The Effectiveness of Smartphone Warnings and Alerts on Pedestrian Road Crossing

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Hank Virtual Environments Lab

http://psychology.uiowa.edu/hank-virtual-environments-lab

The Hank Virtual Environments Lab

Creating realistic, immersive virtual environments that allow full-body movement

- Bicycling simulator
- Pedestrian simulator

Studying human behavior in VR

- How do child cyclists cross roads?
- How do texting pedestrians cross roads?

Bicycling Studies

One-way and two-way traffic

High density traffic

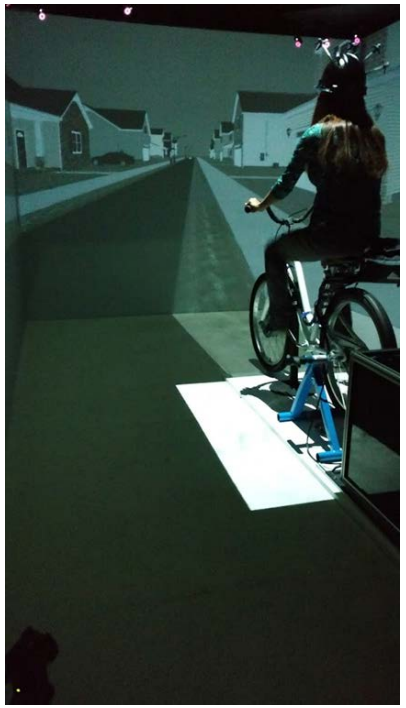
Interception of gaps on the run

Peer influence

ADHD riders

Adaptive Headlights

Road Infrastructure



Pedestrian Studies

Young and older road crossing

Crossing while texting with and without alerts

Joint road crossing

Nighttime vs. Daytime

Adaptive headlights

Connected Simulators

The Pedestrian Simulator

Measures

Gap selection

- ***Average gap size***
- ***Gap seen***
- ***Likelihood of accepting a gap***

Movement timing

- ***Timing of entry***: time between the rider and the rear of lead car in the gap when the rider enters the road
- ***Crossing time***
- ***Time to spare***: time between the rider and the front of the tail car in the gap when the rider clears the path of the cars

Vehicle-to-Pedestrian (V2P) Technology

Alerts using Dedicated Short-Range Communications Technology

Permissive Alerts

When it is safe to cross

Prohibitive Warnings

When it is unsafe to cross

Don’t walk signal

Collision warning

Connected Vehicles: Vehicle-to-Pedestrian Communications *USDOT factsheet*

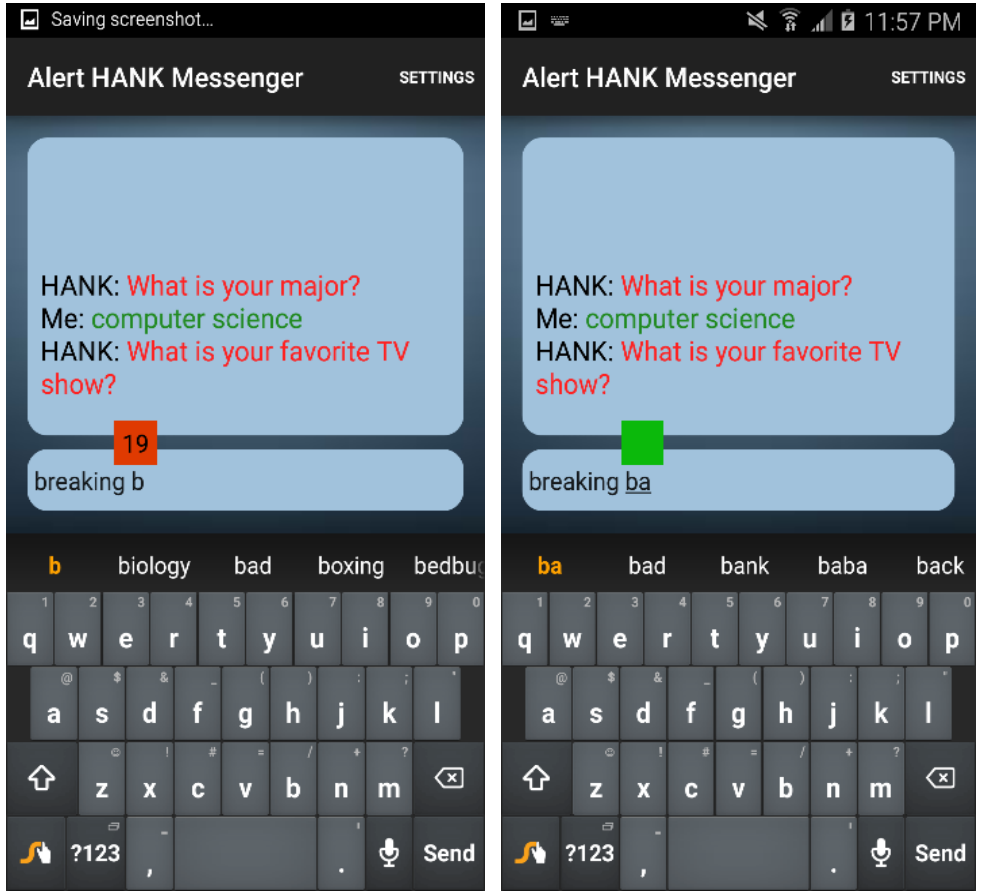
http://www.its.dot.gov/factsheets/pdf/CV_V2Pcomms.pdf

