ILLUSORY SIZE-SPEED BIAS: COULD THIS HELP EXPLAIN MOTORIST COLLISIONS WITH RAILWAY TRAINS AND OTHER LARGE VEHICLES?

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WORLDWIDE STATISTICS

2012: 1786 collisions, 175 deaths
2010: 1330 collisions, 129 deaths
2002-2012: 350 deaths (annual average 35)
Last 12 mths: 8 injuries, 5 deaths
FOCUS OF PREVIOUS RESEARCH

- Visibility – either poor or reduced (Ward & Wilde, 1996)
- Attention overload (Wigglesworth, 2001)
- Familiarity (Tey, Ferreira & Wallace, 2011)

However, one area not well explored is the possibility that motor vehicle drivers appear to visually underestimate the speed of a train, due to its size.
Leibowitz (1985) suggested that an illusion in size and speed was due to the fact that a large object seems to be moving more slowly than a small object travelling at the same speed.
Clark, Perrone and Isler (2013) used computer simulations of a freight train (complete with carriages) vs. a motorcar, set in a New Zealand rural environment.
Clark, Perrone and Isler (2013) used computer simulations of a freight train (complete with carriages) vs. a motorcar, set in a New Zealand rural environment. Paired video sequences (first vehicle presented, then second vehicle (randomised order), 1 second duration).

Car (control stimulus) travelled at constant speed (80 km/h).

Train speed manipulated (60, 70, 80, 90, 100, 110 or 120 km/h).

Observers asked to indicate which vehicle appeared to be travelling faster.
LIMITATIONS…

Findings were that observers significantly underestimated the speed of the train, as compared to the speed of the car.

However, we only tested observers’ view from 5 metres away from the level crossing/intersection junction. Motorists often make crossing decisions from further away – while they are still approaching.

Detected size-speed illusion, however underlying reasons for this not explored.

→ One factor that could provide insight may be eye movement behaviour.
RESEARCH QUESTIONS

To test whether or not underestimation of a train’s perceived travelling speed (relative to a smaller vehicle) still occurs when the distance to the intersection/junction is altered.

Measure and compare the eye movement behaviour that occurs while observers view different sized approaching vehicles.
EXPERIMENT 1 - METHOD

Participants shown simultaneous computer-animated sequences of a car and a train approaching (similar stimuli and environment to Clark et al. (2013)).

Asked to make a choice of whether the train or the car appeared to be travelling faster.

Observer was ‘placed’ at one of three distance points away from the intersection/junction.
6 metres
18 metres
36 metres
Which Vehicle was Faster?

First Vehicle
(Left button)

Second Vehicle
(Right button)
RESULTS

Significant differences between the perceived velocity of the train compared to the car in all three distance conditions – train’s speed was underestimated each time.
EYE MOVEMENT ANALYSIS

X and Y positions and velocities were analysed and compared against predicted vehicle movement.

Eye tracking data showed that participants have a tendency to fixate on a point further down the train, rather than the front of the train.
Optical expansion rates for elongated moving objects (such as a train) is not uniform.

Rates of expansion are faster at the front than at points further along along the object.

Therefore participants were fixating on a point that has a slower rate of expansion than the front.
CONCLUSIONS

- Size-speed illusion confirmed, speed of train was underestimated relative to the car.
- This effect was robust over a range of distance conditions.
- Analysis of eye movement behaviour (fixation positions) indicates participants are looking at a region of the train that has a slower optical velocity → possible reason for the illusion?
NEW RESEARCH QUESTION

If eye fixation positions are causing the perceived slower speed of a larger vehicle, could we manipulate this illusion by forcing observers to look at different regions of an approaching vehicle?

In particular, if we force observers to look at the front of the vehicle, would this illusion disappear?
EXPERIMENT 2 - METHOD

- Followed the same procedure as Expt. 1.
- Simplified rectangular shapes were used as vehicle substitutes (featureless – retained basic shape and motion of the vehicles).
- A white ‘fixation dot’ was placed on one of three regions of the rectangle (front, middle, end).
EXPERIMENT 2 - METHOD

- Followed the same procedure as Expt. 1.
- Simplified rectangular shapes were used as vehicle substitutes (featureless – retained basic shape and motion of the vehicles).
- A white ‘fixation dot’ was placed on one of three regions of the rectangle (front, middle, end).
- Eye movement behaviour recorded.
ANALYSIS

Eye movement data analysed first – this was essential in order to determine whether participants were actually fixating on the dot.

Participants data who did not track to within 2 degrees of the dots at lest 50% of the time were excluded.
RESULTS

Significant differences in the ‘train’ shape’s perceived speed, when observers were forced to look at either the middle or the back.

However, when forced to look at the front of the train shape, the findings were non-significant at the specified .05 level (just!).

\[ t(15) = 2.119, \ p = .051 \]
CONCLUSIONS

Placing a fixation dot on the front of the long shape did seem to reduce the size-speed illusion. This suggests that eye movement behaviour (especially fixation locations) may be partly responsible for the illusion.

Our conclusions generalize to other types of large vehicles, in particular heavy-load trucks and buses.

The scenario of these types of vehicles approaching T-intersections is quite similar to the level crossing approach we explored.
WHAT'S NEXT?

Although our result for the front dot position was non-significant, questions over the residual 5.3km/h difference remain.

Exploring the role of motorist self motion:
- Does the illusion still occur?
- Eye tracking behaviour?
http://www.youtube.com/watch?v=xmPoFLAUskI
Proportion of ‘Train faster’ responses were calculated for each distance condition and plotted against train speed (psychometric functions).

The dotted line represents the Point of Subjective Equality (PSE), where the train and car speed were perceived as being identical by the participant.
DATA ANALYSIS

Mean PSEs were calculated for each condition across all participants and compared to the control variable – a car travelling at a constant speed of 80 km/h.

Any PSE value greater than 80 km/h indicated an underestimation of the train’s speed (relative to the car).