EYEWITNESS RELIABILITY: SURVEY RESPONSES OF DISTANCE AND SPEED ESTIMATES IN REAL-WORLD CRASH TESTS

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Background

Eyewitnesses, whether drivers, occupants, cyclists or pedestrians, can provide valuable information regarding a specific incident to law enforcement, the legal industry, or technical investigators. In many situations, where no video surveillance or physical evidence is available, eyewitnesses can provide first-hand observation to the event itself and the circumstances leading up to it. The challenge in using eyewitness testimony is that there may be contradictory information or what seem to be completely different scenarios from various witnesses or errors in various estimates. Even when the physical evidence is preserved and a scientific reconstruction is conducted, the outcome is usually compared and contrasted against the witness information.

It has been illustrated in various experiments and research that witness accounts and estimates (i.e. distances, times, and speeds) are often inherently unreliable, especially in emergency situations.[1,2,3,4,5,6] This can be due to a person's inability to capture every detail of every conscious second of their day or an inability to accurately recall various details of a traumatic event.

Multiple studies have demonstrated that observers have much greater difficulty in estimating vehicle speeds when they were unaware that the vehicle would be travelling past them.[7,8] This is very similar to what occurs during real world collisions where the observer is often unaware that the collision is about to happen. Additionally, many eyewitnesses are distracted by their day-to-day tasks and cognitive tasks (e.g. driver focusing on their own driving, pedestrians, listening to music, etc), so it is not unreasonable that witnesses offer different stories.

Accurate speed and distance estimates from eyewitnesses are sometimes critical in answering some of the most important questions in a crash reconstruction; How far away was the vehicle when you first saw it? How fast was the vehicle travelling? What was the distance between the vehicles at their final rest locations? How far away from the area of impact did the vehicles come to rest? These are estimates, which are sometimes relied upon by collision investigators when the physical evidence is insufficient.

On May 31, 2013 Kodsi Engineering held a crash test conference in Mississauga, Ontario, Canada in order to study specific vehicle collisions with respect to impact speeds, vehicle damage, driver biomechanics, and eyewitness reliability of speed and distance. Several vehicle-to-vehicle crash tests were conducted to observe the dynamics of these vehicle collisions, and surveys by the attendees were completed regarding vehicle impact speeds and post-impact travel distances. There were a total of seven crash tests that were completed; two of which were used for the purpose of this study.

The attendees were informed about the surveys after the crash test events and most elected to participante in the surveys. The age of the attendees (61 female, 72 male) ranged from approximately 25 to 65 years old. During the crash tests, the attendees were positioned approximately 17 to 28 meters away from the area of impact. After witnessing each crash, the participants were allowed to walk up to the vehicles and view the damage and final rest positions of the vehicles up close. After approximately 15 minutes of viewing, the participants returned to their original location and the vehicles were moved to set up for the next crash test. Surveys were then handed out to the participants after the first and fifth crash tests, about 45 minutes after each crash had occurred, and a few minutes after the vehicles were towed away.

The participants' estimated values were compared with the actual measured values using our instrumentation as summarized in the section below. The actual values of distances were obtained using surveying equipment and the actual values of the speeds were obtained using vehicle instrumentation (high speed GPS), coupled with video analysis.

Crash Test #1: Bumper-to-Bumper, Rear End Collision

The first crash test that was conducted was a bumper-to-bumper, offset rear end collision, wherein the front of a blue 2001 Chevrolet Malibu (i.e. bullet vehicle) struck the rear of a white 1998 Chevrolet Malibu (i.e. target vehicle) with its transmission in neutral. A third blocker car was positioned perpendicular to the other two vehicles, 15 metres in front of the white Malibu, in order to halt the unoccupied white Malibu after the impact. Figure 1 illustrates this crash test and where the vantage point of the participants was. Figure 2 provides an overhead shot that was taken after the impact.

In the survey, the attendees were asked to estimate:

(1) The speed of the blue Malibu (i.e. bullet vehicle) at impact,

(2) The distance that the white Malibu (i.e. target vehicle) travelled after it was struck, and

(3) How far apart the bullet and target vehicles were after they came to rest.

