Catalyst

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Contents

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The cover image highlights the structure of the brain within a human head (Bigstock/decade3d)

All in your mind

On pages 8-12 of this issue of Catalyst, Ashok Sakhardande describes how we are becoming increasingly knowledgeable about the structure of the human brain and how it functions. In particular, he is interested in how brains change during adolescence, a time when many new skills must be developed. Much of what we know about how brains work come from studies using magnetic resonance imaging (mri scans), but it is difficult to know how to match up brain activity to the thoughts and actions which make us who we are.

Another way to reveal what's going on in our brains is to use X-rays. On pages 19-21, Silvia Pani describes some of the latest uses of X-rays, from security scanning to scans of the human body. These techniques are always being improved so that their original inventors might be surprised by all that is possible today.

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Jennie Hargreaves

Crash investigators

Understanding road traffic accidents

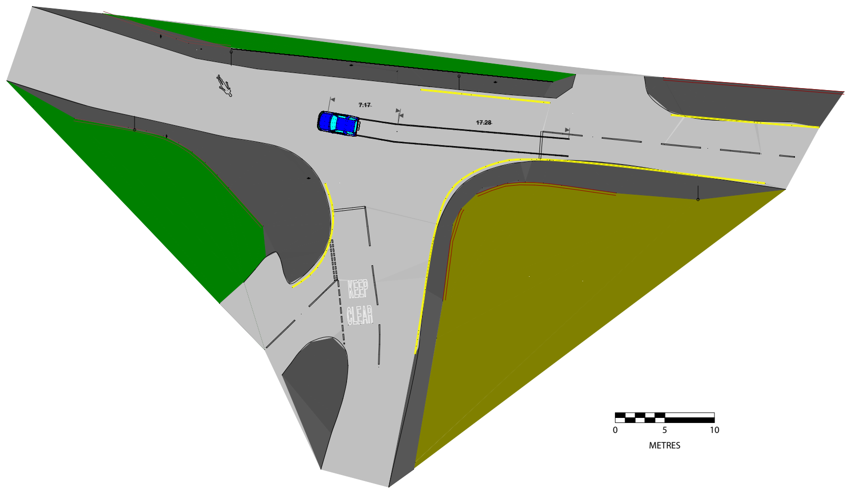
Key words
acceleration
collision
rationalisation
road safety

*Students from Lockerbie Academy have been working with **Inspector Neil Hewitson**, a Road Crash investigator from Police Scotland's Roads Policing Department, to use science to interpret evidence from real car crashes. The Police Accident Investigators provided data from a serious accident that occurred in the region. Their science teacher, **Jennie Hargreaves**, describes how they tackled the problem.*

The accident

The scenario we were faced with was: A man was hit on a quiet, urban road (with a 30 mph speed limit) near a pub at about 10.20 pm on a dark, rainy night. There were street lights. The driver fled the scene. The pedestrian ended up unconscious in hospital. There were witnesses but their reports were contradictory. One thought the pedestrian might have been drunk, the other thought the driver was exceeding the speed limit.

The crash was laid out to 1/3 scale in the Assembly Hall using standard toys. The diagram shows the scene. Our task was to use science techniques to find out the cause of the accident, who was responsible and if any traffic offences were committed. This involved students in observing, hypothesising, recording and noting, measuring, calculating, drawing conclusions and evaluating our work.



Plan of the crash scene

Before we started we secured the scene with police tape and took photos of any evidence that we thought was relevant.

Investigations start at the mock-up of the crash scene.

Interpreting the evidence

Tyre marks: Crash investigators measure tyre marks to determine the speed of the vehicle prior to impact and when the car started to skid. The tyre marks can indicate whether a car was accelerating, decelerating or sliding sideways.

A student measures the skid marks

The lengths of the tyre marks (displacement) were measured and scaled up to find the length of the real skid marks. It was found that the car skidded for 17.28 m before impact and a further 7.17 m before finally coming to a halt, giving a total of 24.45 m.

We were surprised to discover from the police that the tyre marks are not produced from the melting rubber but by melting of the bitumen road surface.

When the brakes go on

It helps to think of four stages when a driver starts braking in an emergency.

1. The driver's foot strikes the brake pedal and pressurises the braking system causing maximum braking effort to the rotating wheels. The speed of the vehicle begins to reduce without tyre marks being left on the road surface.
2. The braking system is still pressurised and the vehicle continues to reduce speed. There is still maximum braking effort but the friction material in the brake linings begins to cause the wheels to 'lock-up'. Still no visible tyre marks.
3. Now the brake linings prevent the wheel from revolving. It is locked and the tyre is sliding over the road surface. Heat is generated due to the friction between the tyre and road. This melts the surface of the road resulting in 'shadow' marks being left on the road surface.
4. The wheel continues to be locked, sliding over the road surface.

