Influence of visible work activity on drivers’ speed choice at roadworks

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Vehicle traffic through roadwork sites creates a hazardous work environment, with speed limit noncompliance a major contributor to the high risk and high severity of roadwork crashes. This paper examines responses to an online survey to better understand the factors underlying drivers’ work zone speed choices. Drivers’ stated speed choice was compared between two photographs of the same work zone section – one with workers and machinery present and another with no visible activity. Drivers also provided comments on any aspect of roadwork safety they thought was important. A paired t-test of stated speed choice revealed that significantly lower mean speeds were nominated when workers and machinery were clearly present and active (41.7 vs 53.5 km/h, p<0.01). Participants expressed concern about roadwork signage and reduced speed limits being left in place when there was no apparent work activity. Driver perceptions, and thus compliance, may be improved through technological and operational changes.

Introduction

Public vehicle traffic through roadwork sites creates a hazardous work environment for traffic controllers and others engaged in roadwork. Dozens of workers are killed or seriously injured by moving vehicles every year at Australian roadwork sites, while similar outcomes also befall many motorists involved in work zone crashes. As reported previously by the current authors (Debnath, Blackman et al., 2012), about 50 deaths and 750 injuries are conservatively estimated to result from road traffic crashes in Australian work zones each year. Due to a lack of systematic reporting it is difficult to quantify these incidents via official Australian records, but in other highly motorised countries they reportedly contribute to about 2% of road deaths and 2% of work-related fatalities (Pegula, 2004; SWOV, 2010).

Crash rates have been found to increase during roadwork compared to pre-work periods (Whitmire II, Morgan et al., 2011). Doege and Levy (1977) found that Illinois Tollway injury crash rates nearly doubled during construction compared with pre-construction rates. Khattak, Khattak et al. (2002) reported more moderate increases in injury crash rates on California freeways (17.3%), but noted importantly that crash frequencies increased significantly with work zone duration. Crashes in work zones are also more severe than those occurring elsewhere (Pigman & Agent, 1990).

The relationship between speed and crash risk is well documented in the road safety literature, with excessive or inappropriate speed a prominent causative factor in road crashes generally (Aarts & van Schagen, 2006). It follows that poor compliance with reduced speed limits is a major contributor to the high risk and relatively high severity of roadwork crashes, which often involve public vehicles. Studies demonstrating poor speed limit compliance as a major causative factor in work zone crashes are numerous, including those listed by Garber and Patel (1995). The speed-crash rate relationship was discussed more recently by Chen and
Tarko (2012), who also reported that work zone crash rates increase with greater speed variance as well as with higher speeds.

Construction workers, traffic controllers, engineers and site managers clearly recognise the hazard of working close to moving traffic, having cited speeding as a major common cause of work zone crashes in recent interviews with the authors (Debnath, Blackman et al., 2013). The perceptions of workers are justified in light of the literature, but many were largely resigned to accepting that their work exposes them to numerous hazards and as such is often dangerous. While noting the perceived limitations of current traffic control measures, there was relatively little input from interviewees as to how speed limit compliance might be improved through innovative interventions.

The workers interviewed at Queensland worksites (Debnath et al., 2013) were correct to perceive that the overall effectiveness of current speed control measures is limited. Recent measurement of speeds at Queensland roadwork sites demonstrates high levels of non-compliance with reduced speed limits in typical situations (Debnath, Blackman et al., 2014; Debnath, Banks et al., 2014). For example, a study of pilot car effectiveness at a long term Queensland site found that approximately 98% of vehicles exceeded work zone speed limits when the pilot car was not operating, reducing to 85% of vehicles under pilot car operation (Debnath et al. 2014). Similar observations have been made in other Australian and international jurisdictions. More than 40% of cars and 70% of trucks were observed exceeding signed speed limits at roadworks in Victoria (Haworth et al., 2002). In another Victorian study, more than 60% of drivers exceeded the 60 km/h work zone speed limit (VicRoads, 1990), with 10% of drivers exceeding the limit by 15 km/h or more. In the United States, a survey of 930 truck drivers found that half of the respondents admitted to exceeding work zone speed limits (Benekohal & Shim, 1999). Improving speed limit compliance thus remains a high priority in efforts to improve roadworker safety.

