Virtual and Augmented Reality in Transportation: Examples from Academia

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Hank Virtual Environments Lab
http://psychology.uiowa.edu/hank-virtual-environments-lab

Overview of Presentation

- Review of Academic Research Labs
  - Real-time interactive simulation
  - Virtual environments

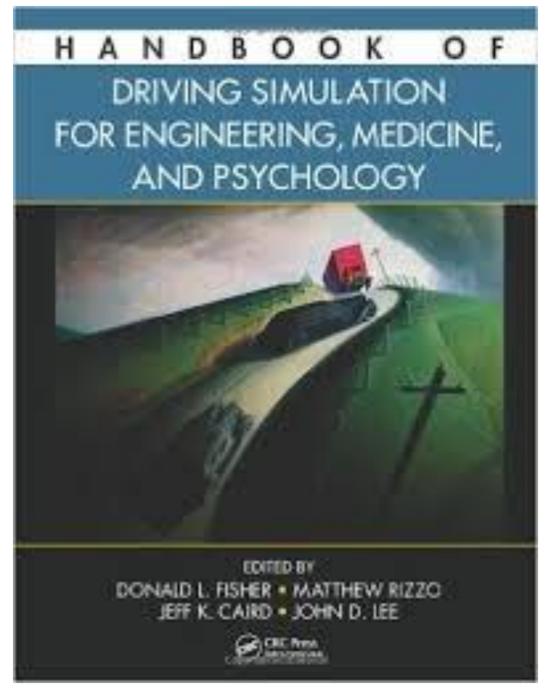
- Critical Issues
  - **Stereoscopic display (Does it matter?)**
  - **Display type (HMD vs. Large Screen)**
  - Interaction modality and motion
  - Scenario design and development
  - Validation

Driving Simulators: VR, AR, or not?

- Immersive
- Interactive
- 3D
- Multi-Sensory

- Separate communities
  - Separate conferences
  - Separate publication venues

    TRB.org search
      virtual reality 11 hits
      driving simulation 237 hits
    IEEE VR search
      virtual reality 1651 hits
      driving simulation 20 hits



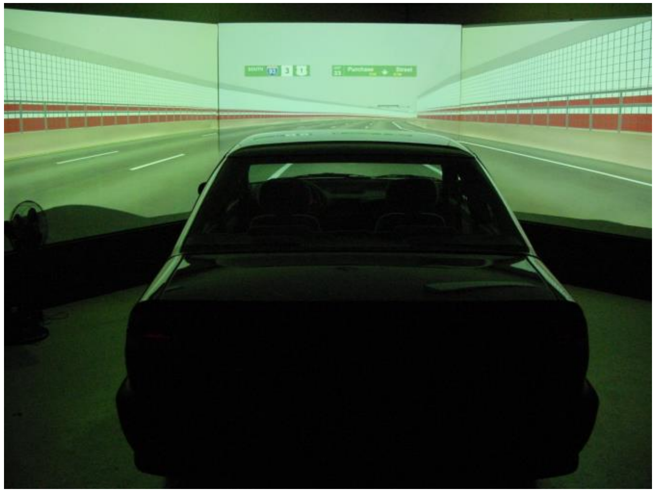
National Advanced Driving Simulator (NADS)

University of Iowa

- Driver Assistance Systems
- Driver distraction
- Night Vision Enhancement
- Safety warning systems for older drivers
- Young drivers