Dark tyre marks are left on the road surface once the frictional temperature increases to a point where the surface melts. As the vehicle continues to slide its speed will decrease and tyre marks will continue to be left until either the vehicle slides to a stop or the driver reduces the pressure on the brake pedal.

Pedestrian collision: The body of the pedestrian and the car bear different marks depending on where and how they hit each other. If the pedestrian is hit below the waist, the body is thrown upwards and the vehicle passes under the pedestrian, so the pedestrian is 'run under'. If the pedestrian is hit above the waist, they are knocked down and 'run over'.

The tags on the victim's body shows where he was hit during the collision.

In our accident the pedestrian was run under so his initial velocity was the instantaneous velocity of the vehicle. He travelled through the air straight ahead of the vehicle until hitting the ground and was found a long way in front of the car which had decelerated to a halt. He had marks on his upper right leg, right abdomen, right shoulder and on the right side of his head. The car had marks on its bumper, the top of its bonnet and the windscreen.

The car was damaged where it was struck by the victim during the collision.

Witness statements: Further evidence about the collision comes from two fairly contradictory witness statements. The police had to determine if their accounts were true, or whether the witness got confused in some of the detail. It is an offence to give wrong information to the police, but people are bad at recalling events accurately. This is called 'rationalisation' and happens when you don't quite know what has happened so you unintentionally and subconsciously fill in any gaps in what you observe.

We had a flipchart page with six small sketches. When a whistle was blown we were given a few seconds to take in the pictures before they were covered over again. Not one student or adult correctly identified even five of the shapes and most of us made up items that were not present. We were all shocked at how badly we performed as witnesses.

Calculations

To calculate the speed of the vehicle at impact we needed an estimate of its deceleration as it skidded along the road. Crash investigators do a skid test to establish this value. Where possible they use the actual vehicle involved in the collision; otherwise they use a car of the same make and model loaded to the same extent. This is fitted with an accelerometer and is driven on the same road in the same weather conditions. The driver applies the brakes fully to lock all four wheels and stop the vehicle. The accelerometer shows the car's deceleration (its negative acceleration) in m s^{-2}. Two of these tests are carried out; if the results are within 10% of each other then the lower value is selected to use in the calculations.

Calculating initial speed

For our scenario, the crash investigators found values for the deceleration of -6.80 m s^{-2} and -7.01 m s^{-2}. The smaller result is used as it gives the lowest speed for any calculations made, giving the benefit of the doubt to the driver.

To calculate the car's speed when the driver braked, we used the formula $v^2 = u^2 + 2as$: The list in the margin shows the values:

$0 = u^2 + (2 - 6.8 \times 24.45)$

so $u^2 = 332.52$ and $u = 18.23$ m s^{-1} or 41 mph.

initial velocity u = ?
final velocity v = 0 m s^{-1}
acceleration a = -6.80 m s^{-2}
displacement s = 24.45 m

The driver was clearly exceeding the 30 mph speed limit.

Calculating impact speed

We measured from the centre of the front wheels back to where the skid mark deviated slightly indicating where the impact occurred. This was 7.17 m. Using the equation above we found the speed at impact to be 9.87 m s^{-1} or 22 mph.

We then asked ourselves: if the car had been travelling at the speed limit of 30 mph would the collision have happened? Using the same equation with an initial velocity of 13.4 m s^{-1} (30 mph) gives a stopping distance of 13.22 m.

Therefore had the car been traveling at 30mph it would have stopped approximately 4 m short of the pedestrian's position, and would not have hit him.

Our conclusion

The results clearly demonstrated that the driver was to blame as he was exceeding the speed limit. Had he obeyed the speed limit no collision would have occurred and the pedestrian would not have incurred life-limiting injuries.

The driver was banned from driving and spent 8 months in jail. Don't let something like this happen to you!

The work described in this article was supported thanks to a Partnership Grant from the Royal Society. In July 2014, students from Lockerbie Academy spent a week in London demonstrating their work at the Royal Society's Summer Science Exhibition.

***Jennie Hargreaves** teaches science at Lockerbie Academy (www.lockerbieacademy.com).* *We acknowledge the assistance of officers Neil Hewitson, Peter Monteith, Chris Parker, Alan Hope and Ewan Cannon from Police Scotland without whose help this project could not have happened.*

Look here!

Test your own ability as a witness.
http://www.youtube.com/watch?v=vJG698U2Mvo

Investigating the scene at Lockerbie Academy July 2013:
http://www.youtube.com/watch?v=MJbjKqPxUkY
http://www.youtube.com/watch?v=RY_GRIFcpeU