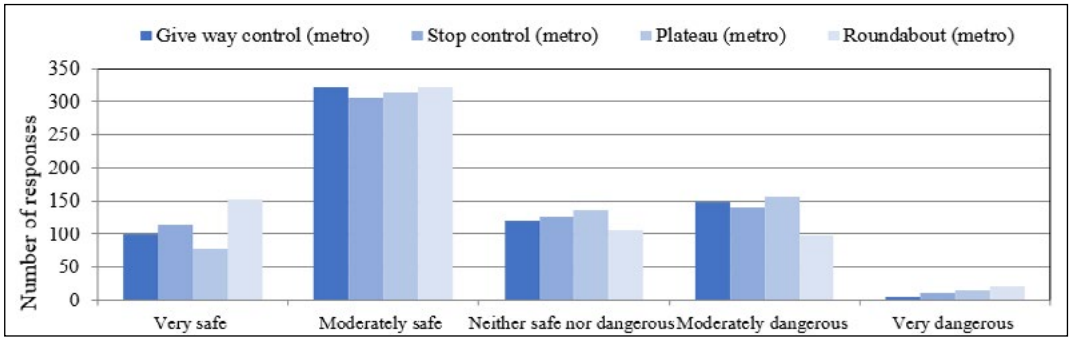


Figure 2. Results of perception of personal safety at metro non-signalised intersections given four different control/design scenarios

Table 9. Results of perception of personal safety at metro non-signalised intersections given four different control/ design scenarios

Type of control	Response category					Chi-squared analysis		
	VS*	MS*	N*	MD*	VD*	$X^{2\#}$	df	p-value
Give way	99	321	121	149	6	2.89	4	0.58
Stop	115	305	125	141	10			
Give way	99	321	121	149	6	7.95	4	0.09
Plateau	76	314	136	155	15			
Give way	99	321	121	149	6	31.65^	4	0.00
Roundabout	152	321	105	97	21			

*VS = Very safe; MS = Moderately safe; N = Neither safe nor dangerous; MD = Moderately dangerous; VD = Very dangerous.

#Right tail Chi-squared statistic

^Statistically significant difference between response category distributions at a 95% confidence level

Table 10. Aggregated results of perception of personal safety at metro non-signalised intersections given four different control/design scenarios

Type of control	% responses moderately safe or very safe	% responses moderately dangerous or very dangerous
Give way	60.3%	22.3%
Stop	60.3%	21.7%
Plateau	56.9%	24.4%
Roundabout	68.4%	17.0%

As with the metro scenarios, the results for the rural scenarios were broadly similar, with a substantial proportion of respondents perceiving each scenario as "moderately safe" (see Figure 3). The results for the give way control and stop control scenarios showed a near statistically significant difference at a 95% confidence level (p = 0.07) (see Table 11). A lesser proportion of respondents perceived the stop control scenario to be moderately or very dangerous when compared to the give way control scenario (26.0% versus 29.5%, respectively) (see Table 12). The results for the roundabout scenario showed a statistically significant difference compared to the give way control scenario (p = 0.00) with a lesser number of respondents perceiving the roundabout scenario to be moderately or very dangerous (15.2% versus 29.5%).

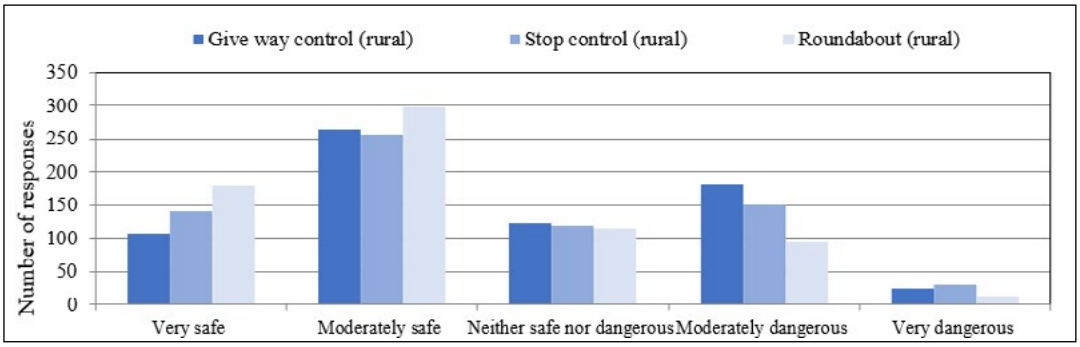


Figure 3. Results of perception of personal safety at rural non-signalised intersections given four different control/ design scenarios