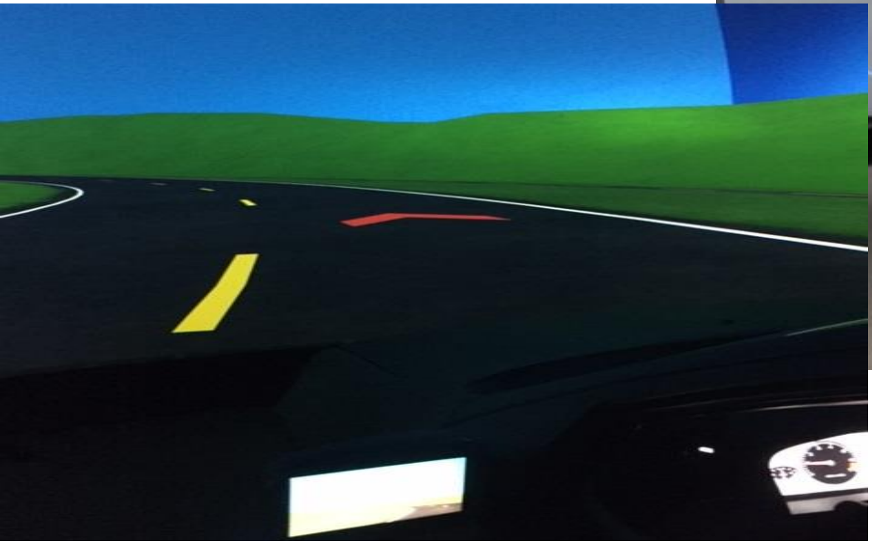
University of Massachusetts - Amherst

- Advanced Yield Marking (shark teeth)
- Boston Central Artery (big dig)
- Roadside Vegetation and Clear Zone
- Toll Lane Configurations
- Deflection Angle on Roundabouts
- Infrastructure Strategies for Safer Cycling



University of Wisconsin TOPS Lab

Holographic Traffic Controls



Markosian, J., Santiago-Chaparro, K.R., Chitturi, M., and Noyce, D.A. (2015). *Holographic Traffic Controls Evaluation Using a Full Scale Driving Simulator,* **Road Safety & Simulation International Conference**, Orlando, FL.

Mini-sims

low cost, fixed based driving simulators

Umass - Amherst

NADS

University of Alabama Youth Safety Lab

Teaching children how to safely cross a road

Semi-immersive virtual environment
Three screens show a simulated roadway
Participants take one step off a curb
Triggers third-person view of an avatar crossing traffic

Schwebel, D. C., McClure, L. A., & Severson, J. (2014). *Teaching children to cross streets safely: A randomized, controlled trial.* **Health Psychology**, 33(7), 628.

Ben-Gurion University

Child pedestrians' ability to identify traffic hazards

Meir, A., Parmet, Y., & Oron-Gilad, T. (2013). *Towards understanding child-pedestrians' hazard perception abilities in a mixed reality dynamic environment*. **Transportation Research Part F: Traffic Psychology and Behaviour**, 20, 90-107.

University of Illinois at Urbana-Champaign
Beckman Institute Illinois Simulator Laboratory

Cell phone Distraction

Treadmill Interface

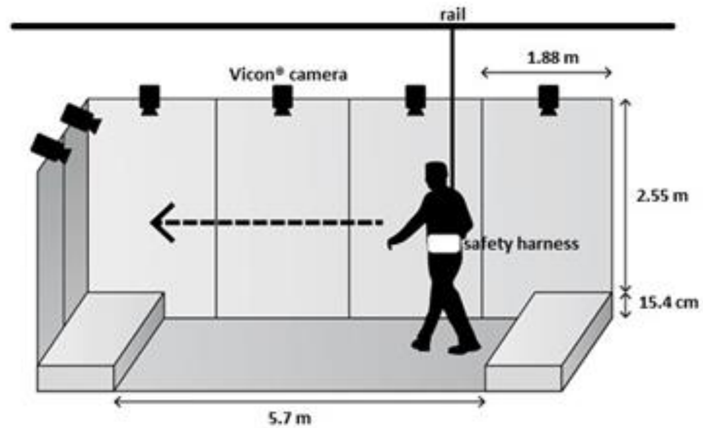
Neider, M. B., Gaspar, J. G., McCarley, J. S., Crowell, J., Kaczmarski, H., & Kramer, A. F. (2011). *Walking and talking: Dual-task effects on street crossing behavior in older adults*. Psychology and Aging, 26(2), 260.

