THE RELATIONSHIP BETWEEN REAL CRASH BASED AND BARRIER TEST BASED VEHICLE SAFETY RATINGS: A SUMMARY AND INTERPRETATION OF THREE RECENT STUDIES.

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ABSTRACT

The provision of information on comparative vehicle safety has become an important mechanism to encourage consumers to consider safety aspects in the purchase of a new or used vehicle. Two major sources of consumer vehicle safety information are available in Australia. They are the Australian New Car Assessment Program, based on results of vehicle crash barrier testing, and the Used Car Safety Ratings, based on analysis of driver injury outcome in real crashes reported to police. Three major studies have now been completed examining the relationship between vehicle safety ratings based on crash barrier testing with those obtained from analysis of real crash data, analysing real crash and barrier test data sources from Australia, the USA and Europe. This paper investigates global conclusions that can be drawn from these studies as well as discussing key differences. It goes on to relate the likely impacts of the observed similarities and differences in the two different ratings systems on consumer interpretation of parallel presentation of ratings from two different systems. Finally, based on the results of the three studies, various options for the consistent presentation of vehicle safety ratings from the two systems are explored along with the likely feasibility and acceptability of each.

INTRODUCTION

Motor vehicle occupant protection continues to be a priority not only for Government authorities concerned with road safety, but also for motor vehicle consumers and manufacturers. A number of ongoing major initiatives have been established in Australia to assess vehicle occupant protection performance for consumer information. Two of these initiatives are the Australian New Car Assessment Program (ANCAP) and the Used Car Safety Ratings (also known as Vehicle Crashworthiness Ratings and Driver Protection Ratings). The first of these estimates the relative occupant safety of current model vehicles by measuring dummy responses in controlled crash testing. The second initiative estimates the relative risk of severe driver injury for individual models of vehicles involved in real crashes by examining mass crash data.

Crash barrier test programs similar to ANCAP are carried out in a number of countries around the world including in Europe, Japan and the USA. Similarly, a number of countries around the world publish vehicle safety ratings based on the analysis of real crash outcomes reported to police or in insurance claims records (Haag et al, 1992; Huttula et al, 1997; Transport Statistics Report, 1995). Given the parallel existence of these two styles of vehicle safety rating systems, an important question, particularly for consumers, is whether relative vehicle safety assessment produced by crash barrier test programs is consistent with that produced by the analysis of real crash data. The Monash University Accident Research Centre has completed three major studies attempting to answer this question. The first examined the relationship between ANCAP and real crash based ratings in the form of the published used car safety ratings (Newstead and Cameron 1999). The second examines the relationship between results from NHTSA and IIHS barrier test programs in the USA with real crash outcomes reported to police in the USA (Newstead, Farmer, Narayan and Cameron 2002). The final pilot study examines the relationship between EuroNCAP barrier test measures and real crash outcomes in the United Kingdom (Newstead, Cameron and Narayan, 2001). Full details of each study, including data, design considerations and results can be found in each of the referenced papers.

This paper reviews the key results of these studies and identifies common conclusions and discrepancies from the results of each. Subsequently, it relates the likely impacts of the observed similarities and differences in the two different ratings systems on consumer interpretation of parallel presentation of ratings. Finally, options for the consistent presentation of vehicle safety ratings from the two systems are explored along with their likely feasibility and acceptability.

AN OVERVIEW OF STUDY METHODS

Vehicle Safety Measures Based on Real Crashes

In each of the three studies being considered, the real crash measure of vehicle safety was the estimated risk of serious injury (including death) to a vehicle driver given involvement in a crash of defined minimum severity. In Australia and the USA, the minimum severity was a crash where at least one vehicle was towed from the scene or a minimum cost of damage was attained, regardless of anyone being injured. In the UK the minimum crash severity was one where at least one person was injured. The overall safety measure was computed as a product of two components. The first was the risk of driver injury given involvement in a crash of the defined minimum severity, the second being a risk of serious injury given that some level of injury to the driver was sustained. The real crash injury risk measure in the Australian and US studies is that used by Newstead et al (2000) whilst in the European study it is equivalent to that used by the DETR in the UK (Transport Statistics Report, 1995). The injury severity measure is that used by Monash University Accident Research Centre in producing vehicle safety ratings in Australia (Newstead et al 2000). Separate sets of real crash measures were estimated based on all crash types and frontal impact crashes respectively, in all three studies, as well as crashes to the near (driver's) side of the vehicle in the European study. In each case both components were estimated using logistic regression analysis, adjusting for the influence of driver sex and age, speed limit of crash location and number of vehicles involved and, where possible and relevant, point of impact on the vehicle, road junction type and level of urbanisation. First and higher order interactions between these factors were also included. Mass effects in the real crash ratings were taken into account using a method of adjustment proposed by Craggs and Wilding (1995).

