Visual Attention Failures during Turns at Intersections: An On-road Study *

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THE VARSITY
The University of Toronto's Student Newspaper Since 1880

Cyclist fatally struck in the Annex

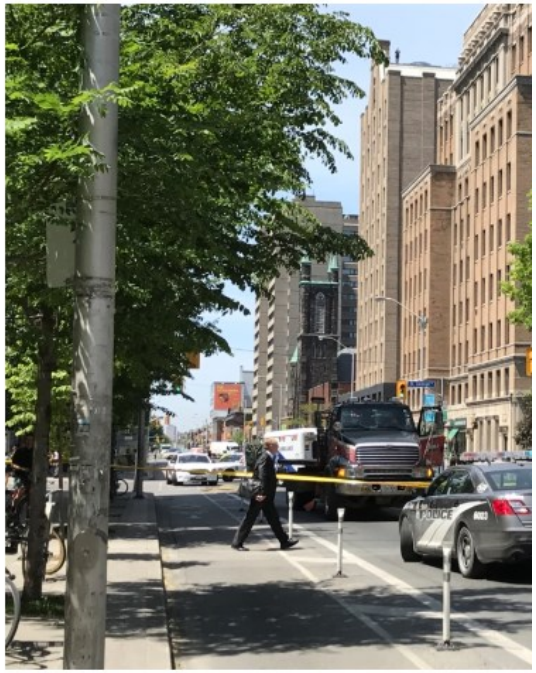
North end of campus closed off for investigation

By Ilya Bañares

Published: 12:43 pm, 12 June 2018

Modified: 6:27 pm, 15 June 2018

under News
Tags: fatal collision, road accident

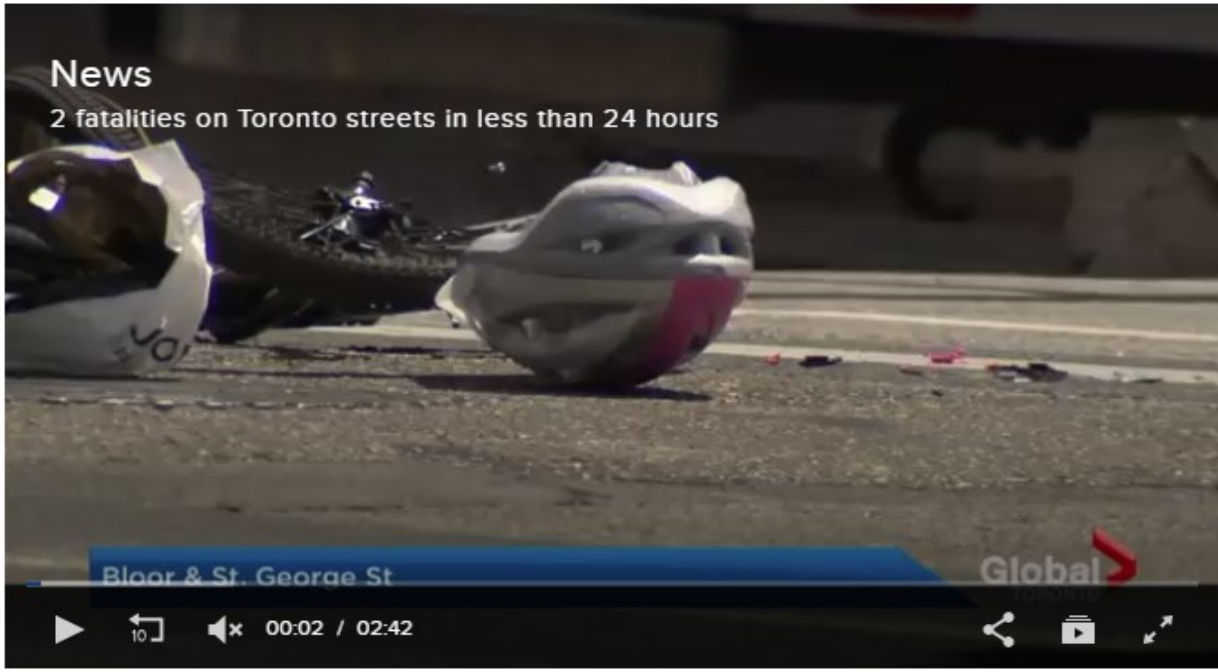


JACK DENTON/THE VARSITY.

