

A nighttime street scene with light trails from traffic and a digital billboard. The billboard is illuminated and displays text. The background shows a street with tram tracks, a blue light, and a building.

LED

Light Evoking Distraction?

Kristof Mollu

*Guest worker / PhD Candidate (Hasselt University)
Engineer Traffic Safety (Agency for Roads and Traffic)*

Introduction

Distraction

- Contributing factor in 10 to 30% of all European road accidents (*European Commission, 2015*)
 - No uniform definition (some elements)
 - Diversion away from (safe) driving
 - Attention diverted towards a competing activity inside or outside the vehicle which may or may not be driving related
 - Implicit or explicit, assumption that safe driving is adversely effected
 - Visual and/or cognitive
- ➔ Advertising signs / digital billboards

Advert featuring woman's breasts causes 500 accidents in a DAY among Moscow's distracted male drivers - before being impounded by police

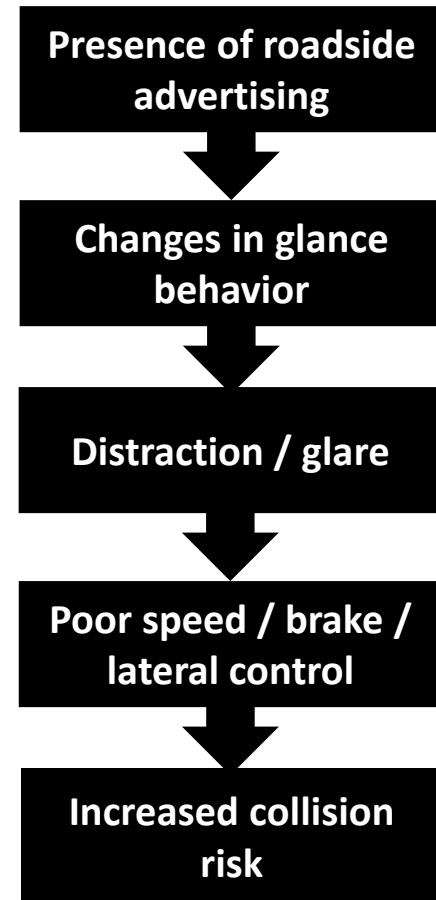
- Campaign was intended to show off the visibility of mobile ad hoardings
- But as trucks trundled around the capital they left trail of carnage
- Stunt backfired when Moscow police impounded all the risque trucks



Preliminary literature study (Brijs et al., 2014)

- Literature study on the effects of LED advertising signs (Brijs, Brijs & Cornu, 2014)
 - Some characteristics of LED advertising signs may have a negative impact on glance behavior, distraction and driving related parameters:
 - A) Functional characteristics & placement conditions
 - Panel location
 - Position: Longitudinal /lateral/vertical location Size
 - Luminance level
 - B) Message-related factors
 - Type, content and complexity of message
 - Display time
 - Transition speed
 - Potential confusion with road signs

- ➔ No hard scientific evidence for collision increase
- ➔ No uniform guidelines



Chattington, Reed, Basacik, Flint, & Parkes (2009)

Follow-up driving simulator study (2016)

Mollu, K., Cornu, J., Brijs, K, Geraerts, M., Pirdavani, A., & Brijs, T. (n.d.). Influence of digital LED-illuminated billboards on driving behavior near pedestrian crossings. In: HUMAN FACTORS [In review]

- Research questions of Flemish Agency for Roads & Traffic → new guidelines
 - 1) Is the **glance behavior** of road users (in)directly influenced by LED advertising signs?
 - 2) Does distraction due to LED advertising signs lead to **changes in driving behavior**?
 - 3) Which **effects on road safety** can be expected by placing LED signs?