Crash Barrier Test Programs: Configurations and Measures

The US New Car Assessment Program (USNCAP), conducted by the National Highway Traffic Safety Administration (NHTSA), consists of a frontal impact test conducted at 56.3 km/h (35 mph), with the full width of the front of the vehicle hitting a rigid crash barrier. Instrumented dummies in the driver and front right passenger seating positions, restrained by the vehicle’s seat belts, record injury measures on the head, chest, and legs. The two key injury measures used to rate cars in USNCAP are the head injury criterion (HIC, a measure of the risk of head injury which is a function of the deceleration experienced by the dummy’s head during impact) and the chest acceleration measured on the dummy’s rigid spine. Other injury measures such as chest deflection and forces on the upper leg also are recorded but not used in the consumer ratings.

The Insurance Institute for Highway Safety (IIHS) test, which commenced in 1995, is an offset frontal crash into a deformable barrier, conducted at 64 km/h (40 mph). The impact is offset such that 40 percent of the front of the car on the driver’s side overlaps the barrier, and the barrier has a crushable aluminium element to simulate the effect of crashing into another vehicle. Estimates of injury risk in the IIHS offset test program are obtained from a restrained dummy in the driver seating position. Injury measures derived from the dummy readings include those in the USNCAP program plus several lower leg injury measures. The IIHS program also records a number of measures of deformation on the test vehicle after impact. They include steering column displacement, brake pedal displacement, and measurements of instrument panel and footwell intrusion (IIHS 2000).

From 1994 to November 1999, the Australian New Car Assessment Program (ANCAP) consisted of two components: a full-front test similar to USNCAP and an offset test similar to IIHS’s. Using injury assessment functions relating the dummy measures to real life injury risk and weighting the results of the two test configurations, ANCAP published an overall risk of AIS 4 or above injury to the driver and front left passenger of the tested vehicle. From November 1999 ANCAP was harmonised with EuroNCAP using the same test configurations. The EuroNCAP program covered the three different test procedures. These were the 64km/h 40% offset barrier test (equivalent to the IIHS test), the 50km/h side impact test using a 950kg mobile barrier and the pedestrian impact test which has not been considered in the studies summarised here. EuroNCAP publishes ratings on a five star scale derived from summing the test results from the four body regions in each of the two barrier test configuration giving equal weight to each. A pole side impact test has been added to EuroNCAP but has not been considered in the studies reviewed here.

Each of the programs considered derives an overall score for each tested vehicle model to summarise the individual dummy and, where used, deformation measures. The overall score is the basis for consumer information published from the tests.

Methods of Comparing Real Crash Injury Measures with Barrier Test Scores

A number of methods were used to compare the estimated real crash vehicle safety ratings with the outcomes of barrier testing. In the Australian and US studies, analysis focussed on measuring the correlation between the real crash ratings, including their injury risk and injury severity components, with both the raw barrier test dummy measures as well as injury risk probabilities and overall ratings. In the European study, analysis focused on examining the average real crash ratings (and their components) of vehicles within each overall star-rating category assigned by the EuroNCAP test program. Both the EuroNCAP overall star rating was considered along with score ranges for each of the offset and side impact tests separately. Real crash ratings adjusted for the effects of vehicle mass were also considered in each study, along with the use of logistic regression analysis to confirm the results of the correlation or average rating within star category comparisons. In the US and Australian studies, the logistic regression analysis was extended to build models to best predict the real crash ratings as a function of barrier test scores. Through use of detailed injury descriptions found in insurance claims data, the Australian study was also able to compare average injury severity by body region in real crashes against the corresponding dummy measurements for each body region obtained from the barrier test.

