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

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WORLDWIDE STATISTICS

- 2012: [illegible]75 deaths
- 2010: [illegible]9 deaths
- 2002-2012: [illegible] deaths (annual average 35)
- Last 12 mths: 8 injuries, 5 deaths

FOCUS OF PREVIOUS RESEARCH

- Driver behaviour – particularly risk-taking (Leibowitz, 1985; Ward & Wilde, 1996; Wilde, 1994; Witte & Donohue, 2000).
- 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.

SIZE-SPEED ILLUSION

- 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.

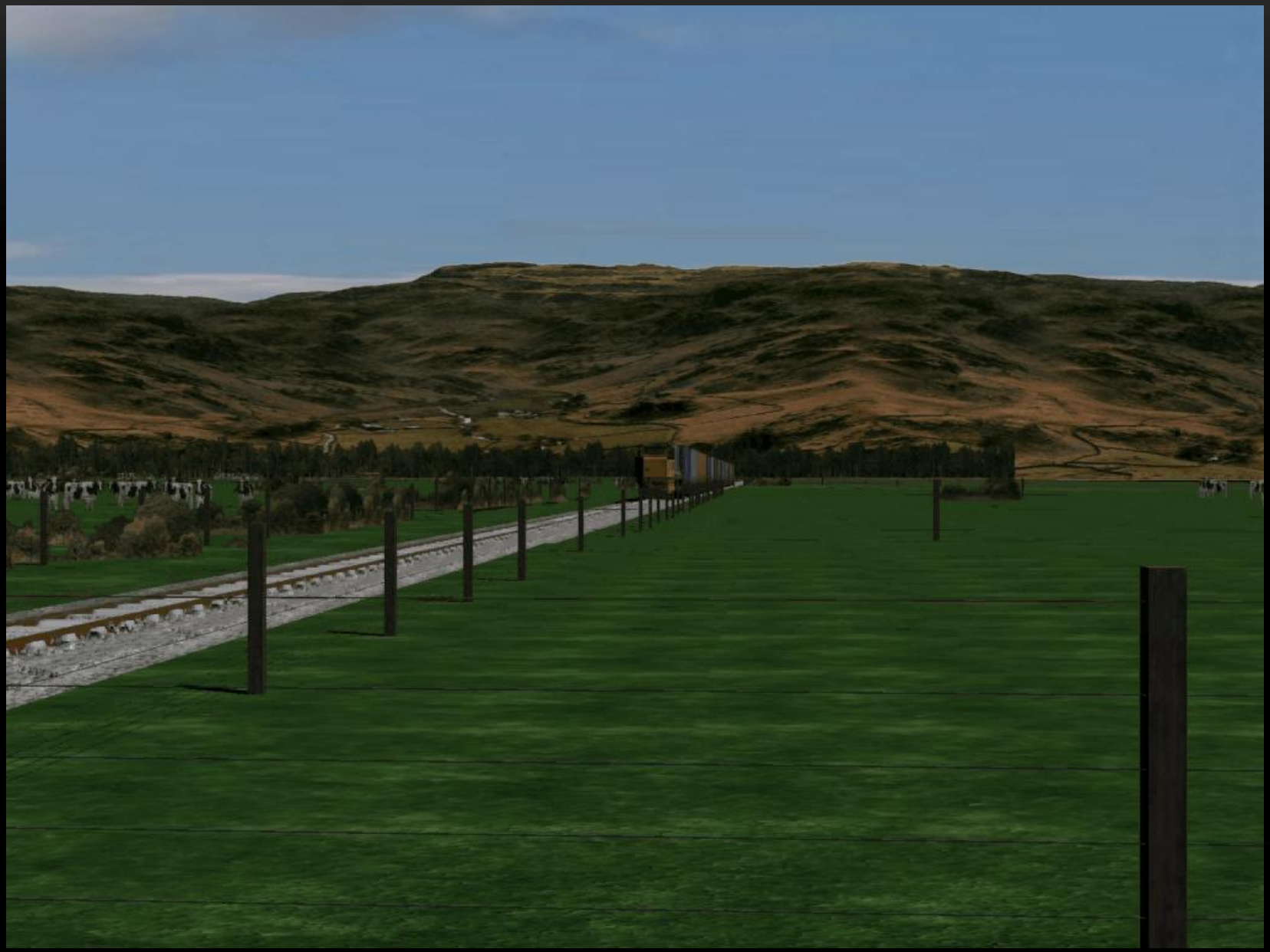
APPLYING SIZE-SPEED ILLUSION THEORY TO TRAINS

- 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

Static images from the movie clips used.