Method

Participants

- 41 test subjects
 - 35 test subjects with usable driving simulator data
 - 2 outliers; 4 simulator sick

	Average	Min.	Max.
Age [years]	39	20	69
Driving licence	19	3	42
% male	54%		

Research plan

- Focus on two characteristics/variables of LED advertising signs
 - **Display time** of a message of the graphical message (message duration)
 - NL: 6s
 - Flanders: 30s
 - US Member States: 4 – 10 s (majority 8s)
 - **Location of the LED advertising sign** relative to a situation that requires focused attention from the driver
 - Examples: minimal distances, not nearby locations where increased attention is needed
- AIM of this study: scientific evidence based guidelines

Design – 2 conditions

1) Display time of message

- **Hypothesis:** shorter message display time leads to higher number of eye glances towards the LED advertising sign, because
 - Increases attention to read the message
 - Less time to read

3 Levels of display time

3s

6s

15s

2) LED signs on locations that require focused attention from driver

- Too much *visual clutter* disrupts visual search behavior (Wallace, 2003)
 - Late perception of obstacles
 - Reaction time increases
 - ➔ Critical near decision locations (e.g. traffic lights, zebra crossing) and more complex road environments (e.g. busy intersection)
- **Hypothesis:** placing LED advertising signs near to intersections, decision points and curves creates distraction and leads to adverse impact on driving behavior
- Recommendations from literature
 - Do not place LED advertising signs where information density is already high, or where focused attention from the driver is needed (*Brijs et al., 2014; Merckx-Groenewoud & Perdok, 2011*)
- Implementation in simulator
 - Increased attention situation = pedestrian crossing

2 Levels of distance

41m

65m

Distances: based on stopping distance and guidelines regarding cut-off distance stop reading

- Other characteristics similar in all conditions
 - Installation angle: 90°
 - Distance between middle of right lane and billboard: 6m to the right
 - Distance between ground level and bottom-side of billboard: 3m
 - Surface area: 5 m²
 - Weather conditions: sunset

- LED sign 2x present/experimental run

LED sign nearby pedestrian crossing in
Road segment with a retail zone



LED sign nearby pedestrian crossing in
Road segment transitioning to built-up area

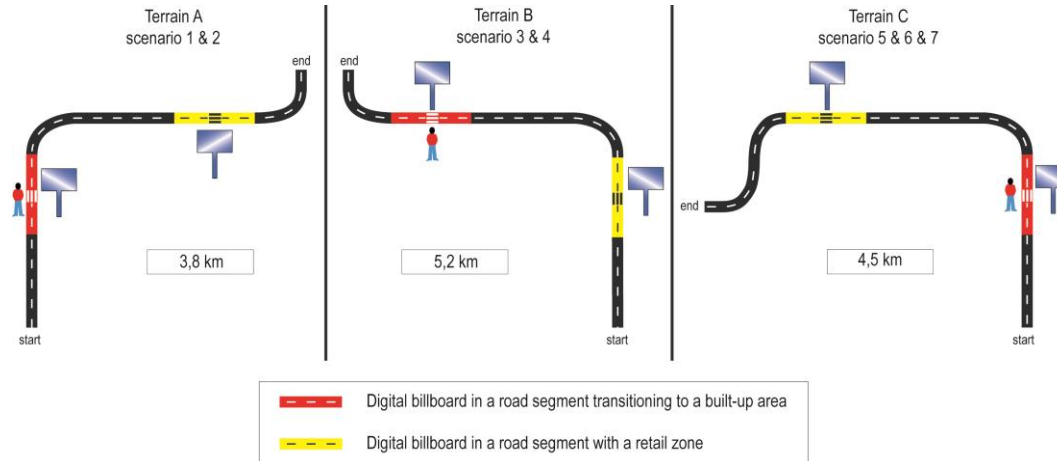


Crossing pedestrian at ped. cross.
From left side
TTC: 4 s (cfr, Lubbe & Rosé, 2014)
Speed: 1.2 m/s

- Full within-subject design
 - Display time (3 levels) x Prior distance from a pedestrian crossing (2 levels) + 1 reference
- ➔ 7 test drives, randomly assigned (first: 1 practice session)

	Display time 3 s	Display time 6 s	Display time 15 s
Distance 41 m	Scenario 2	Scenario 4	Scenario 6
Distance 65 m	Scenario 3	Scenario 5	Scenario 7