SUMMARY OF STUDY OUTCOMES

Australia

The results of correlation of ANCAP test results with real crash outcomes, summarised in Table 1, suggest a number of relationships. Firstly, whilst the results from full frontal ANCAP testing have some association with real crash outcomes, the associations between offset ANCAP testing and real crashes are much stronger. The ANCAP test results and their associated measures have strong association with both the injury risk and injury severity components of the crashworthiness rating when considering all crash types, and with the injury severity component of crashworthiness rating when considering two-car head-on crashes. Correlations were generally stronger between ANCAP results and two-car head-on crashes than with all crash types but this difference was not large. Mass adjustment of the ANCAP probability measures also improved their relationship with real crash outcomes.

Table 1: *Correlations between ANCAP test measures with real crash outcomes.*

(A) FULL FRONTAL ANCAP TEST RESULTS

	All Crashes			Frontal Impact Crashes		
	Crash-worthiness Rating	*Injury Severity*	*Injury Risk*	*Crash-worthiness Rating*	*Injury Severity*	*Injury Risk*
HIC	0.05	0.14	-0.06	0.14	**0.31**	-0.13
Chest Loading	0.11	-0.10	**0.27**	**0.34**	0.22	**0.36**
Femur Loading	-0.01	-0.12	0.10	0.14	-0.14	**0.32**
Pr(Serious head injury)	0.05	0.13	-0.06	0.13	**0.31**	-0.14
Pr(Serious chest injury)	0.07	-0.15	**0.27**	**0.30**	0.16	**0.34**
Pr(Serious femur injury)	0.07	0.03	0.08	0.17	-0.01	0.26
Full frontal total score	0.10	0.05	0.10	0.24	**0.35**	0.02
Mass Adj FF total score	**0.26**	0.17	0.23	**0.44**	**0.56**	0.18

(B) OFFSET ANCAP TEST RESULTS

	All Crashes			Frontal Impact Crashes		
	Crash-worthiness Rating	*Injury Severity*	*Injury Risk*	*Crash-worthiness Rating*	*Injury Severity*	*Injury Risk*
HIC	**0.31**	0.23	0.23	0.29	0.23	0.27
Chest Loading	**0.48**	0.20	**0.51**	**0.39**	0.20	**0.48**
Femur Loading	**0.40**	**0.36**	0.29	0.16	0.12	0.16
Lower Leg Index	**0.44**	0.09	**0.58**	0.30	0.19	0.33
Pr(Serious head injury)	**0.36**	0.24	0.29	0.24	0.24	0.19
Pr(Serious chest injury)	**0.41**	0.16	**0.43**	0.32	0.15	**0.39**
Pr(Serious femur injury)	0.16	**0.31**	-0.02	-0.03	-0.02	-0.03
Offset Total Score	**0.47**	0.25	**0.43**	0.28	0.26	0.26
Overall Score (OS+FF)	**0.32**	0.15	**0.32**	0.35	**0.37**	0.23
Mass Adj. OS total Score	**0.56**	**0.33**	**0.50**	**0.39**	**0.40**	0.34
Mass Adj. Overall Score	**0.51**	**0.30**	**0.47**	**0.55**	**0.61**	**0.40**

= Statistically significant at the 1% level
= Statistically significant at the 5% level
= Statistically significant at the 10% level

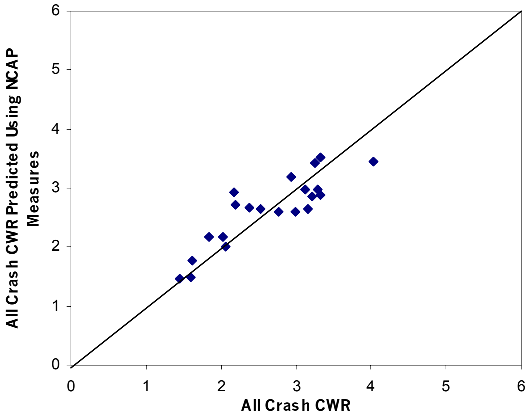
Detailed analysis of injury data by body region was able to identify two specific relationships. A strong statistically significant association was found between full frontal ANCAP femur loading readings and average maximum AIS to the leg region in real crashes along with a strong statistically significant association between the offset ANCAP chest loading and average maximum AIS to the chest in real crashes.