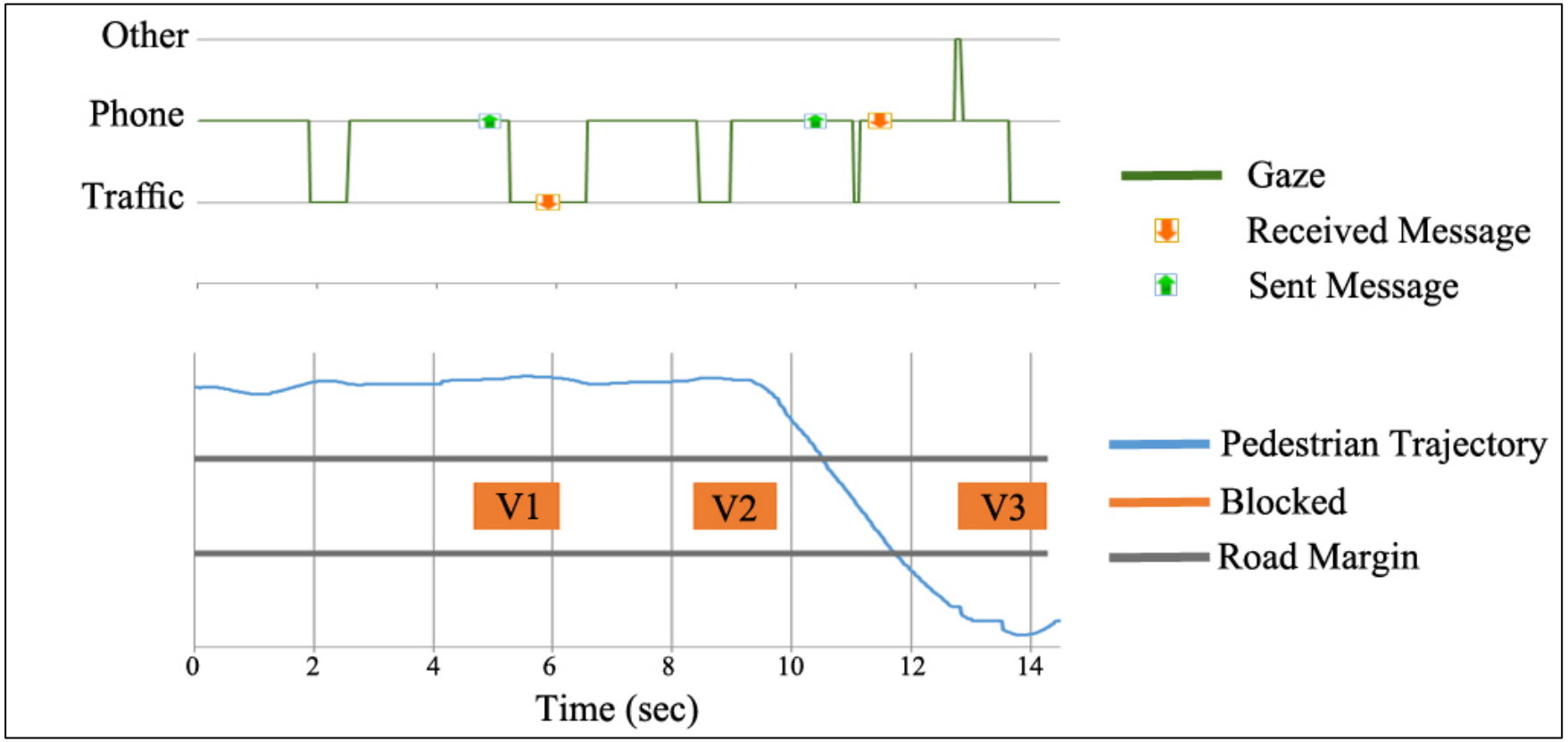
Permissive Alerts

Alerts that tell you when it is safe to cross

- Countdown clock to next gap
- Visual and auditory alert

  1 sec before the gap opens