* Scenario 1: reference scenario without a digital billboard present





© Hasselt University

Data collection

Workload

- NASA Task Load Index: subjective measure for workload
 - 6 subscales: mental demand, physical demand, temporal demand, own performance, effort and frustration
- Fulfilled after scenario 1 en scenario 2

Glance behavior

- Average amount of glances on digital billboard
- Total fixation time on digital billboard

Driving behavior

- Average speed
- Standard deviation of lateral position
- Behavior towards the crossing pedestrian

Results & Discussion

Workload

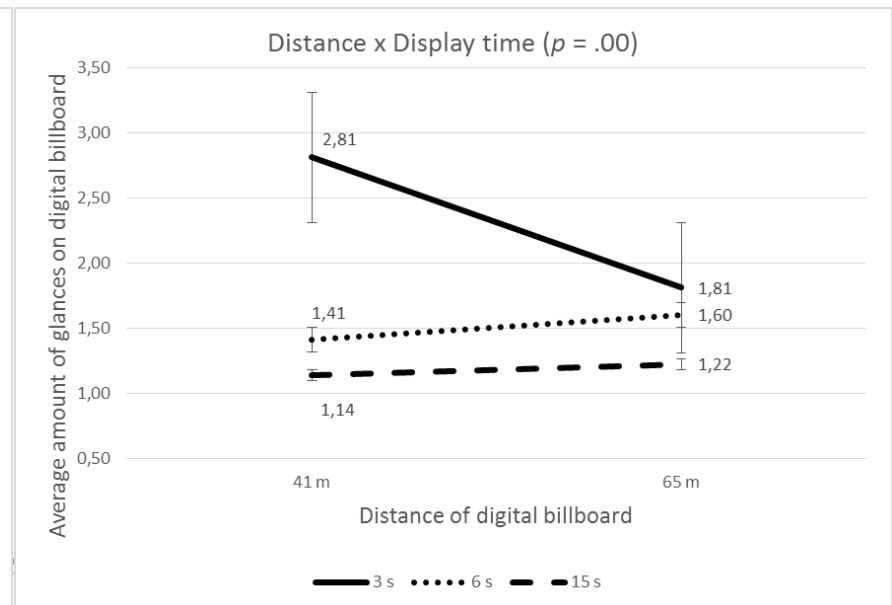
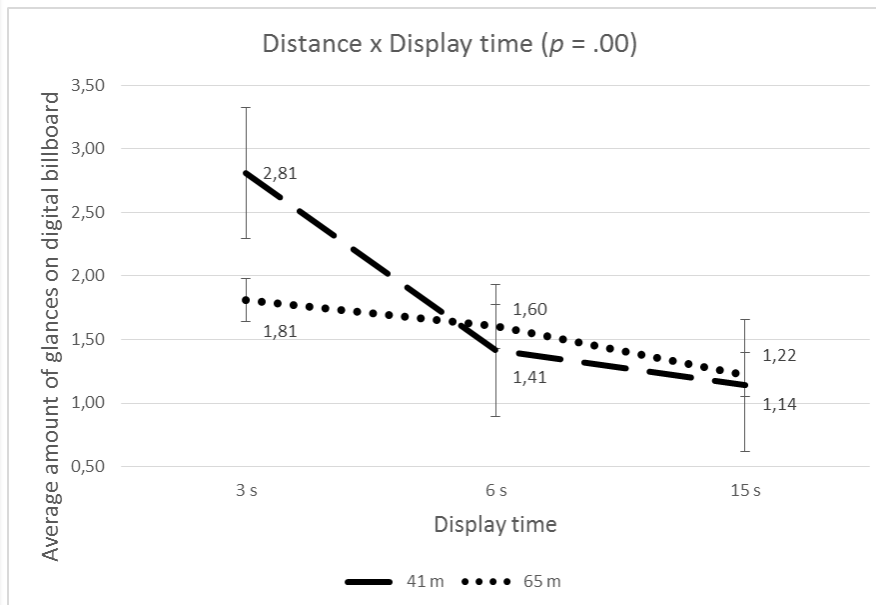
- Significantly higher mental demands and a lower own performance in case of a LED-billboard (display time 3s and distance 41 m)