Multivariate logistic regression techniques were able to successfully build accurate models of crashworthiness ratings and its components as a function of ANCAP measures. The following best fitting model was obtained of all crash type crashworthiness ratings (CWR, a measure of serious injury risk) as a function of the variables selected from the full frontal and offset ANCAP measures and their interactions;

$$logit(CWR) = -3.0983 - 0.00058 \times (Vehicle\ Mass) + 0.00012 \times (Offset\ HIC \times Offset Lower Leg\ Index) \quad \text{..(Equation 1)}$$

The regression analysis found crashworthiness ratings based on all crash type to be best described by vehicle mass along with a first order interaction between offset ANCAP HIC and offset ANCAP lower leg index. Figure 1 shows the relationship between the actual real crash ratings and those predicted by the above equation.

Figure 1 : All crash crashworthiness ratings vs. predicted values from logistic model using ANCAP scores



USA

This study considered relationships between recent U.S. frontal crash test results from the Insurance Institute for Highway Safety (IIHS) and USNCAP, and real-world crash injury risk estimates computed from police-reported crash data from three U.S. states. The crash test results include dummy injury measures by body region from both IIHS offset tests and USNCAP full-width barrier tests plus measures of structural performance from the IIHS offset tests. Table 2 summarises the correlation between estimates of real world serious injury risk in all crashes and in frontal impact crashes, respectively, with measures from the crash barrier tests, including structural deformation measures from the offset test. These results parallel those for the Australian study in Table 1. The real world serious injury risk measures from the US data are largely influenced by the injury severity component of the rating hence only the overall rating is shown in Table 2. (No significant association between the injury risk component of the real crash measure and the barrier test outcomes was found). Mass adjusted real crash ratings are considered in Table 2. Correlation between the mass adjusted real crash measures and barrier test outcomes was generally stronger than when real crash ratings without mass adjustment were used.

Table 2: *Correlation of Mass Adjusted Real-World Serious Injury Risk Estimates from all crash types and frontal impact crashes with US Crash Barrier Test Results*

Barrier test variable	Real Frontal Impacts Correlated With:		All Real Crashes Correlated With:	
	Full Frontal Barrier Test	Offset Frontal Barrier Test	Full Frontal Barrier Test	Offset Frontal Barrier Test
HIC	0.18	0.15	0.06	-0.27
Chest deformation (mm)	-0.04	-0.28	-0.14	-0.05
Peak chest gs	0.29	0.22	0.19	0.20
Maximum femur loading (lbs)	0.21	0.10	0.20	0.47***
Pr(Serious head injury)	0.16	0.18	0.03	-0.20
Pr(Serious chest injury)	0.33*	0.25	0.22	0.17
Pr(Serious femur injury)	0.32*	0.16	0.38**	0.52***
Pr(Serious head or chest injury)	0.28	0.27	0.16	-0.01
Pr(Serious head, chest, or femur injury)	0.34*	0.29	0.25	0.31*
Maximum tibia index		0.14		0.12
Steering column movement (cm)		-0.04		0.18
Brake pedal movement (cm)		0.13		0.11
Right lower instrument panel intrusion (cm)		0.13		0.03
Left lower instrument panel intrusion (cm)		0.20		0.17
Right toepan intrusion (cm)		0.09		-0.09
Center toepan intrusion (cm)		0.19		0.13
Left toepan intrusion (cm)		0.23		0.19
Left footrest intrusion (cm)		0.33*		0.08

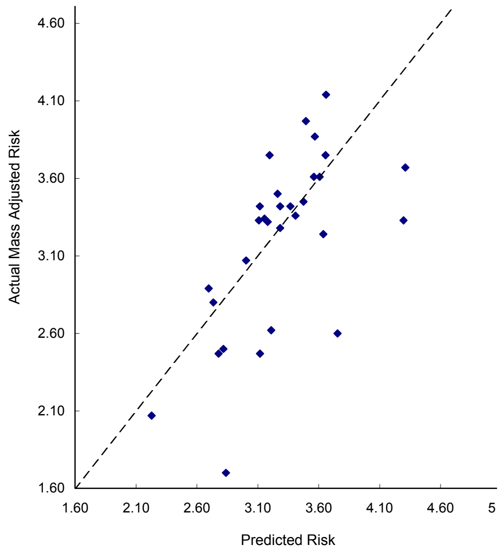
* Statistically significant at the 0.10 level of significance
** Statistically significant at the 0.05 level of significance
*** Statistically significant at the 0.01 level of significance