A review of the effectiveness of various work zone speed control measures categorised them as Physical, Informational, Enforcement and Educational measures, with some clearly more effective than others (Debnath et al., 2012). The review found that enforcement measures have the greatest influence on driver speeds, but limited resources preclude enforcement at the majority of sites and for extended periods at any given site. As such, work zone safety improvement efforts cannot rely on enforcement as the primary speed control and traffic management measure (Austroads, 2012).

Traditional static signage (including regulatory speed limit signs), an informational measure, has some effect in lowering speeds but does not achieve widespread compliance. For example, an Australian study (VicRoads, 1990) found that more than half of drivers (57%) did not adjust their speeds according to work zone speed limits. Similarly, more than one third (36%) of surveyed Queensland drivers reported that they willingly disobeyed roadwork speed limits (TMR, 2009). According to these and other studies (Brewer, Pesti et al., 2006; Haworth, Symmons et al., 2002), drivers’ speed choice is often based on their perceptions of the level of risk present at the time, rather than the posted speed limits. Consistent with this is the finding by Bham and Mohammadi (2011) that vehicles travel slower through work zones during construction activity than in periods of no construction.

Given the information summarised above, it is argued that greater understanding of and attention to driver perceptions and motivations is necessary in order to improve work zone speed limit compliance. In a superficial sense this argument is not new, as reflected in generally high regard for the potential of Educational measures (despite limited positive
evaluations), but it can also be argued that progress in this area has been extremely limited at a practical level.

To address the posited need for greater attention to driver perceptions and motivations, the current paper examines the influence of apparent work activity and the presence of workers on drivers’ speed choice at roadwork sites. This is achieved through mixed methods analysis of two items within a survey of Queensland drivers, wherein qualitative data is presented as complementary to the quantitative analysis. The first item concerns drivers’ stated speed choice in the presence/absence of workers, while the second focuses on issues which most concern drivers about negotiating roadworks according to their comments. This approach is intended to offer a deeper understanding of not only what drivers do when traversing work zones, but also of reasons underlying their behaviour, than is readily available in the current literature.

**Data and method**

An online survey of Queensland drivers was conducted from November 2013 to February 2014 to investigate factors influencing driver behaviour at roadwork sites. In the first and largest section of the survey, participants viewed still images of 12 scenarios photographed at nine different worksites and were asked to nominate the speed at which they would drive through each work zone section. The scenarios appeared one at a time on the screen and in randomised order so that participants did not receive them in the same sequence.

Different roadway, worksite and environmental characteristics were evident in the scenarios, including rural and urban highways, urban arterial and minor suburban roads, day and night works, dry and wet weather conditions, and varied horizontal and vertical alignment. Some scenarios included workers and/or machinery in the foreground or middle ground of the photograph while others presented a worksite with little or no apparent work activity. The worksites pictured in the scenarios all operated under reduced speed limits (with various other traffic control measures), including 7 scenarios under a 40 km/h limit, 4 under a 60 km/h limit and 1 under a 20 km/h limit. All speed limit signage was removed (blurred) in the images so that participants would not know the designated speed limit for each scenario when nominating the speed at which they would drive through the section illustrated.

For this paper the analysis of speed choice focused on 2 of the 12 scenarios presented in the survey, comparing respondents’ stated speed choice on the same 60 km/h work zone section in two different conditions: workers and machinery present/not present (Figures 1 and 2). The same work zone section was used for each scenario to minimise potential perception biases due to varying work zone characteristics other than the presence/absence of work activity. In other words, the two scenarios were essentially the same but for the presence or absence of activity, thereby isolating the variable of interest from potentially confounding site factors (such as differences in geometric alignment, road surface, traffic controls and weather conditions, for example). The two scenarios are referred to hereafter as the Activity scenario (with workers) and the No activity scenario (with no workers).

Reported mean speeds were calculated for each scenario and the means were compared using paired t-tests - both aggregately and dis-aggregately for different age and gender groups - to identify statistically significant differences. The paired t-test was the appropriate choice here for two key reasons: (1) the data were paired (each participant perceived speed values for both scenarios) and (2) the variances of the speeds in the two scenarios were different, so an ‘analysis of variance’ approach was not suitable.
Analysis of responses for all 12 scenarios, including consideration of the many variables present other than presence/non-presence of work activity, was unfortunately beyond the scope of the current paper. Further analyses of the survey data will address this need and will be documented in future work by the authors.