Pair	Scenario	Mean	SE	paired samples t-test
Mental demand	No digital billboard (Sc1)	6.80	.85	$t(34) = -2.87, p = .01, r = .44$ *
	Digital billboard (Sc2)	8.63	.72	
Physical demand	No digital billboard (Sc1)	5.94	.82	$t(34) = .51, p = .61, r = .09$
	Digital billboard (Sc2)	5.57	.65	
Temporal demand	No digital billboard (Sc1)	5.94	.73	$t(34) = .33, p = .74, r = .06$
	Digital billboard (Sc2)	5.74	.67	
Own performance	No digital billboard (Sc1)	13.48	.68	$t(34) = 2.49, p = .02, r = .40$ *
	Digital billboard (Sc2)	11.51	.90	
Effort	No digital billboard (Sc1)	7.37	.89	$t(34) = -.50, p = .62, r = .09$
	Digital billboard (Sc2)	7.65	.82	
Frustration	No digital billboard (Sc1)	6.62	.76	$t(34) = -1.72, p = .09, r = .28$
	Digital billboard (Sc2)	7.77	.83	

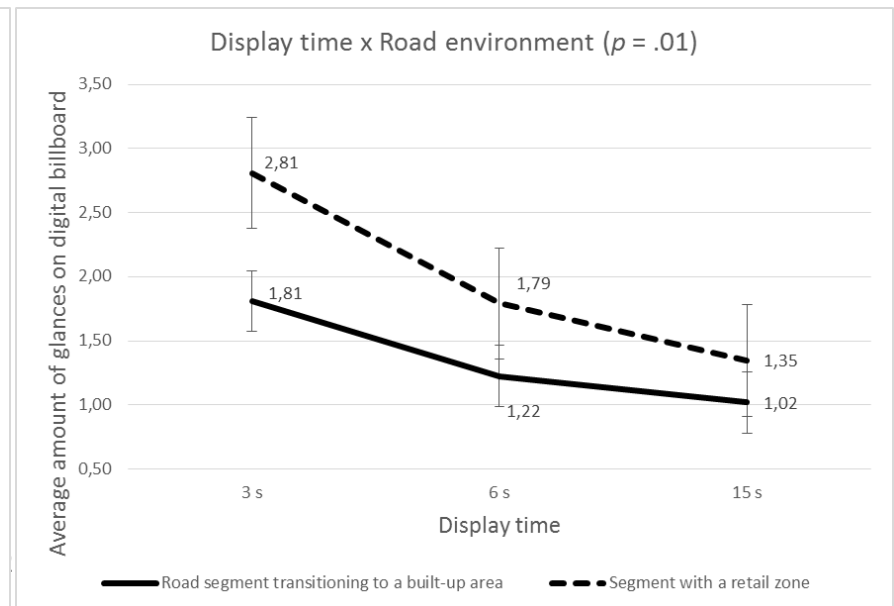
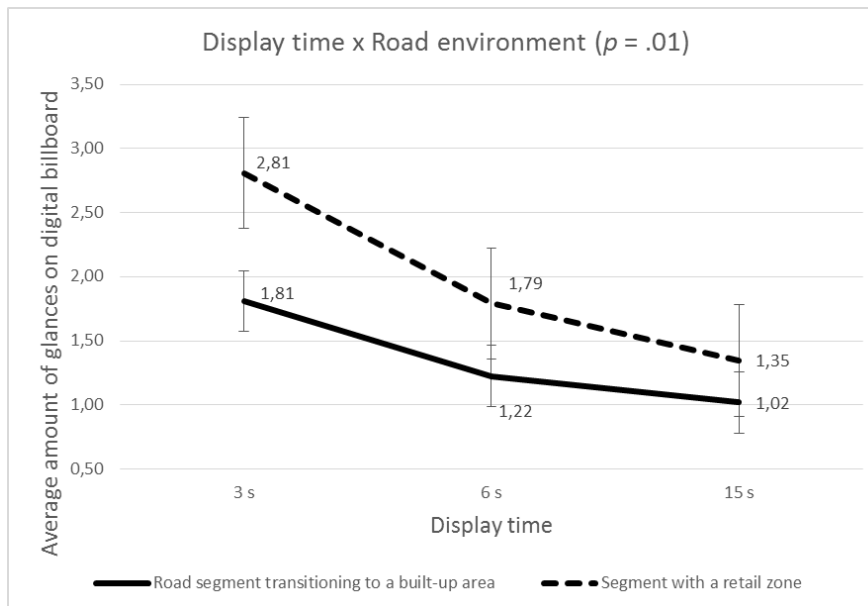
1) Is glance behavior of road users influenced by LED advertising signs?