116 participants completed the survey, of which only 113 provided appropriate answers (54:46 male:female ratio) for question 1, 107 provided appropriate answers for question 2, and 109 provided appropriate answers to question 3. There were some estimates, which were sig-

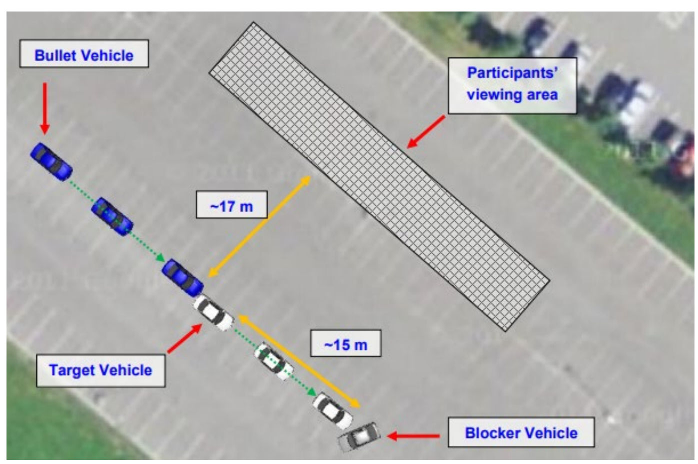

Figure 1: Illustration of crash test #1 as the bullet vehicle (blue Chevrolet Malibu)) collides with the stopped target vehicle (white Chevrolet Malibu). The target vehicle was in neutral and upon being struck from behind, continued travelling forward 15 meters until being stopped by the "blocker vehicle".

nificantly different from the actual data, however, the results generally fit a normal distribution. In order to determine the presence of possible speed or distance estimate outliers, a box plot procedure was utilized where an estimate was determined to be an outlier if it fell more than 1.5 times InterQuartile Range above the third quartile (i.e. 75th percentile) or below the first quartile (i.e. 25th percentile). Upon determining the outliers in the data set, the total number of appropriate estimates for question 1, 2 and 3 were 108, 100, and 99 respectively. The participant's answers are summarized in the table below and are compared with the actual measured value.

Figures 3, 4 and 5 show the results of the of participants' estimates for the three questions for crash test #1.

As seen in Table 1 and Figures 3 through 5, there was a large variance between the smallest and largest value for each of the questions. However, the average of all the answers was close to the actual measured values as other literature suggested. The percentage error for the average estimate was calculated using the following equation.

$$\%\ Error = \frac{(Average\ Estimated\ Value - Actual\ Value)}{Actual\ Value} \times 100$$

TABLE 1. Summary of the Results of the First Survey for Crash Test #1 (Bumper-to-Bumper Rear End Collision)

	Speed of Bullet Vehicle (km/h)	Dist. Target Vehicle Travelled (m)	Dist. Between Vehicles at Rest (m)
Number of Participants	108	100	99
Range of Answers	15 to 55	0.9 to 25.9	0 to 2.4
Average of Answers	33	10.3	0.9
Median	33	10	0.9
Standard Deviation	8.6	5.7	0.6
Actual Speed/ Dist. Measured	31	15	~ 1

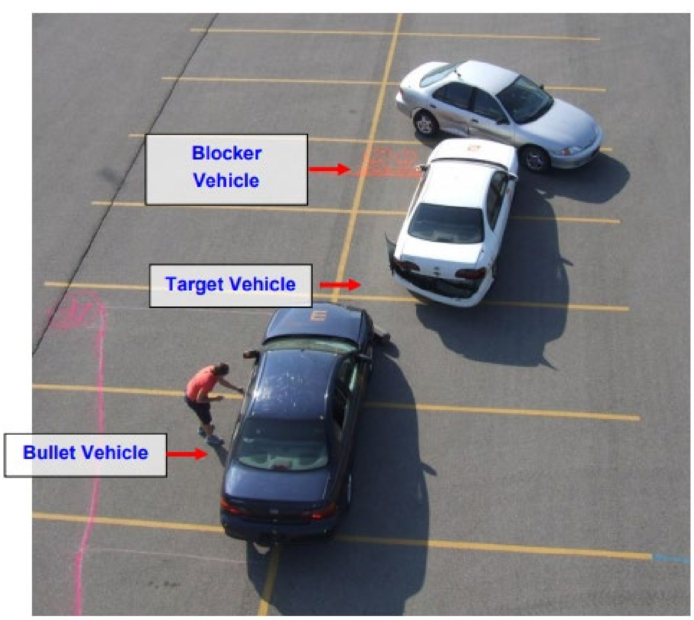

Figure 2. Final position after crash test #1, bumper-to-bumper, rear end collision.

Using this equation, an average overestimation would yield a positive percent error whereas an average underestimation would result in a negative percent error. The percent error of questions 1, 2, and 3 was 6%, -31% and -10%, respectively. From this result of the percent error, the participants in this study were able to estimate speed more accurately compared to distance.