CRIME June 12, 2018 12:44 pm Updated: June 12, 2018 8:03 pm

Female cyclist, 58, dies after being hit by truck in the Annex

By Jessica Patton Web Coordinator Global News



WATCH ABOVE: Two women have died on Toronto streets in less than 24 hours. Catherine McDonald has more on both victims and the search for a suspect in one of the incidents.

Safety at Intersections

- Turning at intersections has **high attentional demands** for drivers
- 42% of Ontario crashes are **intersection-related** (Ministry of Transportation Ontario, 2014)
- Intersections are particularly **risky for vulnerable road users**, e.g., pedestrians and cyclists
  - 69% of crashes involving vulnerable road users were at intersections (Toronto Public Health, 2015)
- **Complex intersections** with high traffic volume require particular attention
  - 64-70% of vulnerable user major-injury/fatalities are on major arterials (Toronto Public Health, 2015)

Driver Error: Attention Misallocation

- Most common driver errors:
  - **"failing to yield the right of way"** and **"distraction and inattention"** (Canadian police reports, 1999-2008)

→ Major source of vulnerable road user crashes: Driver Attention misallocation (Rasanen & Summala, 1998; Wu & Xu, 2017)

- Drivers may be **failing to properly scan** the environment for vulnerable road users

- But its extent at intersections is unknown

Research Objectives

- **Examine attention failures toward vulnerable users** during right turns at intersections
  - Data collected as part of a larger instrumented vehicle study focusing on demands associated with urban driving (Ponnambalam & Donmez, HFES 2018)
  - Eye-tracker and video allowed for accurate gaze position data
- **Validate intersection-related error items** of the Driver Behaviour Questionnaire (DBQ)
  - DBQ is widely used to assess aberrant driving behaviours (Reason et al. 1990; Parker et al. 1995; Lawton et al. 1997)
    - Three subscales: Errors, lapses, violations
  - Validated via
    - Self-reported crash data (De Winter & Dodou, 2012; Donmez et al. 2017)
    - On-road highway study (Zhao et al. 2012)
    - On-road urban study excluding vulnerable user items (Amado et al. 2014)

On-road Data Collection

- **Instrumented vehicle study** conducted in downtown Toronto (Ponnambalam & Donmez, HFES 2018)
  - July to October 2017
  - Good weather conditions
  - On weekends, starting at 10:30 am or 1:30 pm
  - Turn-by-turn directions provided by experimenter
  - ~35 min total driving time after practice drive
- Relevant Apparatus:
  - Head-mounted Dikablis **eye tracking glasses**, 50 Hz
    - Gaze position automatically overlaid on video from front-facing eye-tracking camera
  - Vehicle mounted camera looking forward

19 Participants

- **Low crash risk group** (McGwin & Brown,1999):
  - Age: 35-54 (Mean=42, SD = 5.9)
  - Driving Experience: +3 years
- Self-reported frequency of downtown Toronto driving:
  - Few times a week or more (n=9)
  - Few times a month or less (n=10)
- **Intersection-related error DBQ items** (Reimer et al. 2005):

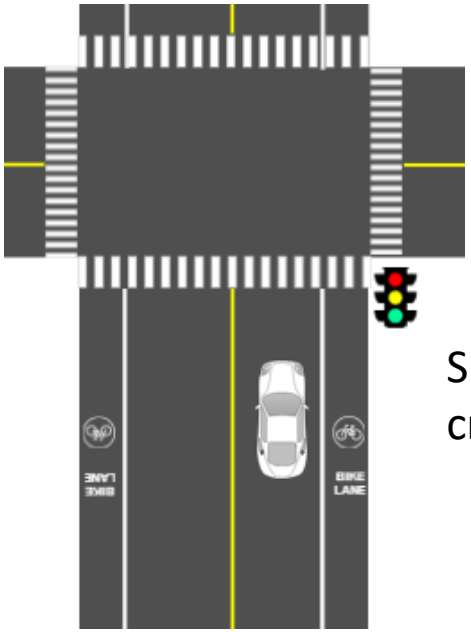
How often do you do each of the following?