Amount of glances

- YES, high message change frequency on LED sign leads to more eye movements
 - Significant interaction-effect Distance x Display time
 - The longer the Display time, the fewer glances (downward curves)
 - ➔ Explanation: Curious for message (cfr. Molino et al., 2009), less time to read message



- **YES**, high message change frequency on LED sign leads to more eye movements (cont.)
 - Significant interaction-effect Display time x Road Environment
 - Higher amount of glances if shorter Display time
 - More glances in zone with retail stores than in transition zone to a built-up area



1) Is glance behavior of road users influenced by LED advertising signs?

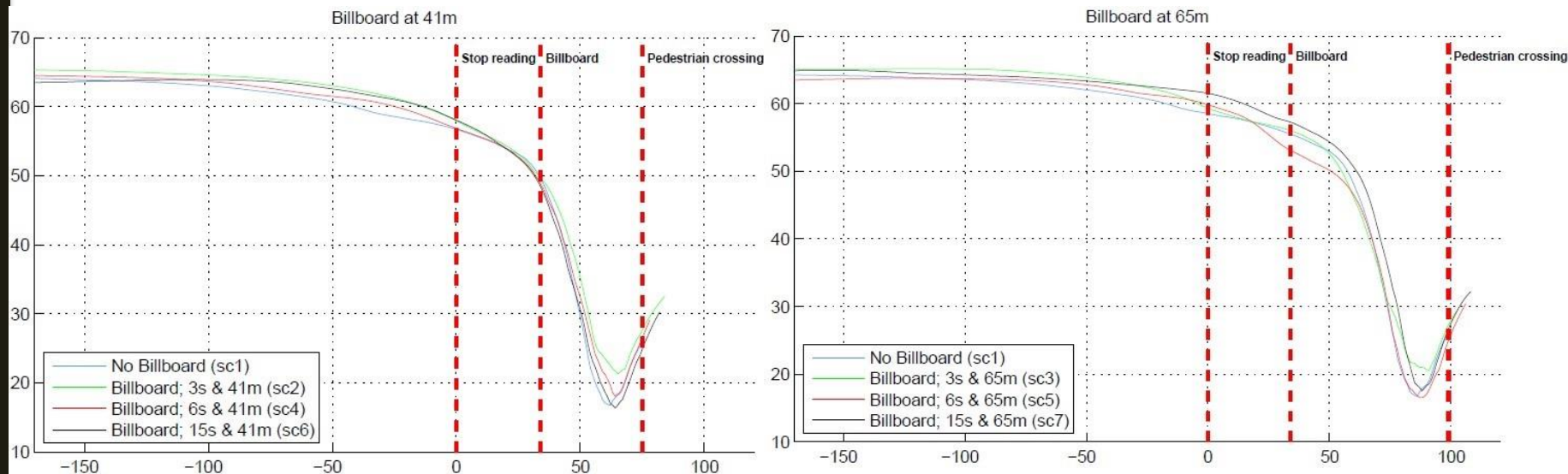
Fixation time

- No main or interaction-effects
- < 2 seconds

2) Does distraction due to LED advertising signs lead to changes in driving behavior?