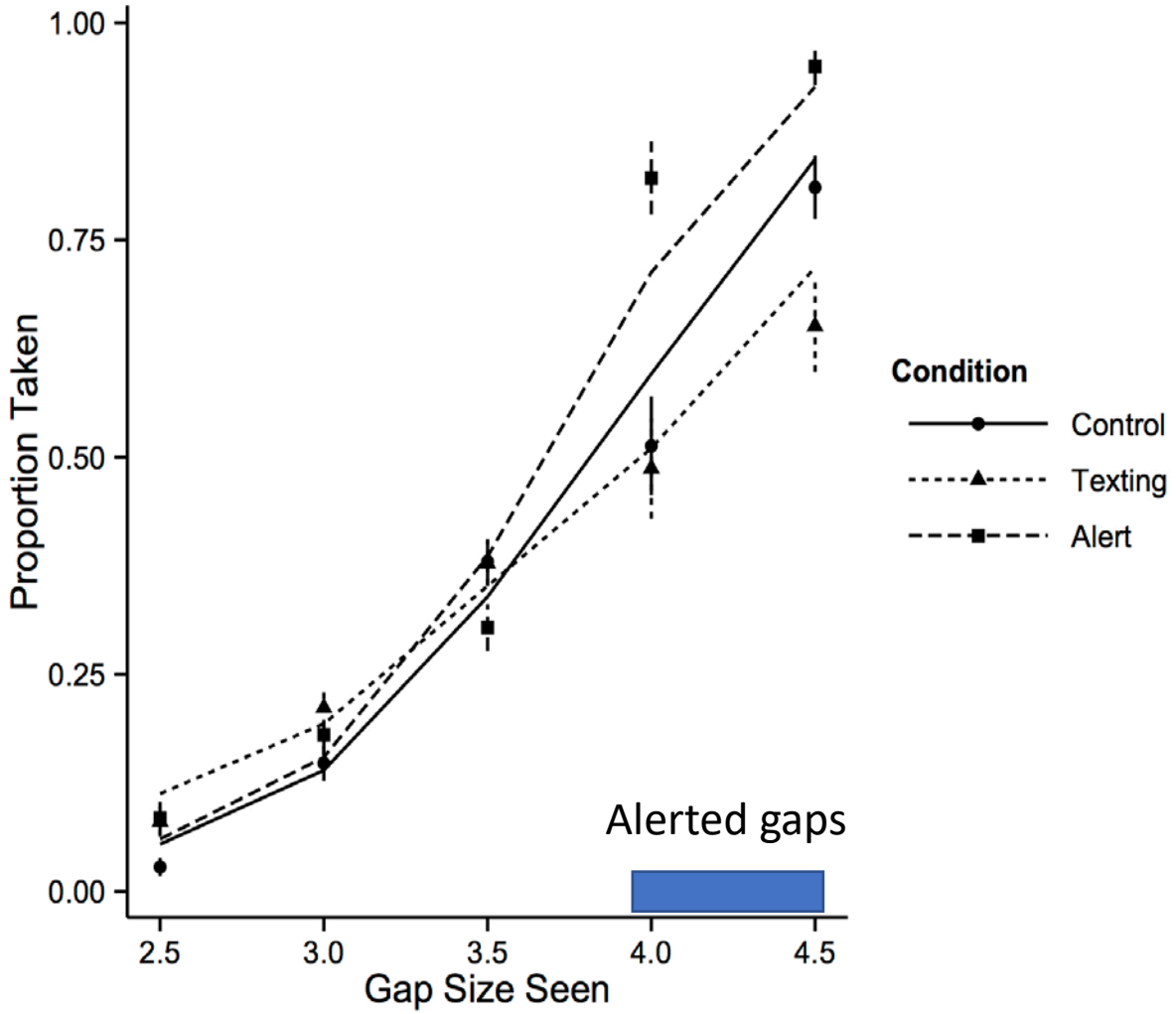



Other
Phone
Traffic
Gaze
Received Message
Sent Message
V1
V2
V3
Pedestrian Trajectory
Blocked
Road Margin
0
2
4
6
8
10
12
14
Time (sec)