APPLYING SIZE-SPEED ILLUSION THEORY TO TRAINS

- 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.

train

6 metres

train

18 metres

train

36 metres

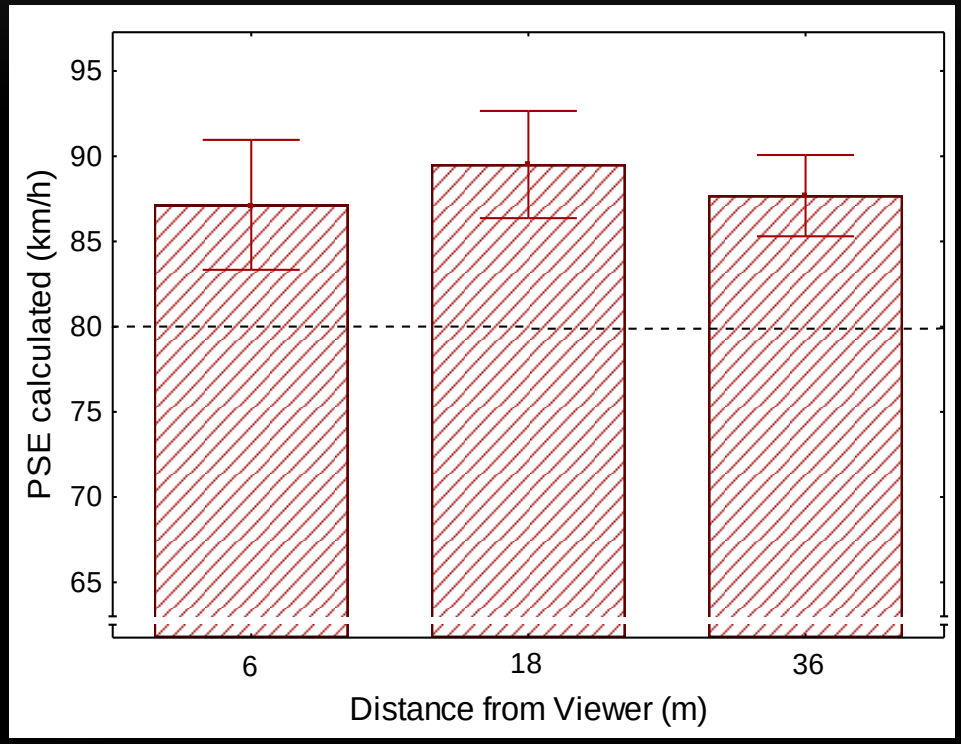
Which Vehicle was Faster?

First Vehicle
(Left button)

Second Vehicle
(Right button)