Speed

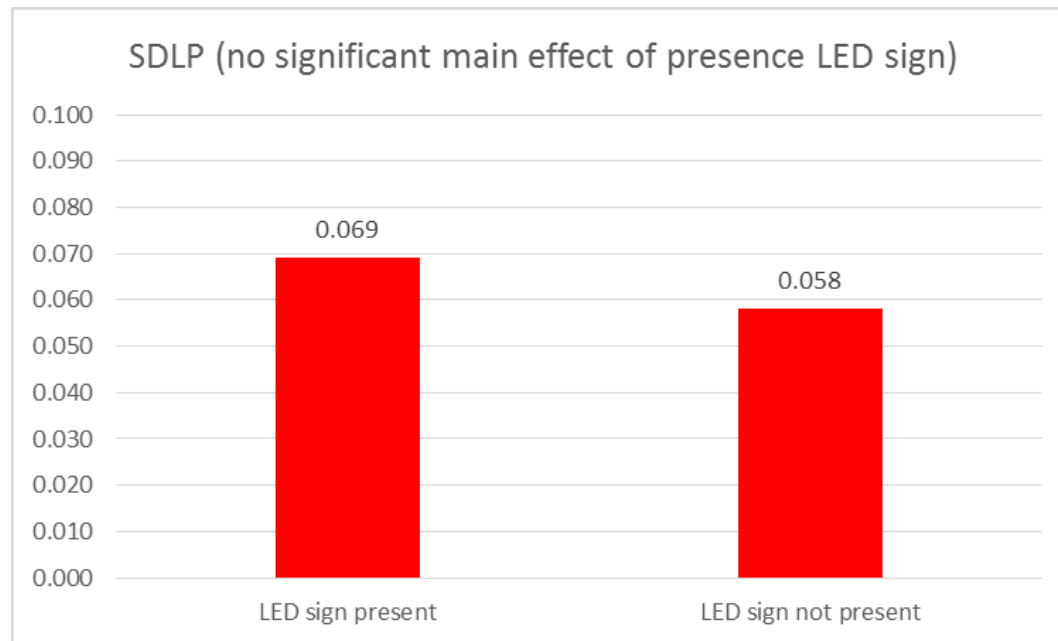
- YES, higher approaching speed to pedestrian crossing in case of LED advertising sign (the highest at display time of 3s)
 - 4 to 5 km/h (ca. 3 mph) or 23% to 27% higher than no billboard
- YES, minimal approaching speed to pedestrian crossing is reached later in case of presence of LED advertising sign



2) Does distraction due to LED advertising signs lead to changes in driving behavior?