Figure 1: Activity scenario

Figure 2: No activity scenario

A later item in the survey gave participants the opportunity to provide free text comments on any aspect of roadwork safety that they felt is important and may have been overlooked in the survey. These unprompted comments were analysed qualitatively to identify any prominent and pertinent themes, and particularly those that were relevant to speed choice. Comments directly relevant to speed choice were then isolated and the posited reasons for speeding in work zones identified, thus permitting a deeper interpretation of the analysis of speed choice than would have been otherwise possible.

Recruitment

Selection criteria for the survey required that participants be Queensland residents, held a current Queensland driver licence, had driven at least weekly in the last 12 months (any registered vehicle type) and had not been employed directly in road construction, maintenance and/or traffic control.

Participants were recruited using a range of strategies, including through the Centre for Accident Research and Road Safety (CARRS-Q) InSPIRS research Panel (Independent Survey Panel in Road Safety). At the time of the survey launch the InSPIRS Panel consisted of approximately 850 members of the public who had previously agreed to participate in
research conducted by CARSS-Q. There were 373 panel members who met the criteria for survey participation and these members were subsequently invited to participate in the survey.

Participants outside of the CARRS-Q InSPiRS research Panel were recruited through advertising on the CARRS-Q website, group email distribution by industry partners to staff, radio interviews, newspaper coverage, and through snowballing techniques (word of mouth). Mainstream media were alerted to the survey by two media releases on the research project which were prepared by the university’s media department.

Participants

A total of 410 participants completed or partially completed the survey, including 99 members of the CARRS-Q InSPiRS research panel and 311 members of the general public. Of the total 410 survey responses, 7 had missing values for stated speed choice, age and/or gender. These cases were excluded from the statistical analysis, leaving 403 valid cases for analysis.

Among the 403 participants, 53.8% were males and 46.2% were females, while 71.5% were aged 25-59 years, with younger drivers (17-24 years) and older drivers (60 or over) comprising 5.7% and 22.8% of respondents, respectively. Younger drivers were somewhat underrepresented in the survey sample (5.7% vs 13.1%), drivers 25 - 59 years slightly overrepresented (71.5% vs 64.2%) and older drivers represented proportional (22.8% vs 22.7%) to Queensland licence holders (TMR, 2013).

Place of residence (postcode) was provided by 64.3% of participants, by which an approximate estimation of geographic distribution was calculated. Based on this estimation the sample appears roughly representative of the Queensland population according to census data in Australian Statistical Geography Standard (ASGS) categories (Major Cities; Inner Regional; Outer Regional; Remote and Very Remote), though Outer Regional residents appear slightly overrepresented (22.4% vs 14.7%) (ABS, 2013). In terms of income distribution, lower income households (<$50,000 pa) appear underrepresented in the survey sample compared with the Queensland population (16% vs 42%), while higher income households (≥$100,000) were overrepresented (47% vs 28%).

The survey sample had a lower proportion of single person households than the Queensland population (10.4% vs 22.8%) and a higher proportion of 2 person households (47.0% vs 35.6%). Households of 3-6 persons were proportionally represented relative to the Queensland population (42.6% vs 41.6%) (ABS, 2013).

Results and discussion

Stated speed choice

The mean speed for the Activity scenario was 41.7 km/h (S.D. = 12.6) compared with 53.5 km/h (15.1) for No activity, a difference of 11.8 km/h. A paired t-test of stated speed choice thus revealed that a statistically significantly lower (t = -18.7; p < 0.001) mean speed was nominated for the scenario in which workers and machinery were clearly present and active. For the Activity scenario, 97.5% of respondents nominated a speed within the designated 60 km/h limit, while 85.6% did so for the No activity scenario (actual speed limit was not displayed to participants).
To examine if drivers’ speed choice was influenced by their age and gender, separate paired t-tests were conducted for each age and gender group. The following test results show that the pattern of speed choice in the two scenarios remains essentially the same when the sample is disaggregated by age and gender. Mean speeds for males were 42.2 km/h for the Activity scenario and 55.0 km/h for the No activity scenario, a difference of 12.8 km/h which was statistically significant (t = -14.4; p < 0.001). For females, mean speeds were 41.0 km/h in the Activity scenario and 51.1 km/h for No activity, a difference of 10.7 km/h which was statistically significant (t = -12.0; p < 0.001).