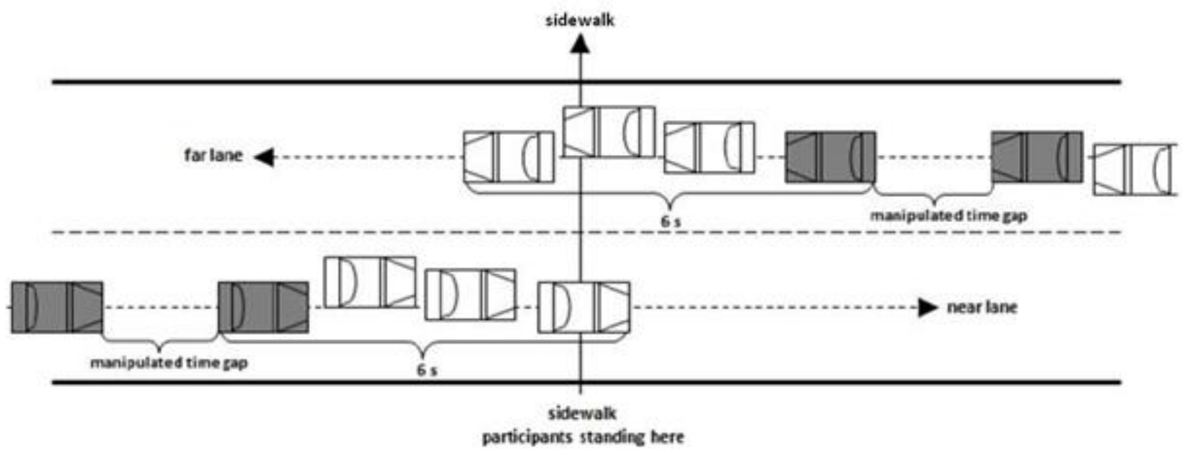
IFSTTAR,

French Institute of Science and Technology for Transport, Development and Networks, Laboratory for Road Operations, Perception, Simulators and Simulations, Versailles, France

Pedestrian Simulator

10 screens (2.55 m high and 1.88 m wide) allowing a pedestrian to walk up to 7 m across two lanes of simulated traffic