Standard deviation of lateral position

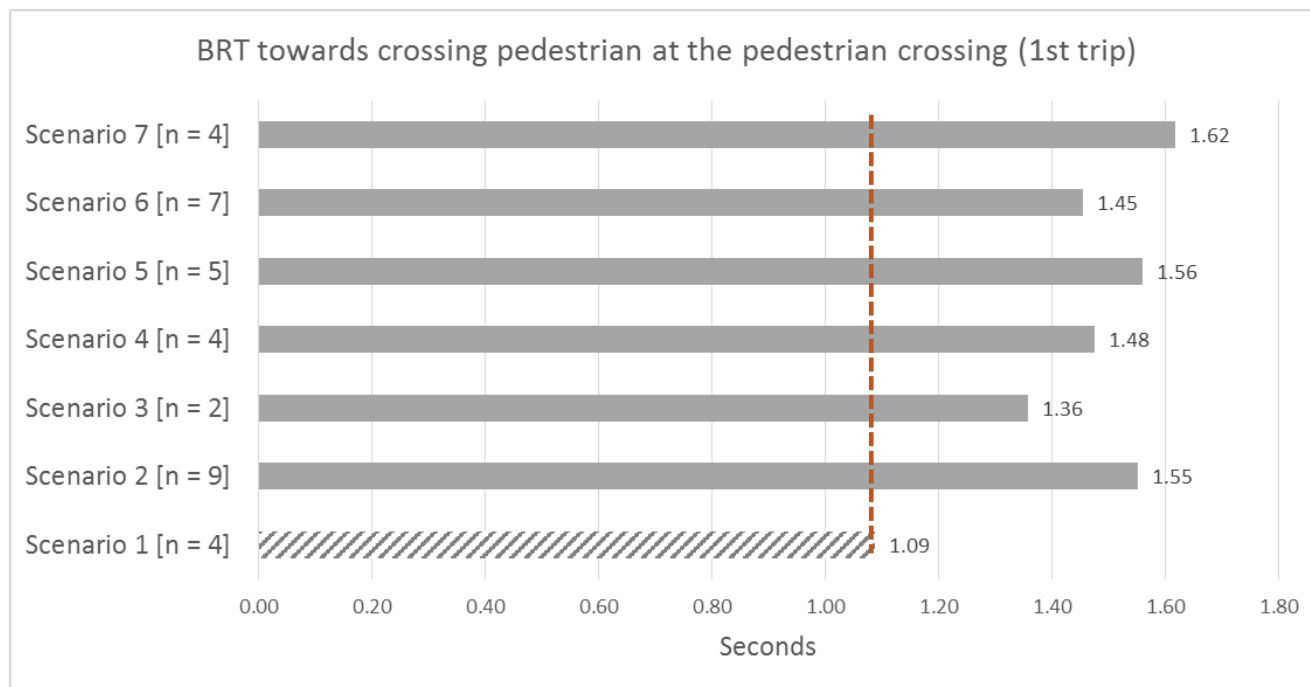
- Indication of increased swerving behavior in case of LED sign (non-sign.)
 - cfr. Summala et al. (1996) & Summala et al. (1998): driving task with peripheral view: reasonably able to stay on course



2) Does distraction due to LED advertising signs lead to changes in driving behavior?

Behavior towards the crossing pedestrian – BRT

- YES, indication that presence of LED sign leads to an increased Brake Reaction Time (BRT)



Behavior towards the crossing pedestrian – complete stops

- YES, indication that majority comes not a complete stop when billboard at 41 m and display time 3 s

Explanation: shorter display time → more glances on LED sign (= not on road)
→ noticing pedestrian later

→ cfr. Summala et al. (1996) & Summala et al. (1998): driving task with peripheral view: Later to notice braking car in front

	Display time	Distance	Total # as 1 st trip	Stopped for pedestrian		Not stopped for pedestrian	
				#	%	#	%
Scenario 1	No digital billboard		4	3	75%	1	25%
Scenario 2	3 s	41 m	9	4	44%	5	56%
Scenario 3	3 s	65 m	2	2	100%	0	0%
Scenario 4	3 s	41 m	4	4	100%	0	0%
Scenario 5	6 s	65 m	5	5	100%	0	0%
Scenario 6	6 s	41 m	7	7	100%	0	0%
Scenario 7	6 s	65 m	4	4	100%	0	0%

3) Which effects on road safety can be expected by placing LED signs?

- In the approach zone to pedestrian crossing, under presence of LED advertising sign:
 - Drivers brake later: higher crash risk
 - Drivers reach their minimal approaching speed later: higher crash risk
 - Drivers also have a higher approaching speed: higher crash impact
 - Drivers have more difficulties maintaining a steady position within the lane

Conclusion & recommendation

- Avoid too short display times (i.e., the longer the better)
- Avoid installation of digital billboards signs in the vicinity of already attention demanding locations



MOLLU Kristof
Agency for Roads and Traffic
(Engineer Traffic Safety)
Hasselt University (Guest worker & PhD-Candidate)

@ kristof.mollu@mow.vlaanderen.be
in be.linkedin.com/in/kristofmollu
@KristofMollu

**Thank you for
your attention**

Study conducted by:



Study conducted on behalf of:



Mollu, K., Cornu, J., Brijs, K., Geraerts, M., Pirdavani, A., & Brijs, T. (n.d.). Influence of digital LED-illuminated billboards on driving behavior near pedestrian crossings. In: HUMAN FACTORS [In review]