Crash test #5: Right Angle Collision with Moving Target

The fifth crash test was completed about 3½ hours after the first survey. The organisers of the crash test purposely left several hours in between the first and second survey so that the participants would not pay any closer attention to the details of the collision in anticipation for another set of questions. This particular crash test was a T-bone impact wherein the front of a 2001 Chevrolet Impala (i.e. bullet vehicle) struck the passenger side front wheel area of a 1998 Toyota Corolla (i.e. target vehicle). Both vehicles were moving at impact. The following diagram illustrates the layout of the crash test and the location of the observers with respect to the collision.

Figure 6 illustrates this crash test and where the vantage point of the participants was. Figure 7 shows shows a overhead view of the vehicles at impact.

For this second survey, the participants were asked to (1) estimate the speed of the Chevrolet at impact, (2) estimate the speed of the

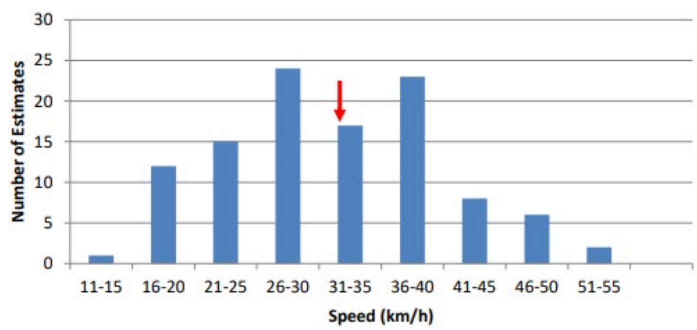

Figure 3. Histogram showing the estimated speed of the bullet vehicle at impact. The actual speed is shown using a red arrow.

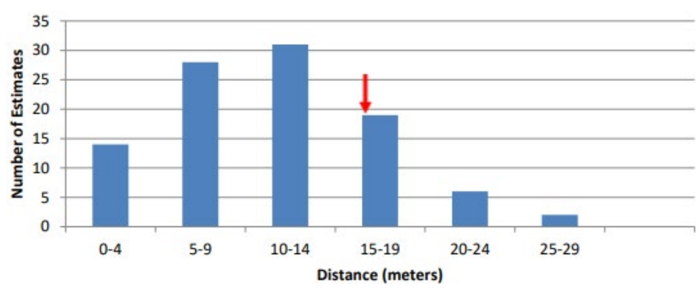

Figure 4. Histogram showing the estimated distance travelled by the target vehicle after impact. The actual distance is shown using a red arrow.

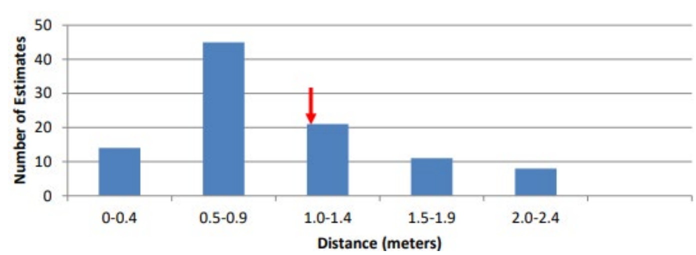

Figure 5. Histogram showing the estimated distance between the bullet and target vehicle when they came to rest. The actual distance is shown using a red arrow.

Toyota at impact, and (3) estimate the distance between the vehicles at rest.

Ninety participants completed the survey, of which only 89 provided appropriate answers for question 1, 87 provided appropriate answers for question 2, and 81 provided appropriate answers to question 3. In order to determine the presence of possible speed or distance estimate outliers, the same box plot procedure was utilized as with survey #1. Upon determining the outliers in the data set, the total number of appropriate estimates for question 1, 2 and 3 were 89, 78, and 66 respectively. The participants' answers are summarized in the table below and are compared with the actual measured value.

It is noteworthy that at final rest, the vehicles were in contact (they were angled, touching at the corner as seen in the photo below). Attendees were also asked about the distance between the vehicles at rest and 66 participants responded:

- Range of answers from 0 to 3 meters
- Average of all answers 0.2 meters
- Median = 0
- Standard deviation = 0.25
- Actual distance measured = 0 (touching) to 3 meters (furthest separation between the vehicles)

Figures 10 and 11 show the results of the of participants' estimates for the three questions for crash #5.

As seen in Table 2 and Figures 10 and 11, there was a large variance between the smallest and largest value for each of the questions, as was the case with the first survey. Interestingly, just like the first survey, the average of all the answers was close to the actual measured values. The percentage error for the average estimate was calculated for question 1 and 2 was 38% and 10% respectively.