Permissive Alerts

Average gap size

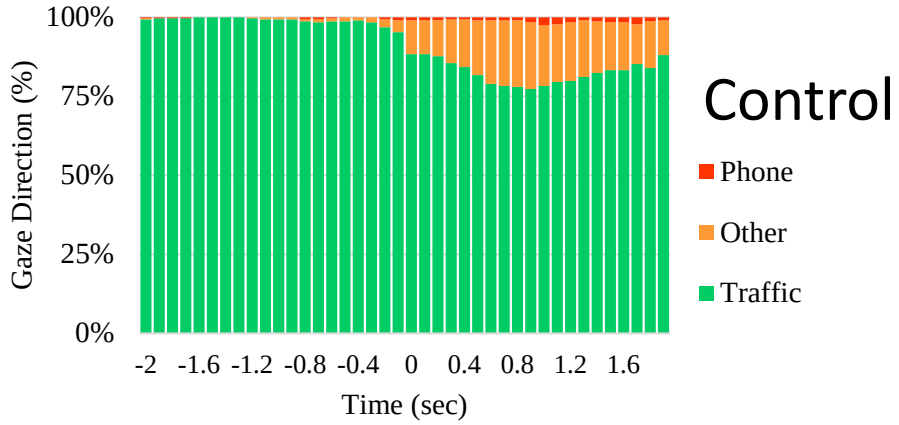
Control	3.72s
Texting	3.50s
Alert	3.71s

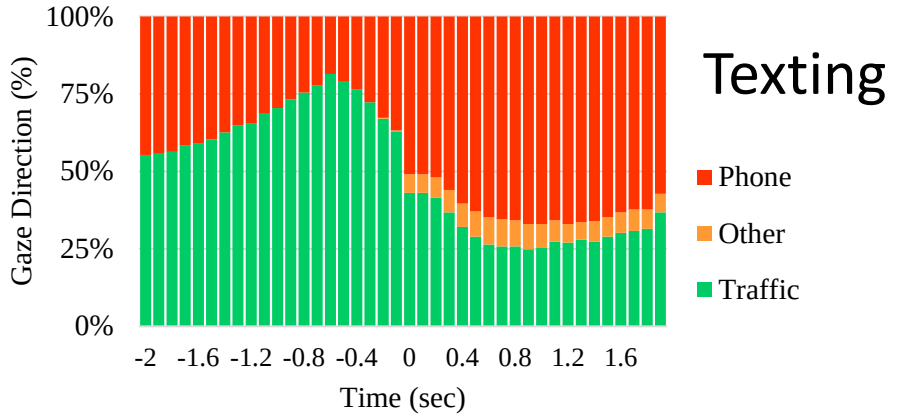


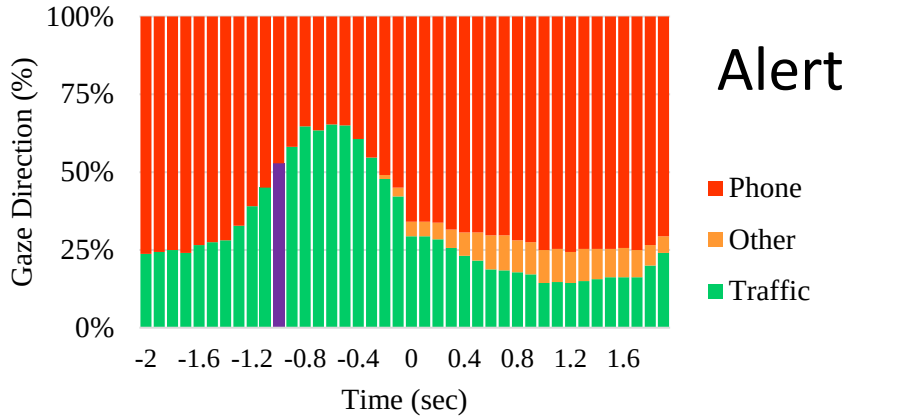
Gaze direction

2 sec before → 2 sec after gap

Condition	Traffic gaze time
Control	97%
Texting	46%
Alert	24%







Results for Permissive Alerts

Gaze direction

- Gaze at cell phone **~76%** of the time
- Glance at traffic immediately before crossing

Gap selection

- High likelihood of crossing identified gaps