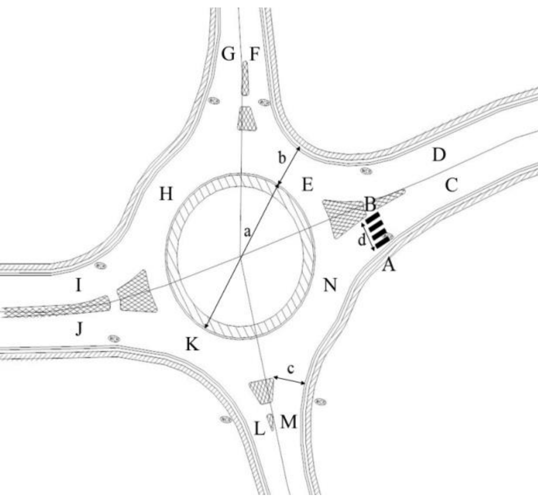


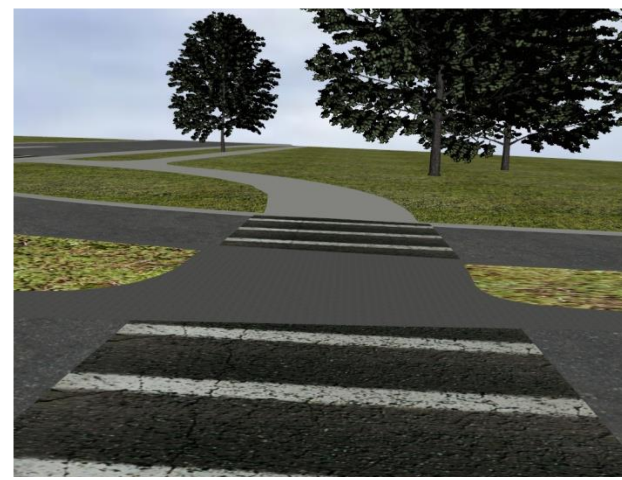


Dommes, A., Cavallo, V., Dubuisson, J. B., Tournier, I., & Vienne, F. (2014). *Crossing a two-way street: comparison of young and old pedestrians*. **Journal of safety research**, 50, 27-34.

Vanderbilt University

Pedestrian Crossing on a Roundabout





Wu, H., Ashmead, D. H., & Bodenheimer, B. (2009, September). *Using immersive virtual reality to evaluate pedestrian street crossing decisions at a roundabout*. In **Proceedings of the 6th