For the younger age group (17-24 years), mean speeds were 44.1 km/h and 55.7 km/h for the Activity and No activity scenarios respectively, a statistically significant difference of 11.5 km/h (t = -5.3; p < 0.001). In the middle age group (25-59 years), mean speeds were 41.5 km/h for the Activity scenario and 54.1 km/h for No activity, a statistically significant difference of 12.5 km/h (t = -16.3; p < 0.001). Older participants (≥60 years) chose marginally lower speeds than other groups with 41.4 km/h and 51.0 km/h for the Activity and No activity scenarios respectively and a statistically significant difference of 9.7 km/h (t = -7.9; p < 0.001).

Higher speeds were chosen for the No activity scenario than the Activity scenario by 61.3% (n=207) participants, while a small minority (2.5%) suggested that they would drive faster in the Activity scenario. About 36.2% (n=146) of participants nominated the same speed for the two scenarios (Table 1). Among these observations, 8 were young (34.8% of all young), 106 were middle aged (36.8% of all middle), and 32 were old (34.8% of all old) – an almost equal share of the three age groups. In terms of gender, 76 were male (35% of all male), and 70 were female (37.6% of all female), showing a slightly higher female share. However, Chi-square tests revealed no statistically significant differences among the age and gender groups.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Speed difference for Activity scenario*</th>
<th>Frequency (% of participants)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Increased</td>
<td>Nil</td>
</tr>
<tr>
<td>Young</td>
<td>0 (0.0)</td>
<td>8 (34.8)</td>
</tr>
<tr>
<td>Middle</td>
<td>6 (2.1)</td>
<td>106 (36.8)</td>
</tr>
<tr>
<td>Old</td>
<td>4 (4.3)</td>
<td>32 (34.8)</td>
</tr>
<tr>
<td>Male</td>
<td>4 (1.8)</td>
<td>76 (35.0)</td>
</tr>
<tr>
<td>Female</td>
<td>6 (3.2)</td>
<td>70 (37.6)</td>
</tr>
</tbody>
</table>

*Compared with speed for No activity scenario for each participant

Table 1: Differences in stated speed by scenario, age and gender

The mean speeds nominated for each of the two scenarios were well below the actual 60 km/h limit for the roadwork section in question. This is inconsistent with the observed tendency toward non-compliance at roadwork sites in numerous studies, including those mentioned above (Debnath et al. 2014; Haworth et al., 2002; VicRoads, 1990; Benekohal & Shim, 1999). Other aspects of the work zone section depicted in the scenarios may help to explain this result in further analysis. Nonetheless, the significantly lower speeds nominated when workers were present validates the comments of participants regarding factors that influence their speed choice, as discussed below. It is not known why 10 participants (2.5%) suggested they would drive faster in the Activity scenario, but several possibilities may be considered, including the particular (randomised) sequence of scenarios received by those participants, accidental entry of incorrect values, and deliberate entry of misleading values.
Driver concerns about roadworks

Approximately half of the participants (n=206) expressed one or more concerns when invited to comment on any aspect of roadwork safety that they felt is important. More than half of those who commented (n=116) raised the issue of roadwork signage and reduced speed limits being left in place while workers and specific hazards were not apparent. Moreover, they revealed a firmly established ‘cry wolf’ syndrome, wherein drivers often do not reduce speeds to posted limits due to having frequently encountered no activity or apparent hazards in designated work zones. Although the point was expressed in a number of ways, this was clearly the dominant theme in comments overall:

I believe people are happy to go slow when there is visible activity on the site. Drivers get very frustrated however when the speed reduction signs are kept in place when there is clearly no work activity going on. This can cause complacency.

After slowing down through 6-7 roadworks sites equipped with reduced speed limit signs only to find the crew have gone home and left the signs up, drivers are going to become more likely to reduce speed when they see a hazard or people working - not when the signs tell them to.