  (In **97%** crossings, the alert group crossed the first alerted gap!)

Timing

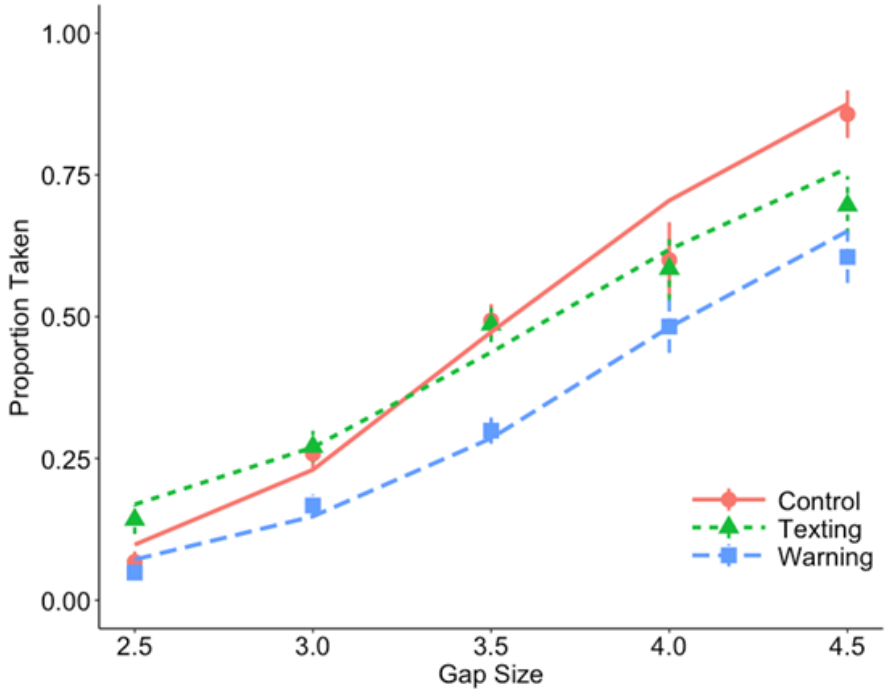
- Fewer close calls and hits compared to texting only
- Time left to spare similar to non-texting control

Prohibitive Warnings

- Three conditions (16 participants in each group):
  - Control
  - Texting
  - Alert
- Alert Trigger
  - Head-movement in crossing direction
  - < 2.75 TLS
- 164 warnings on 151 gaps in 318 trials
  - Crossed road on 28 trials
  - Incidental movement on 107 gaps
  - Early departure on 29 trials