Symposium on Applied Perception in Graphics and Visualization** (pp. 35-40). ACM.

The Transport Systems Catapult (TSC)

Innovate UK Centre for Intelligent Mobility

Pedestrian Simulator

- Omnidirectional Treadmill
- Occulus Rift

Pedestrians interactions with driverless cars

Way finding in new public spaces

https://ts.catapult.org.uk/en_US/visualisation-laboratory

The Hank Virtual Environments Lab

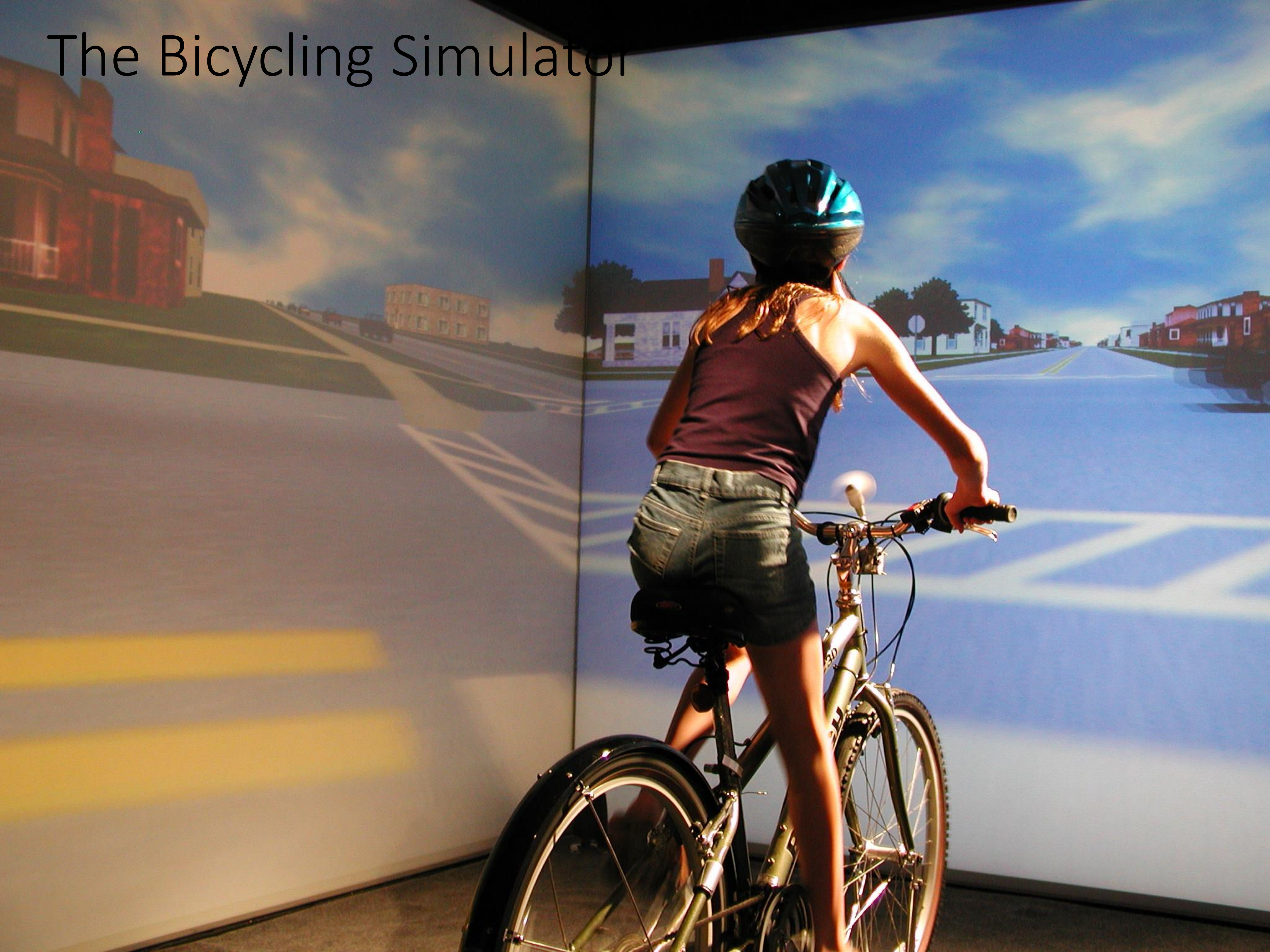
Creating realistic, immersive virtual environments that allow full-body movement