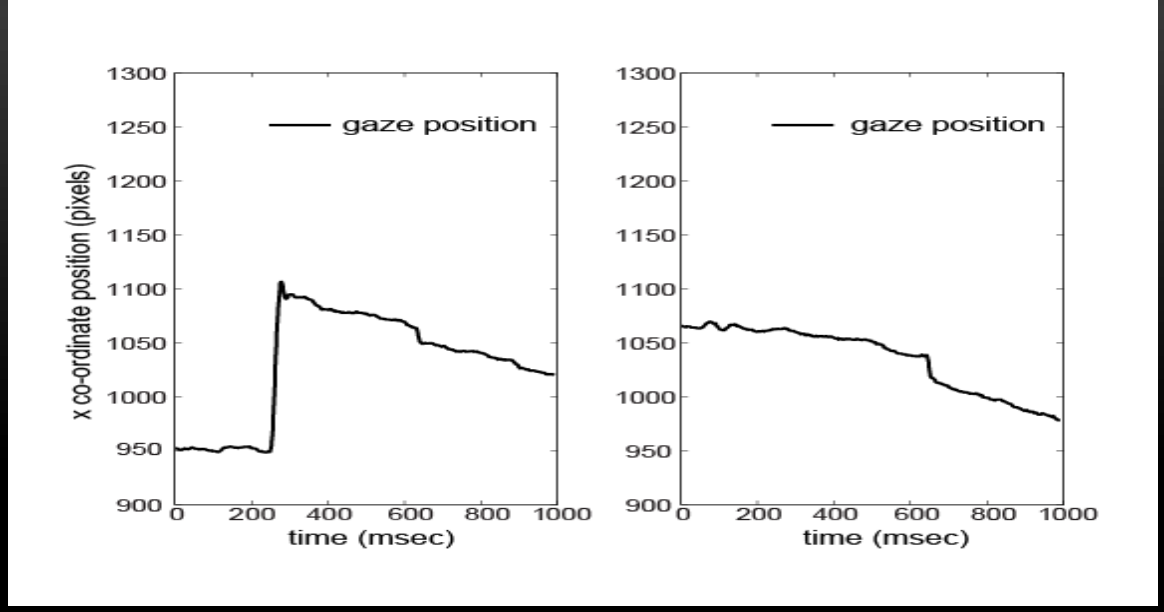
RESULTS

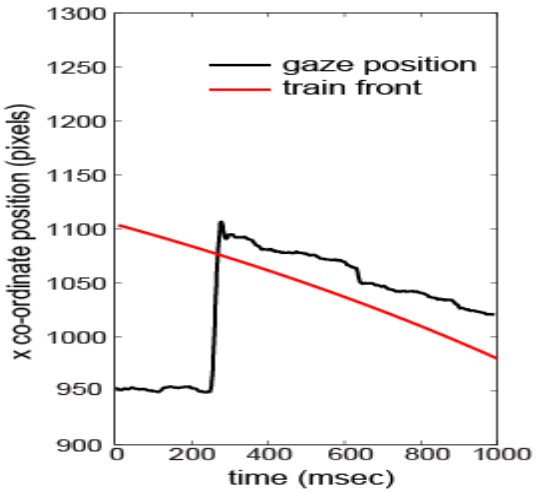
- Significant differences between the perceived velocity of the train compared to the car in all three distance conditions – train's speed was underestimated each time.

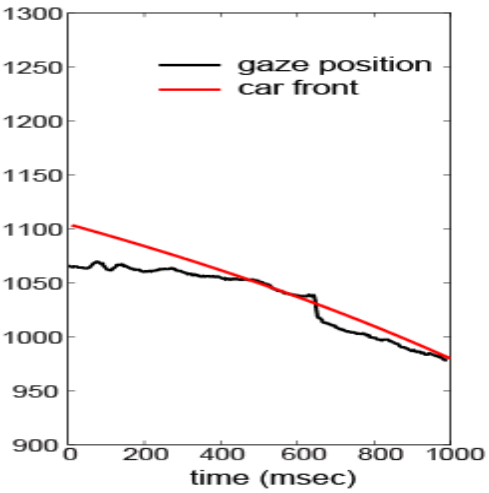


EYE MOVEMENT ANALYSIS

- 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.


gaze position
x co-ordinate position (pixels)
time (msec)
1300
1250
1200
1150
1100
1050
1000
950
900
0
200
400
600
800
1000
gaze position
time (msec)


gaze position
train front
x co-ordinate position (pixels)
1300
1250
1200
1150
1100
1050
1000
950
900
0
200
400
600
800
1000
time (msec)