Warnings

Condition	Ave Gap
Control	3.56s
Texting	3.50s
Alert	3.68s



Condition	Wait time
Control	5.2s
Texting	5.2s
Alert	9.6s

Condition	Hits
Control	10
Texting	34
Alert	10

Crossings with Warnings

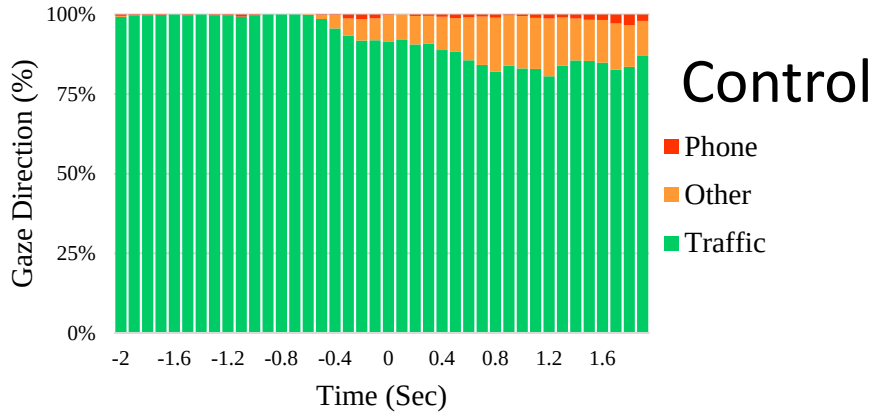
- Average gap size of 3.68s
- Time to spare more variable than control
- 10 hits on 28 crossings (36%)

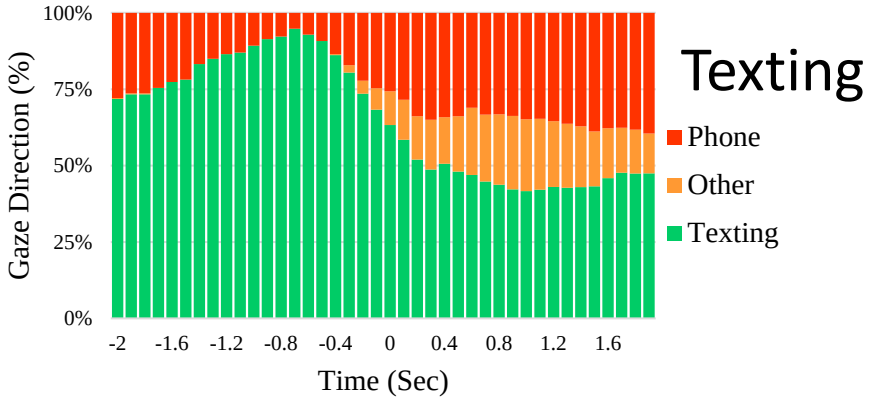
Even though warnings were highly predictive of risk, no one aborted their crossing and returned to the side of the road.