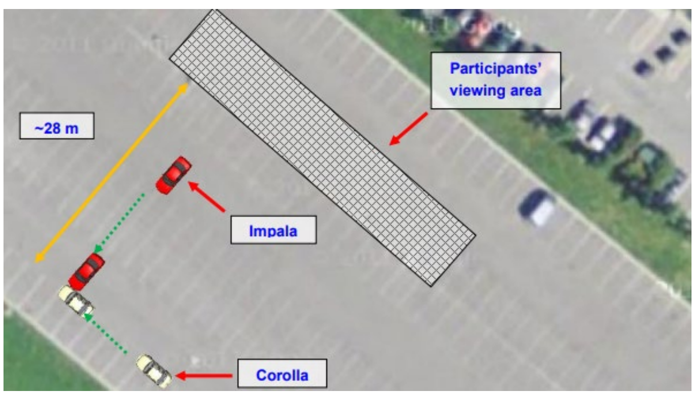

Figure 6. Illustration of crash test #5 showing the relative positions of both vehicles before and at impact as well as where the participant's vantage point was relative to the crash test.

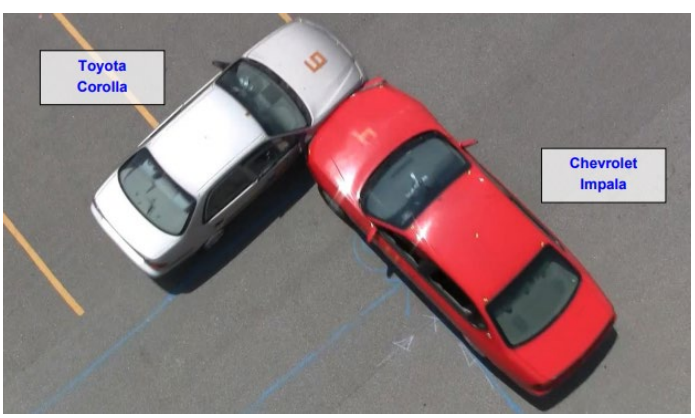

Figure 7. Overhead view of the test vehicles at impact.

Discussion

With the wide range of answers provided for each question, there was a particular trend for the majority of people to estimate a certain way. The results fit a normal distribution and the averages of the speed estimates for crash test #1 and #5 were an overestimation. Strauss *et al*[9] found that pedestrians who estimated speeds of vehicles that passed by at less than 54.7 km/h tend to overestimate the speed of the passing vehicle. All of the above discussed crash tests were conducted at speeds below 54.7 km/h, and the authors found that on average, their participants overestimated the actual speeds as well.

What can become incredibly overwhelming at times is when a case involves many eyewitnesses with various vantage points to an incident and each one estimates a radically different speed. "The car flew right in front of me. He must've been doing at least 80 or 90 km/h", one person may say, while another who is viewing the exact same incident might say "the car was cruising along a few cars in front of me, it couldn't have be going more than 60 km/h".

So does vantage point play any role in the ability of estimating speed? Although, our participants had a different vantage point than drivers, it was interesting to discover that for our crash tests, the participants on average were more accurate in estimating the impact speed of vehicles that drove across from them (i.e. right-to-left bullet Malibu in crash test #1 and left-to-right Toyota Corolla in crash test #5) com-

TABLE 2. Summary of the Results of the Second Survey for Crash Test #5 (Right Angle Collision)

	Speed of Bullet Vehicle (km/h)	Dist. Target Vehicle Travelled (m)	Dist. Between Vehicles at Rest (m)
Number of Participants	89	78	66
Range of Answers	10 to 55	10 to 35	0 to 3
Average of Answers	28	22	0.2
Median	26	20	0
Standard Deviation	9.1	5.5	0.25
Actual Speed/ Dist. Measured	22.5	20	0 to 3 (angled, touching at corner

Figure 8. Final Rest position of test vehicles.

pared to when one of the test vehicles drove away from them (i.e. Chevrolet Impala in crash test #5). The percentage error for estimating the impact speed of the Chevrolet Impala, which drove away from the participants, was the greatest (38%) compared to the Chevrolet Malibu and Toyota Corolla which both drove across the participants (6% and 10%, respectively).

In addition, it was found that the further away a vehicle was from the observer, the more error there was on average in estimating the actual impact speed of the vehicle. The Chevrolet Malibu in crash test #1 was the closest vehicle to the participants and had the smallest average percent error (6%). Compare this to the Chevrolet Impala in crash test #5, which along with the Toyota Corolla was the furthest crash test from the participants, and it yielded a greater percentage error for the average estimated impact speed (10% for the Corolla and 38% for the Impala).