"Never" (0) "Hardly ever" (1) "Occasionally" (2) "Quite often" (3) "Frequently" (4) "Nearly all the time" (5)

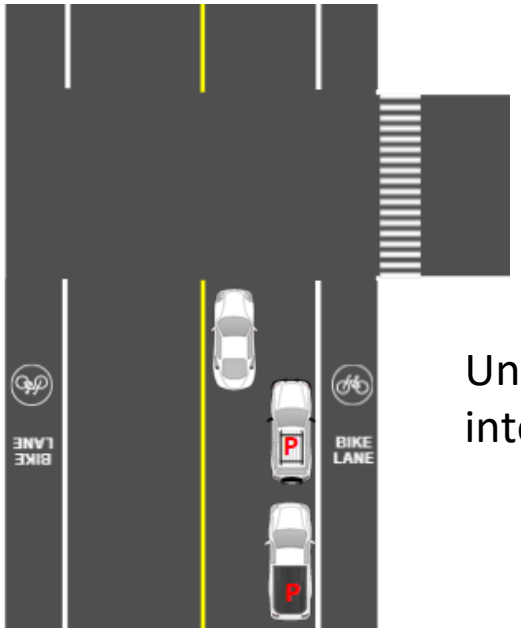
	Average	SD
(1) fail to notice pedestrians crossing when turning onto a side street	0.89	0.57
(2) when making a right turn, you almost hit a cyclist or pedestrian who has come up on your right side.	0.74	0.65
(3) when preparing to turn from a side road onto a main road, you pay too much attention to the traffic on the main road so that you nearly hit the car in front of you.	0.74	0.65

Attentional Failure Coding

- 2 intersections on Bloor St (major arterial):



Signalized 4-way cross intersection



Uncontrolled T-intersection

- Attentional failure to vulnerable road users: participant fails to gaze at a certain area of importance (e.g., bike lane on the right) with enough frequency
  - Three independent coders; fixed marginal kappa=0.67 (Chen et al. 2005)
  - Consensus through discussion

No Failure Case; Cross intersection

Failure Case; T-intersection

Prevalence of failures

- 11 of the 19 participants had a failure in at least one intersection
  - Prevalence concerning given our participants represent low crash-risk age group
- All failures related to cyclists
  - Over-the-shoulder checks require effort (head movements)
  - Pedestrians stay more within the drivers' field of view

- More failures on T- than cross intersection (10 vs. 6 participants)
  - Parked vehicles blocked drivers' view of the cyclists necessitating over-the-shoulder checks

Parked Vehicles

Likelihood of failures

- Ordered logit model in SAS GENMOD
- Dependent variable: No failure (n=8), Failed at 1 turn (n=6), Failed at both turns (n=5)
- Predictor variables:
  - 3 DBQ items' average (higher vs. lower)
  - Self-reported frequency of downtown Toronto driving (frequent vs. non-frequent)
  - No multicollinearity, $\chi^2(1) = 1.35$, $p = .37$
- Both marginally significant at $p = .07$, Odds Ratio: 6.04
- Likelihood of **more failures** for drivers who self-reported
  - making **more intersection-related errors** in DBQ
  - driving **more frequently** in downtown Toronto

Key Points

- First on-road study to analyze drivers' eye tracking data at intersections towards vulnerable users
- Preliminary results on the extent drivers fail to properly scan for vulnerable users at intersections, especially for cyclists
- Validation of the intersection-related error items of DBQ

Limitations

- Variations in signal status and traffic flow
- Sample size
- Directing gaze toward a location is a pre-requisite for perception but it does not guarantee perception
- Potentially intrusive eye tracker

Future Study

- **Prevalence** of driver visual attention failures towards vulnerable road users at intersections
- **Individual Differences:**
  1. Post-drive Questionnaires
  2. Post-drive Attention Tasks:
     i. Posner Task→ Visual-Spatial Attention (Posner, 1980)
     ii. Multiple Object Tracking Task→ Visual-Object Attention (Pylyshyn & Storm, 1988)
- **Road Design:**
  1. Busy & Risky Intersections (Downtown Mobility Strategy, 2018)
  2. Control Types: Signalized, Stop-sign, Uncontrolled

Acknowledgement

- NSERC
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Questions?