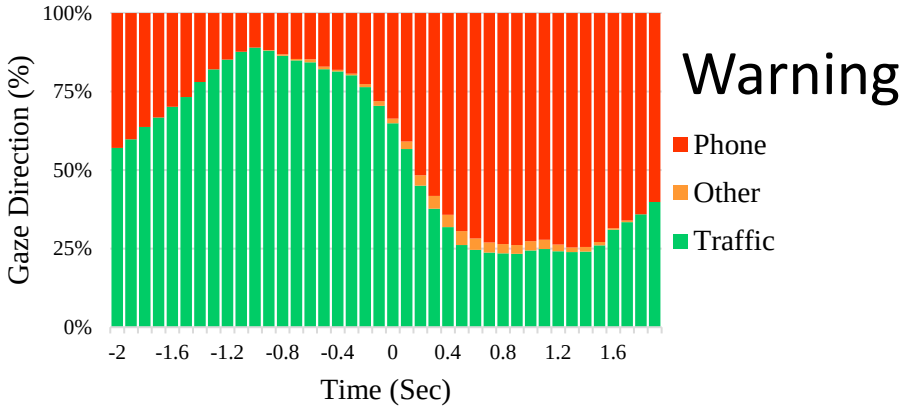
Gaze direction

2 sec before → 2 sec after gap

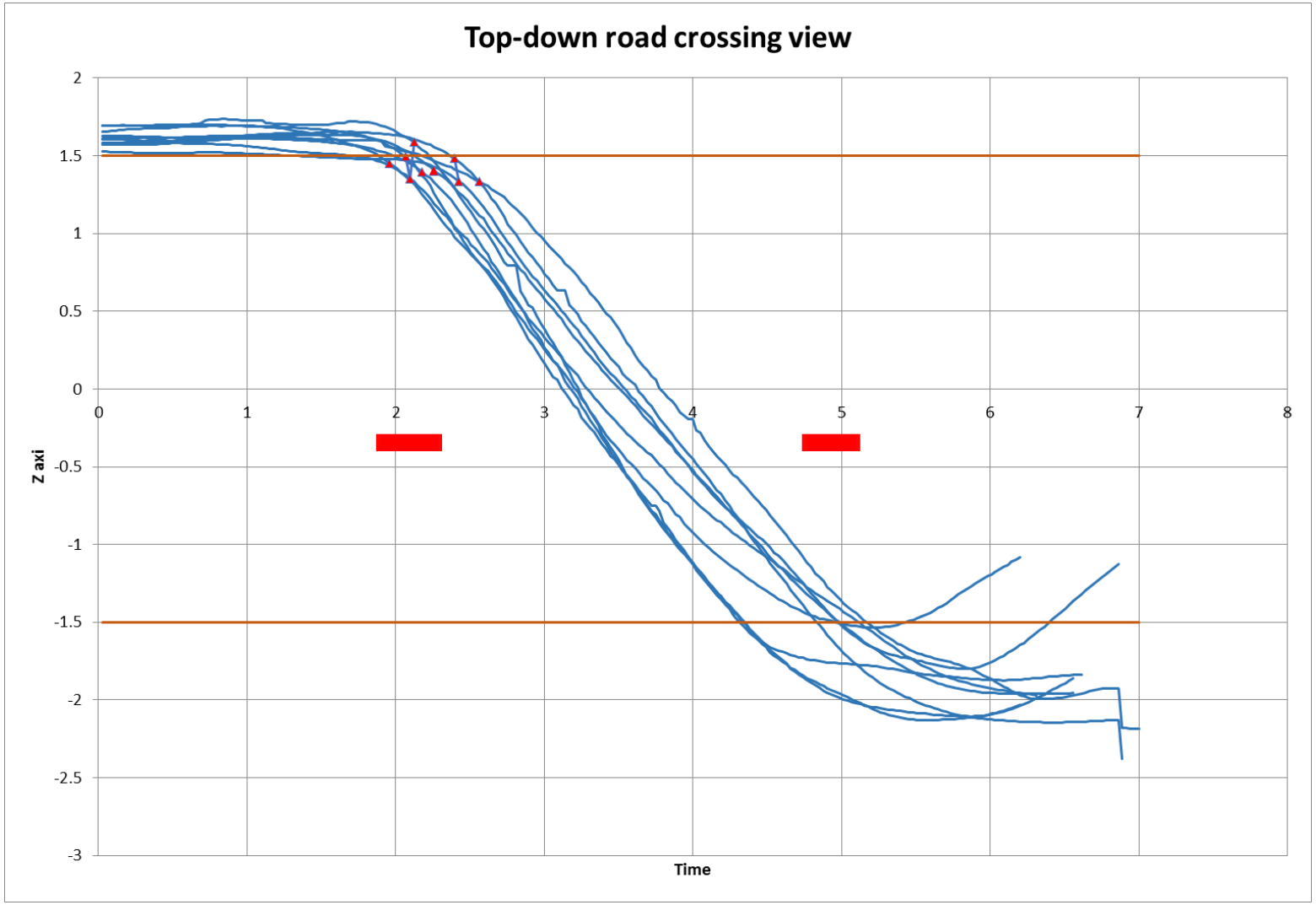
Condition	Traffic gaze time
Control	96%
Texting	60%
Alert	36%







Timing of Warnings



Issues with Alerts/Warnings

1. Is it better to guide crossing or set off an alarm when danger is sensed?

2. Detecting a Cross
    - Difficult to anticipate
    - Setting the Threshold

      Balancing misses and false alarms

Alerts/Warnings for Older Pedestrians

- 20% of all pedestrian fatalities in 2017 were people 65 years and older.

- Age-related decline affects the ability of older adults to choose safe temporal gaps when physically crossing a virtual road.