- Bicycling simulator
- Pedestrian simulator

Studying human behavior in virtual environments

- How do child cyclists cross roads with traffic?
- How do texting pedestrians cross roads with traffic?
- How do children and adults cross roads with peers?

The Bicycling Simulator



Bicycling Studies

One-way and two-way traffic

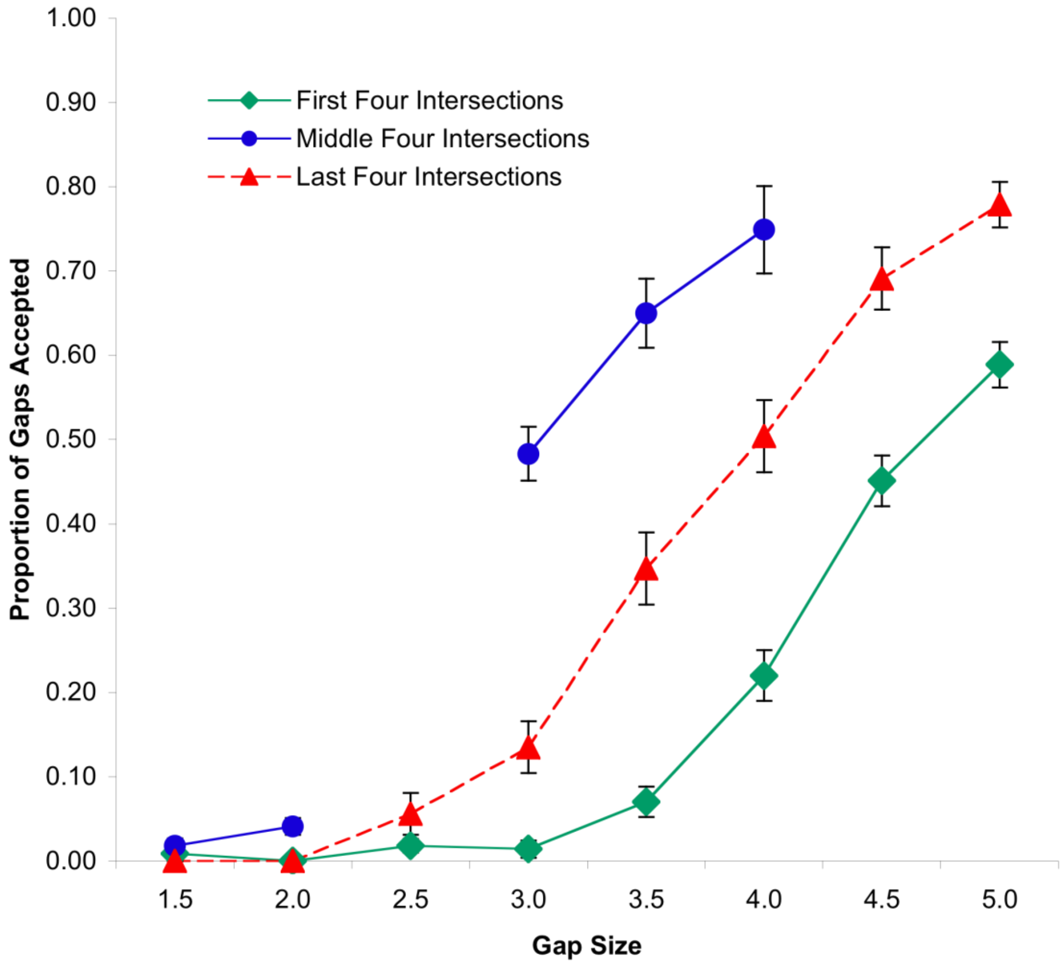
High density traffic

Interception of gaps on the run

Peer influence

ADHD riders

A Typical Response Curve Showing Gap Choice in High Density Traffic



First Four Intersections:
Random Distribution of Gaps

Middle Four Intersections:
High Density Gaps

Last Four Intersections:
Random Distribution of Gaps

Plumert, J. M., Cremer, J., Kearney, K., Recker, K., & Strutt, J. (2011). *Changes in children's perception-action tuning over short time scales: Bicycling across traffic-filled intersections in a virtual environment*. **Journal of Experimental Child Psychology**, 108, 322-337.


PM03:20:47
03/11/2009

What do we find?

Gap Choice

- Children choose the same size traffic gaps as adults
- Aggressive boys take tight gaps
- Virtual Peer influence gap choice

Movement Timing

- Children have less time to spare than adults when they cross through traffic gaps
- Children with ADHD time their movement less precisely

The Pedestrian Simulator

Pedestrian Studies

Influence of Stereoscopic Viewing

Children’s road crossing

Two-people crossing

Crossing while texting with and without alerts

Child Pedestrian Road Crossing

Developmental changes from ages 6 to 12

Gap selection

Movement timing

O'Neal, E.E., Franzen, L., Yon, J.P., Kearney, J.K., & Plumert, J.M. (2015). *How do immature movement timing skills put child pedestrians at risk for motor vehicle collisions with motor vehicles?* **Road Safety & Simulation International Conference**, Orlando, FL, 727-739.

Pedestrian Texting Awareness Campaigns

New Haven, CT, "Look Up" stencils on sidewalks

http://www.newhavenindependent.org/index.php/archives/entry/i_got_caught/

NYC Look! Campaign

http://www.nyc.gov/html/dot/html/pedestrians/look.shtml

Improv Everywhere: Seeing Eye People

http://improveverywhere.com/2013/04/30/seeing-eye-people/

National Geographic Cell Phone Lanes on Sidewalks

https://www.yahoo.com/tech/cellphone-talkers-get-their-own-sidewalk-lane-in-d-c-92080566744.html