Although a phenomenon of desensitisation to work zone speed limits has been previously recognised, there has been relatively little attention in the literature to its safety implications and, more specifically, how it should be addressed. In a promising recent development, however, the need to address this problem in Queensland has been formally recognised (TMR, 2014), with the road authority promoting action in the areas of engineering, enforcement and education. While this is encouraging, the matter is somewhat complex in terms of the different situations in which reduced speed limits are used and the various risks and hazards that they are intended to address. An understanding of this complexity was not generally conveyed in the comments of participants. This could potentially be addressed through improved information provision and education, as noted by TMR (2014).

Participants referred to several specific situations where they felt that reduced speed limits and related signage were unwarranted due to the apparent absence of work activity. These included when reduced speed limits and signage were left in place outside of work hours (not removed at night or on weekends) and when they were left in place for extended periods of several days or more. Some participants expressed frustration at worksites with a long section of reduced speed limits but only a relatively small active work area.

If the signs are left out all night and there are no workers to be seen, it reduces the effect of the signs.

Some road works seem to drag on, with limited or slow activity, or have large areas of road closed with minimal activity on much of the closed sections.

Despite the overwhelming driver perception that it is easy and preferable to remove signage and lower speed limits when work is finished for the day/night, or for the week, some survey respondents were aware that various hazards may remain outside of work hours. Those participants alluded to a need for education and awareness campaigns to reinforce the safety message:

Reinforcing to the general public that observing speed limits both during and out of work hours is vitally important. Don't take the view that just because there are no workers on the road, or work occurring, then it is ok to speed.
I think that many drivers are not aware that speed limits are reduced (not only) for the safety of the workers, but also for their own safety - in many cases where workers are not visible they think it is fine to drive at the normal speed limit even where there have been changes to the road.

As noted by a few participants, hazards for drivers certainly do remain at worksites when there are no workers present, evidenced by crashes which occur in work zones outside of construction periods. Although especially difficult to identify in records as work zone crashes unless the work activity was deemed at least partly causative, road deficiencies may contribute to such crashes (Wang, Hughes et al., 1996). Such hazards may be concealed or inconspicuous in comparison to the presence of active workers and machinery, and therefore overlooked by drivers who assume that signage remains in place purely for worker convenience, or that it has simply been forgotten. Thus there are often good reasons in regard to (single vehicle) crash risk for leaving reduced speed limits and related roadwork signage in place when work is not occurring.

Importantly for traffic controllers in particular, the removal and replacement of traffic control devices, including temporary signage, is a dangerous activity in itself. The installation and removal of devices typically occurs on the actual roadway or road shoulder, placing workers in close proximity to traffic and often with no separation or advanced warning for approaching motorists. These operations also consume valuable time and resources, thereby extending project timeframes, increasing exposure of workers to traffic and increasing project costs, while arguably doing little to alleviate overall driver frustration across the life of a project.

For reasons stated above, it can be impractical to change speed limits and signage at the beginning and end of each shift, or even each working week or block of shifts, but it is more difficult to sustain this argument in the case of longer site closures. Electronic and remotely controlled variable message signs have a greater role to play here in reducing the exposure of workers to live traffic, though the cost of equipment currently precludes its deployment to the extent where maximum benefit could be realised.

The various limitations often associated with self-report data should be borne in mind when considering the results of the current analyses. These include the potential for socially desirable responses and the potential oversampling of participants relatively averse to risk. Nonetheless, the survey sample is thought to be reasonably representative in terms of the demographic characteristics of the Queensland population (although younger drivers were slightly underrepresented).

Conclusion

Drivers tend to choose significantly lower speeds in work zones where they detect the presence of workers than in those where there is no apparent activity. According to drivers surveyed, the perception of having often been delivered false information about roadwork activity frustrates motorists and undermines the effectiveness of reduced work zone speed limits. Although anecdotal reports of this phenomenon are widespread, its magnitude and importance has received little attention in the literature. The current research used a mixed methods approach to elaborate on issues associated with poor work zone speed limit compliance, linking analysis of driver perceptions with an assessment of concerns underlying behaviour. The combined quantitative and qualitative results imply that drivers are generally willing to comply with work zone speed limits if they perceive the limits to be justified. Currently this is often not the case, but there is strong potential to improve driver perceptions.
and thus compliance, through technological and operational changes. More specifically, the findings are supportive of recently publicised efforts (TMR, 2014) to improve speed limit compliance through improving the delivery and accuracy of information and reducing the amount of roadwork signage where possible.

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