  [Dommes and Cavallo 2011, *Ophthalmic and Physiological Optics*]

Permissive Alerts

"Safe to cross"

3 x 0.5-second vibrations

Prohibitive Warnings

"Do not cross"

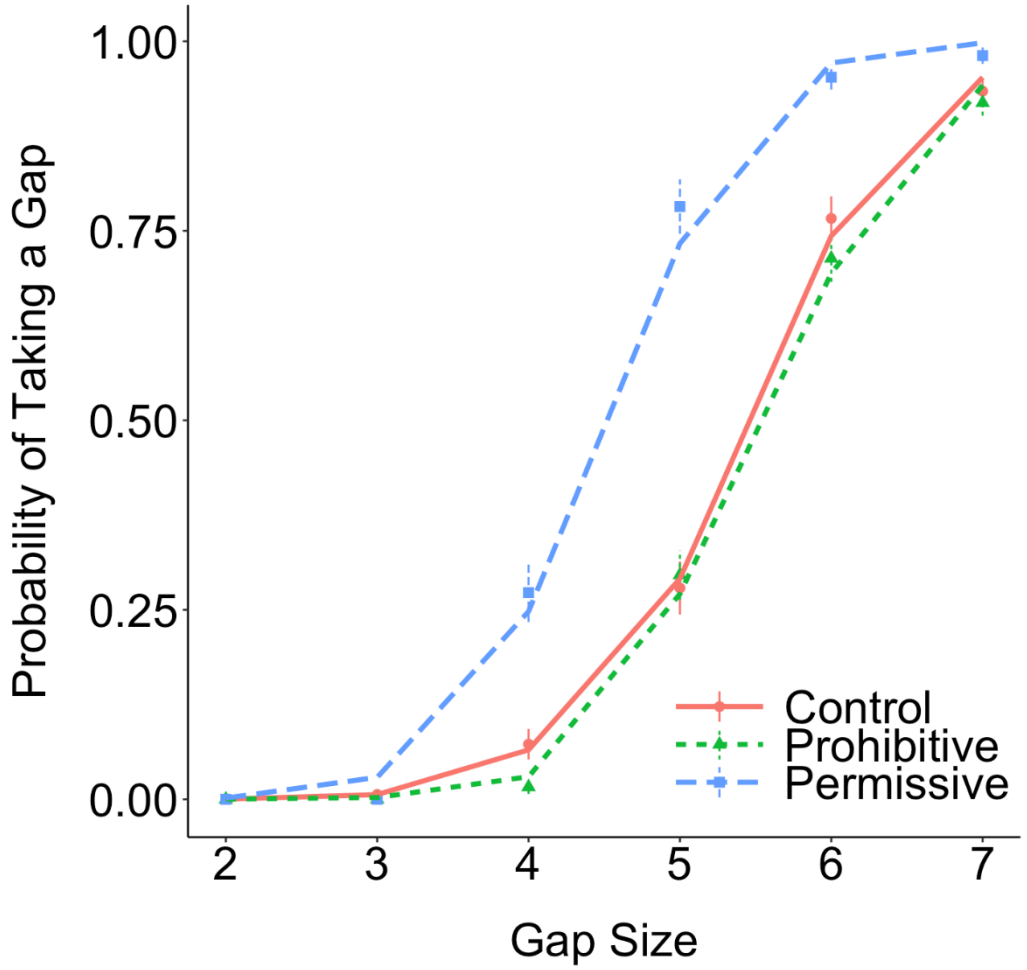
3 x 0.5-second vibrations

Alerts and Warnings were Ability Based

- Based on their walking speed, we:
  - Estimated their crossing time
  - Added a 2-second buffer to account for time to start crossing and safe time to spare
- Alerts and warnings finish speaking just before the next gap opens

Condition	Mean Age	Age Range	M/F
Control	71.32	65-83	11/11
Prohibitive	69.67	65-84	10/12
Permissive	71.39	65-79	10/12

Participants took smaller gaps in Permissive



Movement Timing

Condition	Timing of Entry	Crossing Time	Time to Spare
Control	0.79 (0.18)	2.17 (0.26)	3.37 (0.42)
Prohibitive	0.87 (0.22)	2.12 (0.22)	3.38 (0.53)
Permissive	0.72 (0.16)	2.16 (0.28)	3.09 (0.45)

Participant Responses to Alerts and Warnings

- Permissive Alerts encouraged taking smaller gaps

  “[The alert] was helpful cause some of the times I wouldn't have crossed because there was that other car coming.”

- Prohibitive Warnings were annoying

  “Well like anything if you hear it over and over. After a while you're just like, ok, I'm tired of hearing that.”

Future Work

- Larger gap threshold
  Can we use permission alerts to push older pedestrians to take larger gaps?

- Augmented Reality

Hank Lab

Faculty: Joe Kearney, Kyle Rector, and Jodie Plumert

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