gaze position
car front
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1100
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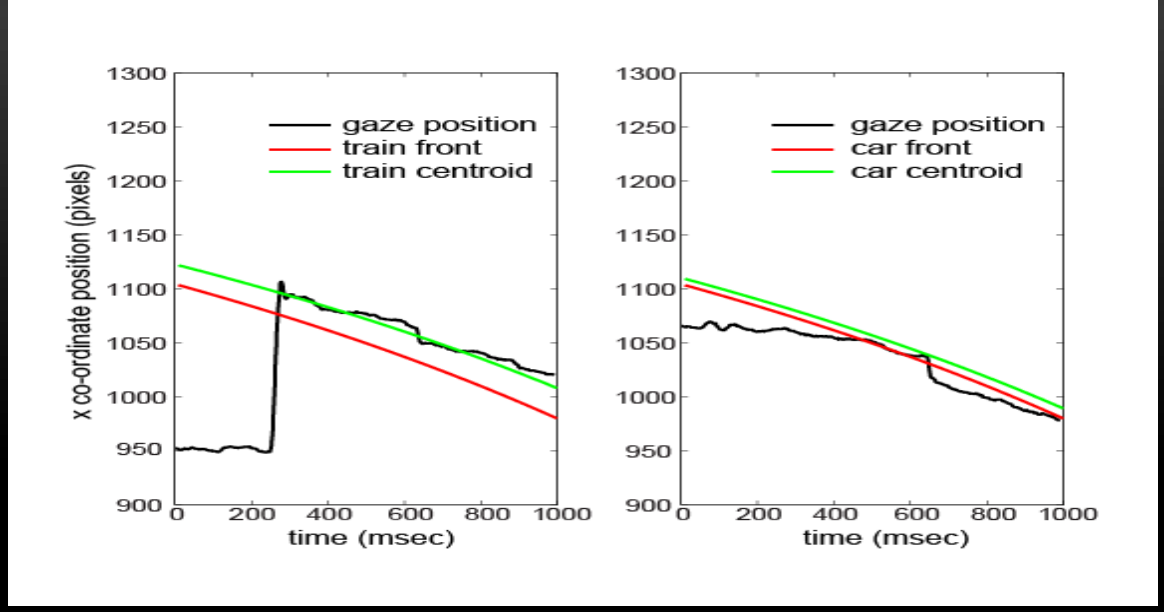
1000
950
900
0
200
400
600
800
1000
time (msec)


x co-ordinate position (pixels)
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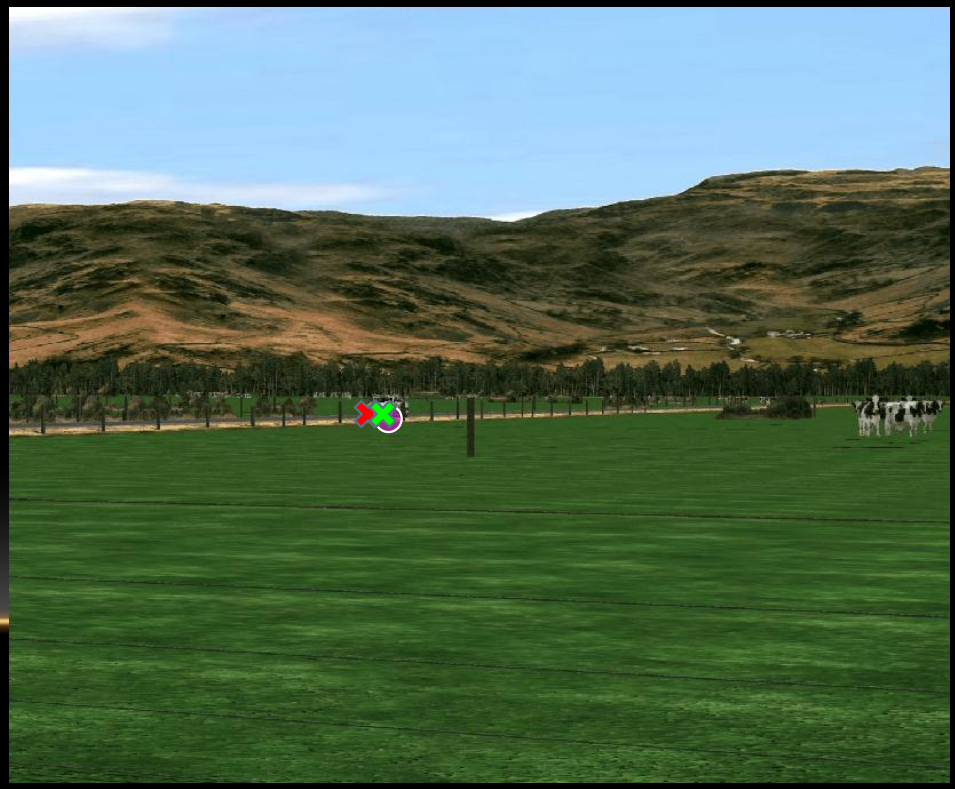
time (msec)
gaze position
train front
train centroid
gaze position
car front
car centroid



- 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 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).