Individually, results from the full-width and offset tests were not significantly correlated with the real-world serious injury risk estimates apart from femur loading in the offset barrier test when considering all real crash types. Stronger relationships were found when a combination of overall ratings from the full frontal and offset tests was used. The results found only weak correlations between both full-front and offset frontal crash test performance and the real-world injury risk estimates.
In the same manner as for the Australian study, a best fitting relationship between the available crash barrier test scores and real crash ratings was estimated using logistic regression analysis. The model estimated for real crash ratings for all types of crashes is:

logit(Serious Injury Risk) = -2.4066 (*If 3 star rating in FullFrontal*) - 2.5034 (*If 4 star rating in FullFrontal*) - 2.2789 (*If 5 star rating in FullFrontal*) - 0.0309 × (*Offset Chest Deformation*) - 0.0662 × (*Offset Left Instrument Panel Intrusion*) + 0.00226 × (*Offset Chest Deformation*) × (*Offset Left Instrument Panel Intrusion*). ..(Equation 2)

Figure 2 plots the actual serious injury risk against that estimated from the logistic model above.

Figure 2: *Observed Frontal Impact Crash Real-World Risk Estimates vs. Predicted Values from Logistic Regression Model*



Europe

Comparison of the relationship between real crash outcomes and barrier test ratings in Europe centred around comparing differences in the average serious injury risk (crashworthiness), injury risk and injury severity of vehicles in each of the overall EuroNCAP star rating categories. Table 3 presents the results of logistic regression analysis of UK real crash based safety ratings (crashworthiness, injury risk and injury severity) as a function of the published EuroNCAP star rating. The entries in the table are the estimated ratio of the average real crash measure for vehicle models in each EuroNCAP star rating category, relative to the average of the real crash measure across all star categories. Also shown in the final column of the table is the statistical significance of the association between the EuroNCAP star rating and the real crash measure being considered. Low statistical significance values indicate the EuroNCAP star rating has a strong association with the real crash injury outcome measure whilst high statistical significance values indicate poor association between the EuroNCAP star rating and the real crash injury measure.

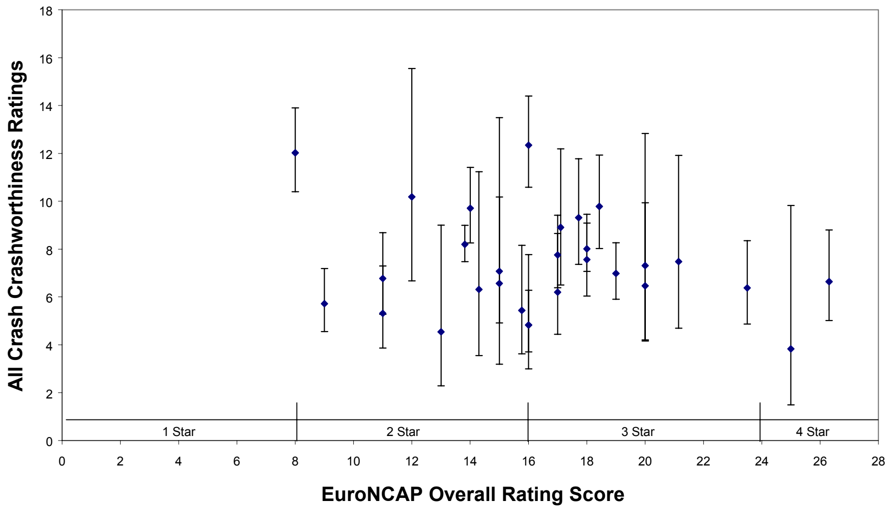
Table 3 shows the EuroNCAP star rating is statistically significantly associated with each of the real crash measures based on all crash types. Further, examination of the confidence limits on each of the estimated relative risks shows that the EuroNCAP star rating is able to significantly differentiate both the average crashworthiness and injury severity based on all real crashes of vehicles in star rating categories 1, 2 and 4. The average crashworthiness and injury severity of vehicles with EuroNCAP star rating 3 can almost be significantly differentiated from that of vehicles in star categories 2 and 4. The lack of significance in this category is most likely due to insufficient number of vehicle models in the analysis, particularly in star category 4.