Table 11. Results of perception of personal safety at rural non-signalised intersections given four different control/ design scenarios

Type of control	Response category					Chi-squared analysis		
	VS*	MS*	N*	MD*	VD*	$X^{2\#}$	df	p-value
Give way	106	263	122	181	24	8.50	4	0.07
Stop	141	255	119	151	30			
Give way	106	263	122	181	24	52.56^	4	0.00
Roundabout	179	297	114	94	12			

*VS = Very safe; MS = Moderately safe; N = Neither safe nor dangerous; MD = Moderately dangerous; VD = Very dangerous.

#Right tail Chi-squared statistic

^Statistically significant difference between response category distributions at a 95% confidence level

Table 12. Aggregated results of perception of personal safety at rural non-signalised intersections given four different control/design scenarios

Type of control	% responses moderately safe or very safe	% responses moderately dangerous or very dangerous
Give way	53.0%	29.5%
Stop	56.9%	26.0%
Roundabout	68.4%	15.2%

Discussion

The results indicate that, for both metro and rural scenarios, roundabouts were perceived as being safer than other forms of non-signalised control, which is in-line with professional knowledge of roundabout performance with regard to vehicle occupant safety (Austroads 2018). However, plateau (or raised platform) intersections seem to be perceived as less safe than a similarly controlled intersection without a plateau. This is counter to professional understanding and could suggest a lack of public understanding of the design.

The difference between the results for the roundabout scenario and the conventionally control scenarios (i.e. give way and stop control scenarios) was greater for the rural scenarios than for the metro scenarios. This suggests that an awareness of the environmental differences skewed the perception of the respondents. In other words, the difference between the perceived safety of a roundabout intersection versus a conventionally controlled intersection is greater for the rural environment where the speeds are fast, compared to the metro scenario where the speeds are generally much slower. For the metro scenarios, the speed environment appears to be sufficiently slow that the difference between intersection control does not play as greater role in determining the perceived safety.

For the rural scenarios, the stop control was perceived as safer than the give way control. This result is counter-intuitive considering the justification for installing stop control instead of give way control is a lack of sight distance (a generally more dangerous scenario) or as an informal treatment for intersections with a poor safety record.

Limitations

The primary limitation in the present study is the use of a convenience sample for data collection, including:

- The recruitment process was not randomised and was selective of a specific cohort.
- The wider population outside of RAA members were not recruited.
- The Member Panel demographic does not generally reflect the demographic of the wider population of South Australian road users

The generally older and more experienced demographic of the survey respondents was the most noticeable difference between the survey sample and the general population in South Australia. This could lead to results that do not accurately reflect the younger and less experienced cohort.

In general, the limitations of this study mean that systematic bias could be introduced by recruiting RAA Member Panel members such that the results that may not accurately reflect the perceptions of the broader population of South Australian road users. Future research should endeavour to recruit a more representative sample.

Conclusions

This study has shown a possible mixed understanding of safety risk associated with Safe System aligned intersection design; more commonly encountered roundabouts are seemingly perceived as safer while less commonly encountered raised plateaus are perceived as less safe. Such a finding suggests safe intersection designs may not be intuitively perceived as safe and highlights the importance of demonstrations in pursuing the Safe System aligned innovations required to eliminate harm from the road network.

Acknowledgements

This study was undertaken with the support of personnel from the Royal Automobile Association of South Australia (RAA), who helped to design the study survey and distributed the survey amongst its members. This study was also supported by personnel from the Department of Planning, Transport and Infrastructure (DPTI) in South Australia, who helped design and manage the project of which the survey was a part.

Funding: This study was funded by the South Australian Department of Planning, Transport and Infrastructure (DPTI) through a Project Grant to the Centre for Automotive Safety Research. The DPTI Project Manager was Alex Duerden.

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