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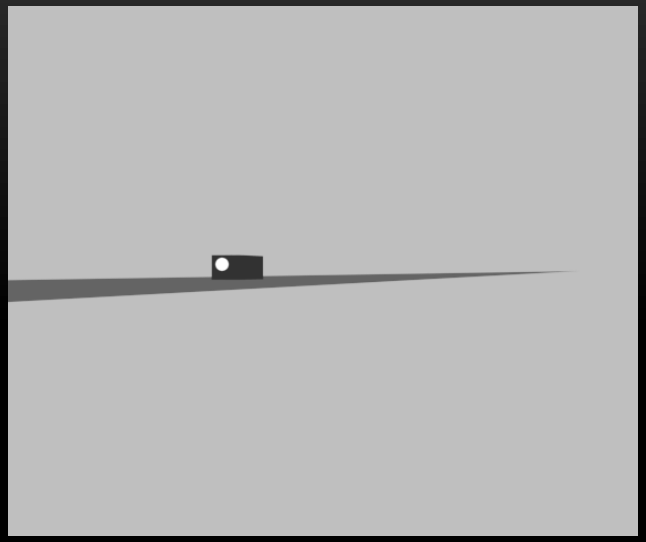
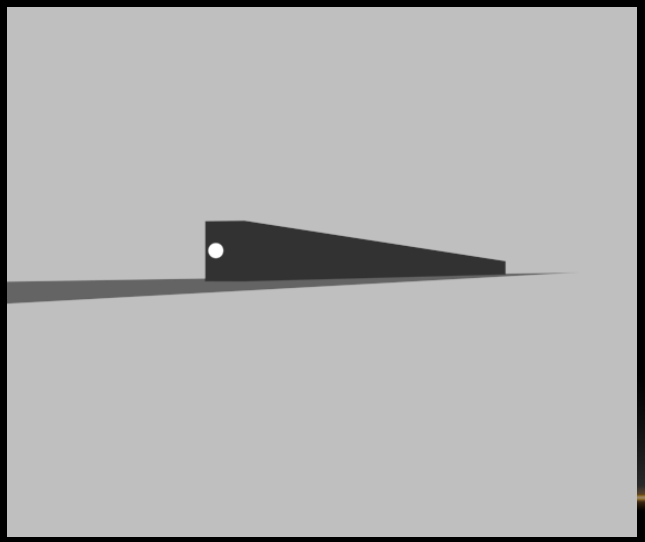
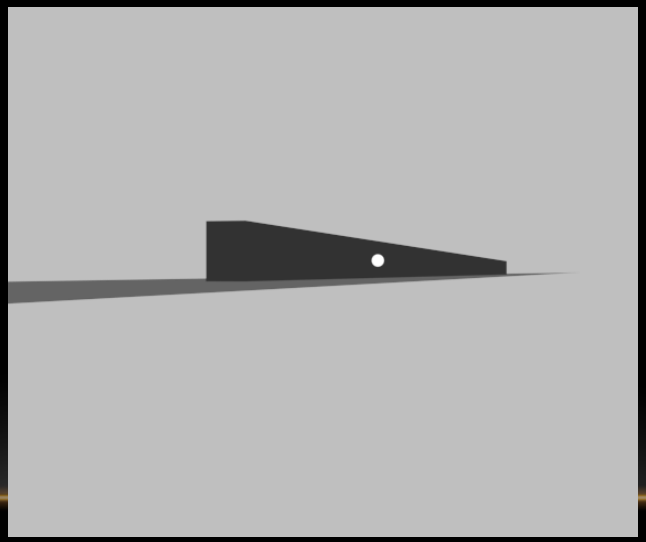
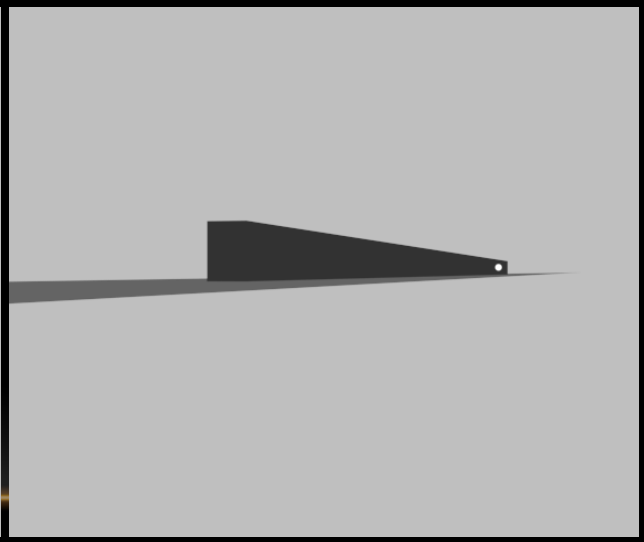
- Eye movement behaviour recorded.