Table 3: Real Crash Based Safety Ratings Estimated Relative Risks and 95% Confidence Limits Within Overall EuroNCAP Star Rating Categories: UK Crash Data

		Overall EuroNCAP Star Rating				
		1	2	3	4	Star Rating Significance Value
Real Crash Measures based on All Crash Types	Injury Risk	1.40 (1.26, 1.55)	0.889 (0.828, 0.933)	0.879 (0.825, 0.935)	0.927 (0.811, 1.06)	p<0.0001
	Injury Severity	1.37 (1.22, 1.55)	1.00 (0.925, 1.09)	0.973 (0.894, 1.06)	0.746 (0.613, 0.908)	p<0.0001
	Crashworthiness Rating (Serious Injury Risk)	1.50 (1.36, 1.67)	0.968 (0.902, 1.04)	0.933 (0.865, 1.01)	0.736 (0.619, 0.876)	p<0.0001

Despite the general associations observed in the above analyses, the analysis does not demonstrate how much of the total variation between vehicles in the real crash ratings is explained by the EuroNCAP star rating. Figure 1 shows the EuroNCAP score plotted against crashworthiness estimated from all crash types in the UK data. Figure 1 shows there are statistically significant differences in the real crash measures between vehicle models within the same EuroNCAP star rating, and even between vehicle models with almost the same EuroNCAP rating score from which the star ratings are derived. This result suggests there are other factors, apart from those summarised in the EuroNCAP score that are determining real crash outcomes. Similar findings were observed for estimates of injury risk and injury severity based on all real crash types, related to the EuroNCAP score for each vehicle model.

Figure 3: Overall EuroNCAP test score vs. UK Real Crash Crashworthiness Rating Based on All Crash Types



COMMON CONCLUSIONS FROM EACH STUDY AND IDENTIFIED DIFFICULTIES IN PARALLEL PRESENTATION OF CONSUMER INFORMATION

Even though each of the three studies summarised considers a different set of barrier test measures, comparison across the three is possible because they each use fundamentally the same real crash measures. In addition there is some degree of similarity in the barrier test measures, particularly in the concept behind the overall test scores. From the three studies a number of common conclusions about the relationship between real crash measures of injury risk and results of crash barrier testing can be drawn.

1. Overall summary barrier test measures generally showed the strongest associations with the real crash measures. Only weak associations were observed between real crash measures and individual dummy or structural deformation measures from the crash tests.
2. On average, there appear to be consistency between the real crash injury severity measure and overall barrier test score, although the consistency was only weak in the US study. There was less consistency in the case of the real crash injury risk measure.
3. Of the frontal impact barrier test configurations, real crash measures have a higher association with the offset test configuration rather than the full frontal configuration. It is difficult at this stage to assess the relationship the side impact test and real crashes due to insufficient real crash experience.

4. Removal of vehicle mass effects from the real crash measure generally increased the strength of the association with the barrier test measures, as did consideration of real crash configurations similar to the barrier test configurations.
5. On average, overall barrier test measures appear to be consistent with the real crash measures of vehicle safety. However, there is a significant possibility that individual vehicles predicted to have the same safety level by barrier testing will have significantly different estimates of safety based on analysis of real crash outcomes. The converse is also true.

Conclusions 1 to 4 above auger well for parallel presentation of vehicle safety information from barrier test programs and real crash analysis. They suggest that there is an overall degree of consistency between information presented from the two sources. However, conclusion 5 must qualify this optimism by some margin. Typically when consumers use vehicle safety ratings for advice on the safety of a vehicle purchase, either new or used, they will be interested in comparing vehicles on an individual level. Because safety is typically not the first priority for vehicle choice by consumers (VicRoads 1994), comparison will perhaps only be made across a narrow range of vehicles within a particular price, size and style range being considered. Conclusion 5 shows that at this level, there is potential for ratings from each of the two systems to draw different conclusions about the relative safety of the group of vehicles being chosen from. Both Figure 3 above and the fact that measured correlations in Tables 1 and 2 are typically far from unity demonstrate the level of discrepancy that may exist between the two rating systems.