Generally, it is more difficult to estimate the speed of objects that are further away from an observer. In order to understand this, a hyperbolic analogy would be a speed estimate of a plane. While in the sky, commercial planes can reach speeds of up to about 1000 km/h. While on the ground, it may be very difficult for an observer to estimate anything close to this speed while the plane is at its cruising altitude since it appears to be covering little ground. However, if the plane was able to cruise close to the observer, that individual may gain a greater appreciation of the speed and estimate something closer to the actual value.

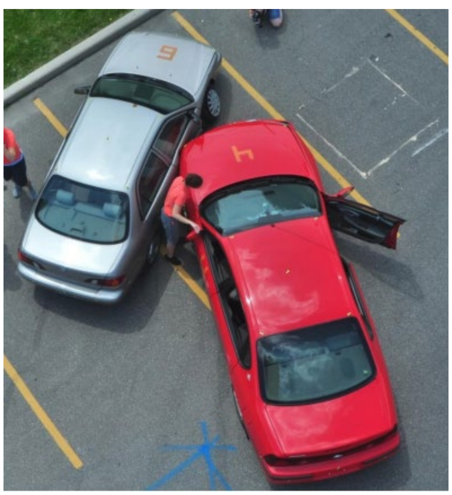

Figure 9. Overhead view of the Test #5 vehicles at Final Rest.

Lastly, it is noteworthy that the distances that were estimated in crash test #1 were underestimated with a wide range of answers compared to crash test #5, which did not have as much variance. This could possibly be because the vehicles in test #5 were in contact at rest and the volunteers may have remembered that. It becomes more difficult to estimate a distance when you know that the vehicles were not in contact at rest, as was the case in crash test #1.

Final Thoughts

So what can be learned from these surveys? As with most literature on this topic suggests, we found that an individual's estimate of speed and distance can be unreliable. However, if there is a large number of witnesses or participants, the average of all the speed and distance estimates may be fairly accurate.

Of course, as with any experiment, there are limitations that are inherently part of the procedure. Attendees of our crash test conference were anticipating, as the name suggests, crashes. Many eyewitnesses in real world collisions often report how the event took place "so quickly" or in a "split second" with many critical values often not estimated due to the lack of specific attention, vantage point and recollection. Research has found that the less time that a witness has to view a piece of information, the less accurate their perception and recollection of an event will be.[10] The attendees were not only anticipating a collision between vehicles, but once the area was deemed reasonably safe, they were permitted to approach the vehicles and closely observe the outcome of the crash before they elected to participate in the survey. Many real world eyewitnesses do not have this advantage. Even with all these advantageous circumstances for the participants from our crash test conference, many individuals provided extremely inaccurate estimates.

Understanding eyewitness reliability has practical implications to collision investigators as they compare the reported information, along with the limitations with their reconstruction science.

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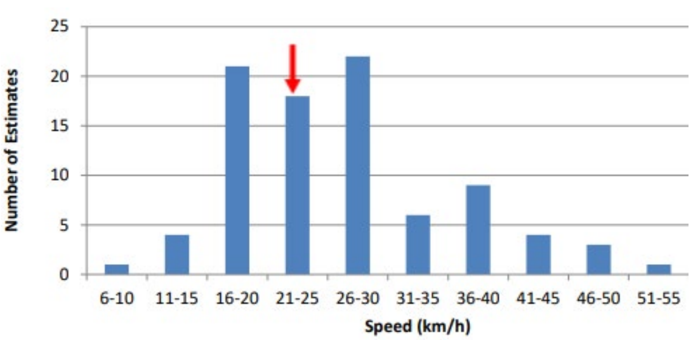

Figure 10. Histogram showing the estimated speed of the Chevrolet Impala (i.e. bullet vehicle). The actual speed is shown using a red arrow.

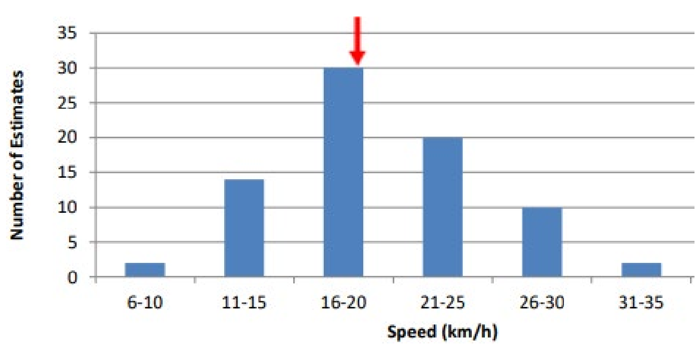

Figure 11. Histogram showing the estimated speed of the Toyota Corolla (i.e. target vehicle). The actual speed is shown using a red arrow.