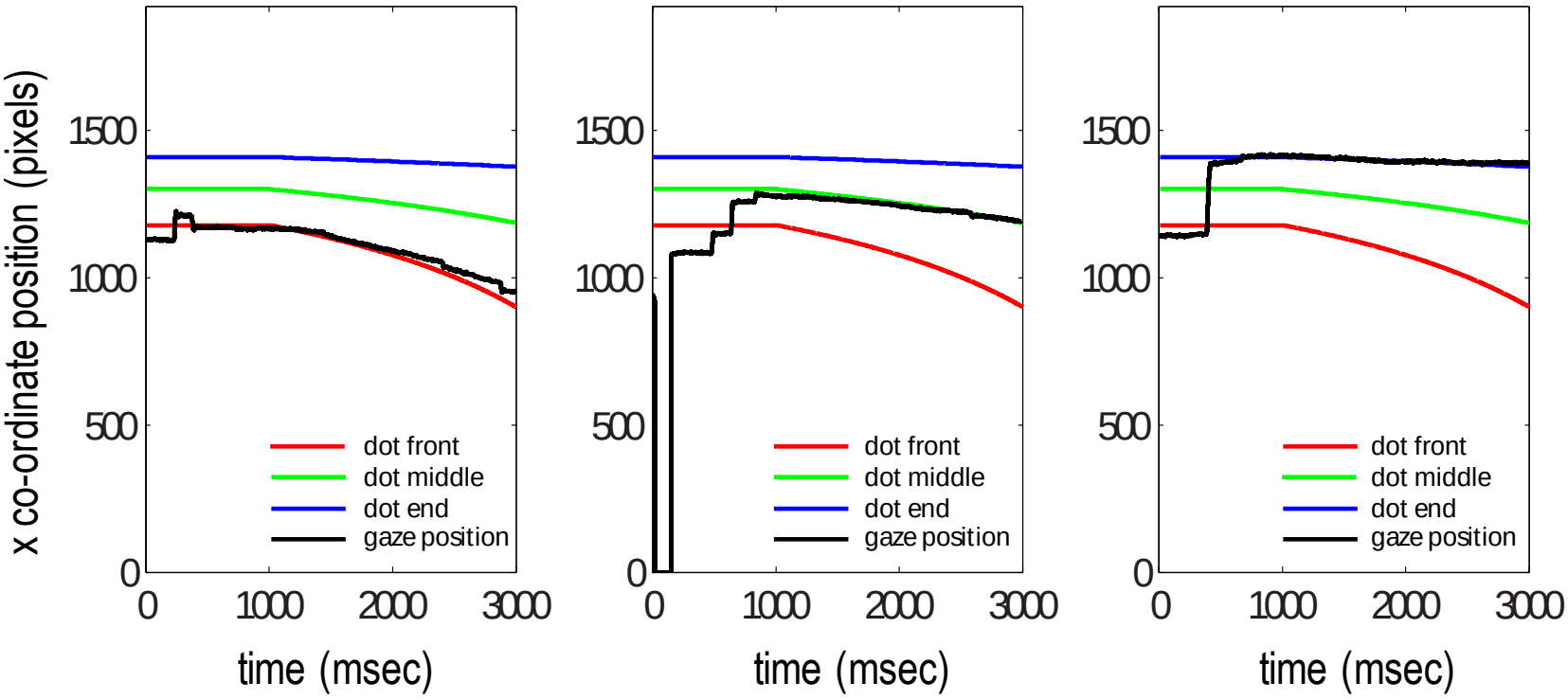






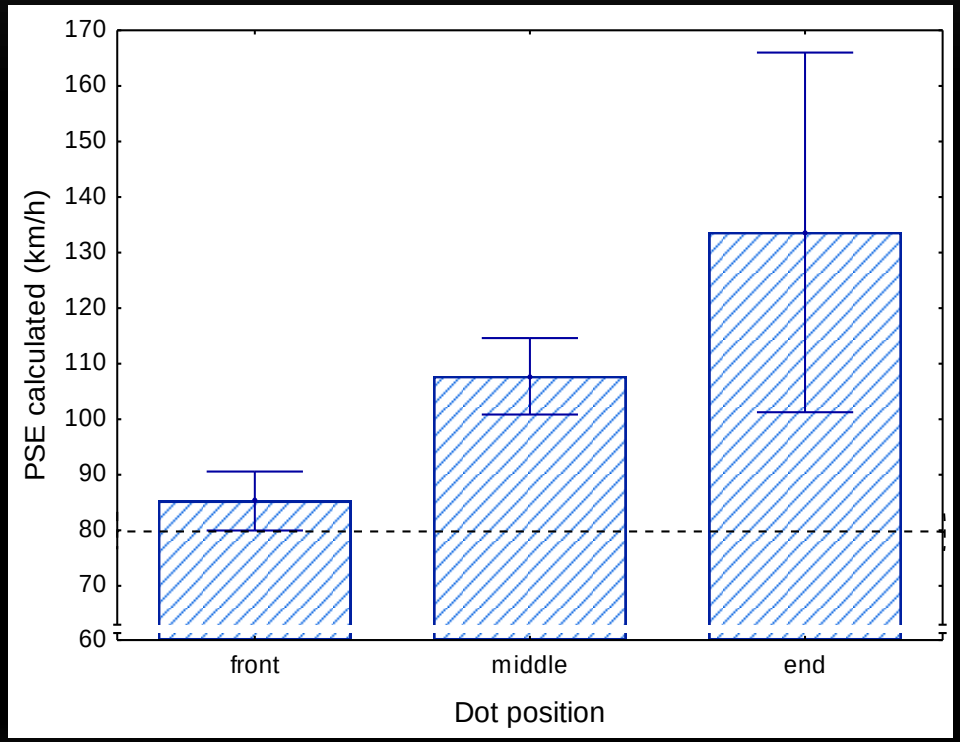
ANALYSIS

- 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.


x co-ordinate position (pixels)
1500
1000
500
0
0
1000
2000
3000
time (msec)
dot front
dot middle
dot end
gaze position

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?

THE UNIVERSITY OF WAIKATO