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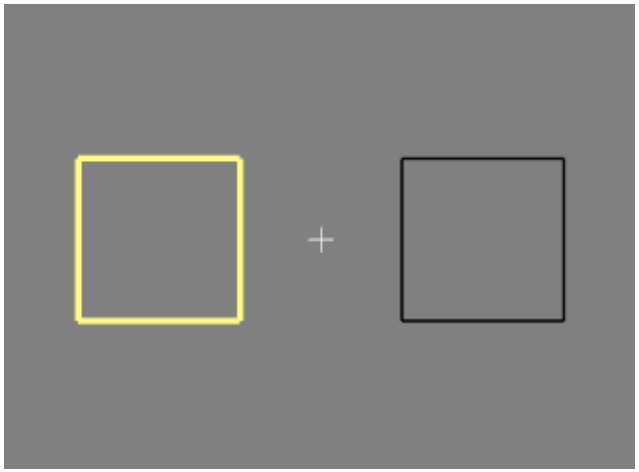
More about us..

http://tiny.cc/cbc-eyetracker

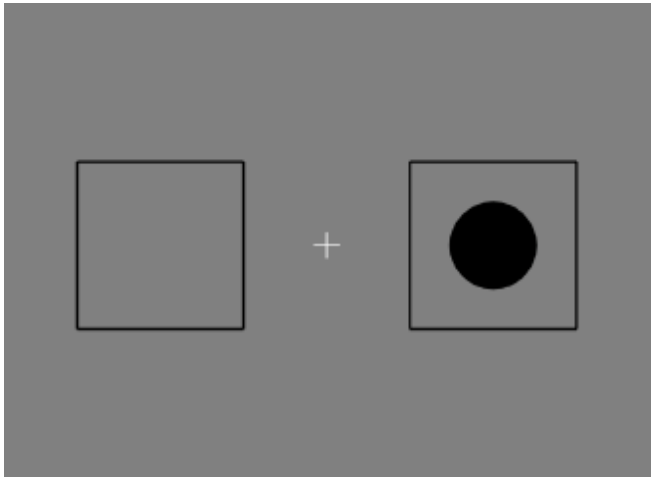
Limited Resources for Visual Attention

- Important to understand where and with which mechanism people allocate their attention under complex environments (Soto & Blanco, 2004)
- **Visual-Spatial Attention Theory:** One attends to a particular **location** within their field-of-view (FOV).
- **Visual-Object Attention Theory:** One attends to a specific **object** based on their features.

Visual-Spatial Attention: Posner

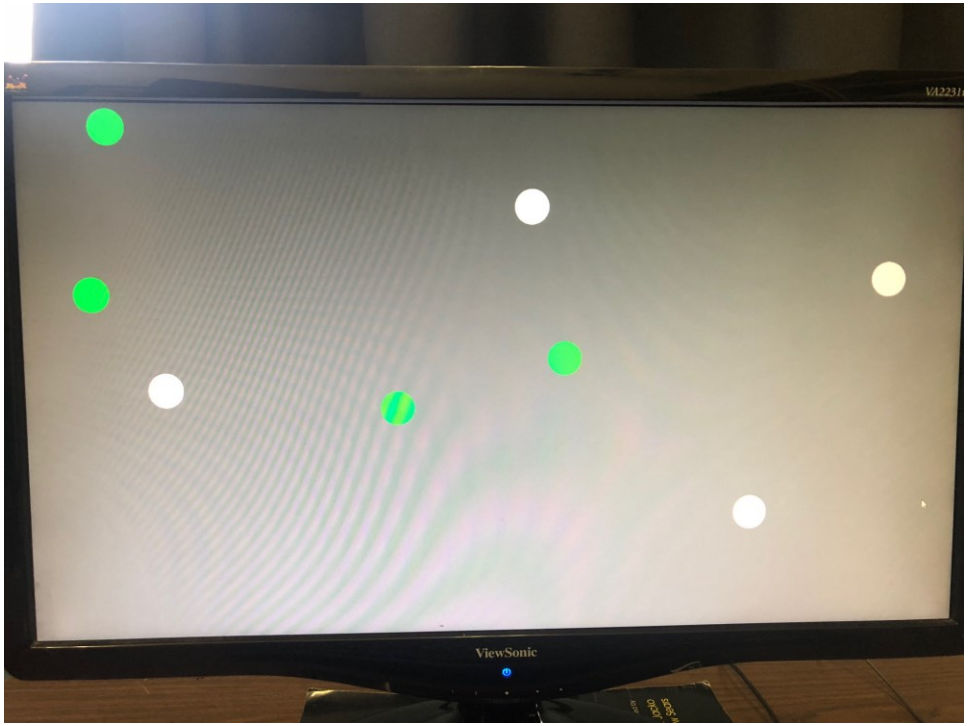


- Cue: Flashing



- Target: Circle
- Invalid vs. valid trials
- Reaction time
- Response accuracy

Visual Object Attention: Multiple Object Tracking



- Aim: Tracking 4 Circles
- Reaction time
- Response accuracy