To understand the reasons for discrepancies between barrier tests and real crash analysis in rating relative vehicle safety it is useful to examine the basis on which each system rates vehicles. There is a fundamental difference in level of detail and injury information in police crash reports, compared to the information used in deriving crashworthiness ratings from the crash tests. Unlike crash test data, police reported crash data, and hence real crash ratings, cover all crash configurations at all levels of severity involving all sizes and gender of people. However, police-reported crash data have limited detail on injuries. For example, injuries coded as "serious" by police include significant numbers of injuries that would be classified as minor using the widely accepted Abbreviated Injury Scale (AIS). Also, injury severity is not coded by body region in police data. In comparison, crash test ratings are based both on dummy measures, which indicate the likelihood of serious and life-threatening injuries to key specific body regions, and on vehicle deformation measures, which also are likely to be related to more serious injuries. Thus it is not necessarily surprising that these various crash test measures show some discrepancy with real-world injury risk estimates, which are dominated by less serious injuries and cover all body regions.

Attempts to minimise consumer confusion through parallel presentation of conflicting ratings from the two systems have been made in the past in Australia through targeted marketing of results from each system. Barrier test results have typically been marketed to consumers considering new vehicles whilst the real crash ratings have been marketed as used car safety ratings. These decisions reflect the ability to barrier test a vehicle as soon as it is released onto the market as well as the inevitable lag of a real crash rating behind the date of vehicle release whilst real crash experience is accumulated. Despite these attempts, there are still a number of vehicles that are rated under both systems for which comparison can be drawn. These typically are the most popular vehicles because, for obvious reasons, these tend to be the primary focus of barrier testing as well as the vehicles that accumulate real crash experience the fastest. The potential for consumer confusion has recently been heightened with the introduction of new vehicle safety consumer information sites on the world-wide-web, presenting barrier test ratings and real crash ratings side by side. There is no doubting the immense value of such sites in promoting vehicle safety awareness. However, presentation of the two rating systems side by side with no suggestion to the consumer which rating system should be preferred if there is conflicting information may potentially damage the credibility of the information presented.

POTENTIAL FOR CONSISTENT PRESENTATION OF CONSUMER INFORMATION

One of the products of the research from the three studies summarised here is a potential mechanism to present consistent vehicle safety ratings from both barrier testing and real crash analysis. Both Figures 1 and 2, from the Australia and US studies respectively, show that logistic regression modelling can be used to estimate functions of NCAP test scores that predict the real crash ratings with a reasonably high degree of consistency. Using such functions would allow the 'translation' of barrier test measures to give a safety rating consistent with that obtained from real crash analysis.

One difficulty in achieving consistent real crash and barrier test ratings from the information presented is that equations 1 and 2, giving the estimated relationship from the Australian and US studies respectively, are quite different. This is at least partly due to the fact that the US barrier test results have structural deformation measures that proved important in the estimated relationship, but were not available in the Australian barrier test measures. It may also partly represent differences in the sample of vehicles analysed in each study. For

Australian application, a further problem exists in that both equations relate to estimating real crash serious injury risk from frontal barrier test scores. With the adoption of EuroNCAP protocols in Australia, including an offset frontal and side impact test, neither equation 1 or 2 is necessarily relevant to the new protocol. Unfortunately, consideration of the EuroNCAP protocol in the European study discussed here did not extend to building models predicting real crash ratings as a function of EuroNCAP test scores, though this is planned for future research.

The main point to be drawn from this discussion is the demonstrated existence of potential methods for making barrier test ratings consistent with those estimated from real crashes. Clearly, more work needs to be carried out to establish the most appropriate functional relationship for current test protocols.

A perhaps more fundamental problem with the concept of building functions of barrier test measures that give ratings consistent with those from real crash analysis will come from difference in belief as to which system is more representative of relative vehicle secondary safety. As it is currently proposed, unification of the two systems makes an implicit assumption that the real crash based ratings are the appropriate basis on which to present overall ratings from both systems. Some would argue, however, that barrier test ratings are a more accurate representation of vehicle safety because they are conducted in controlled circumstances identical for each vehicle. Others would argue that real crash ratings are more representative given they cover the full range of real crash circumstances, impact severity and occupant characteristics. Consideration and some resolution of such conflicting views will be necessary before a consolidated system of real crash and barrier test based ratings becomes a practical reality.

CONCLUSION

For the first time, this paper has drawn together the results from three major studies of the relationship between vehicle safety ratings derived from crash barrier testing and from the analysis of real crash outcomes to draw some global conclusions. It has considered how these conclusions relate to the current presentation of ratings from each system in Australia for consumer information on vehicle safety. Finally, it has offered a potential method for unifying ratings presented under each system to achieve consistency in ratings between the two.

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