Te Whare Wānanga o Waikato

THANK YOU

TARS

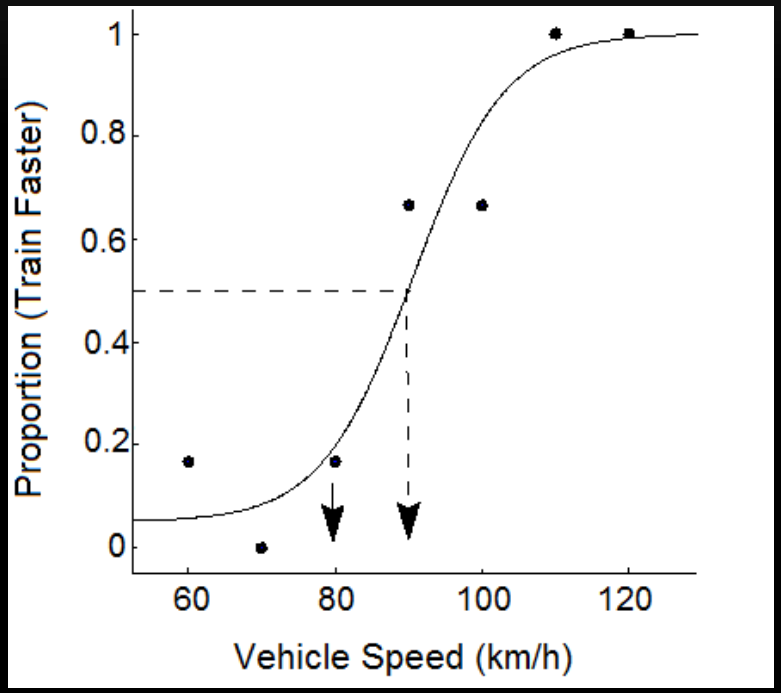
Traffic and Road Safety Research Group

Celebrating 20 years

http://www.youtube.com/watch?v=xmPoFLAUokI

DATA ANALYSIS

- 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 80km/h indicated an underestimation of the train's speed (relative to the car).