Eyes down, minds elsewhere, 'deadwalkers' are among us

Washington Post, September 27

Vehicle-to-Pedestrian (V2P) Technology

Alerts using Dedicated Short-Range Communications Technology

Permissive Alerts

When it is safe to cross

Prohibitive Alerts

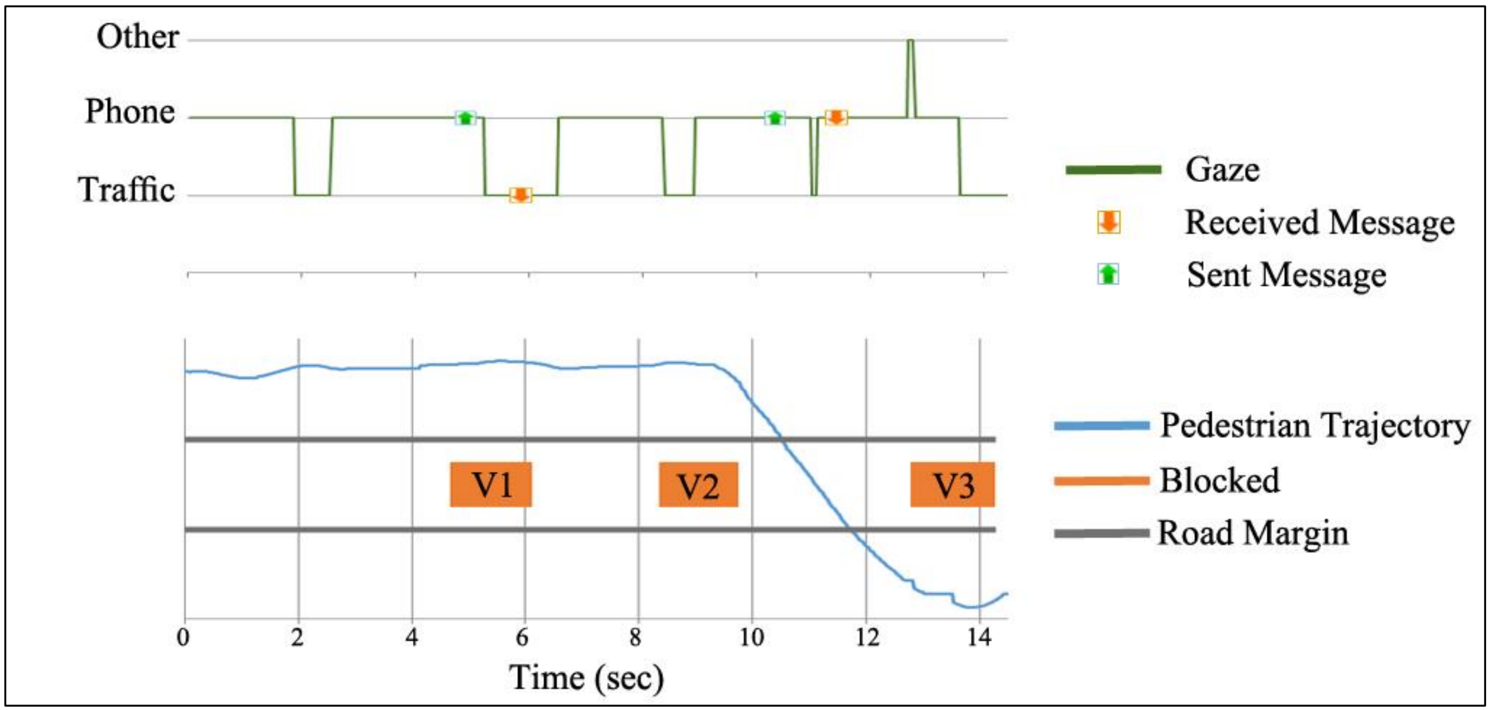
When it is unsafe to cross

Don't walk signal

Collision warning

Connected Vehicles: Vehicle-to-Pedestrian Communications
USDOT factsheet

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



Rahimian, P., Jiang, Y., Yon, J.P., Franzen, L., Plumert, J.M., & Kearney, J.K. (2015). *Designing an immersive pedestrian simulator to study the influence of texting and cell-phone alerts on road crossing*. **Road Safety & Simulation International Conference**, Orlando, FL, 828-837.

Permissive Alert Study

Interface:

Count down to next safe gap + signal when gap opens

Results:

Gaze

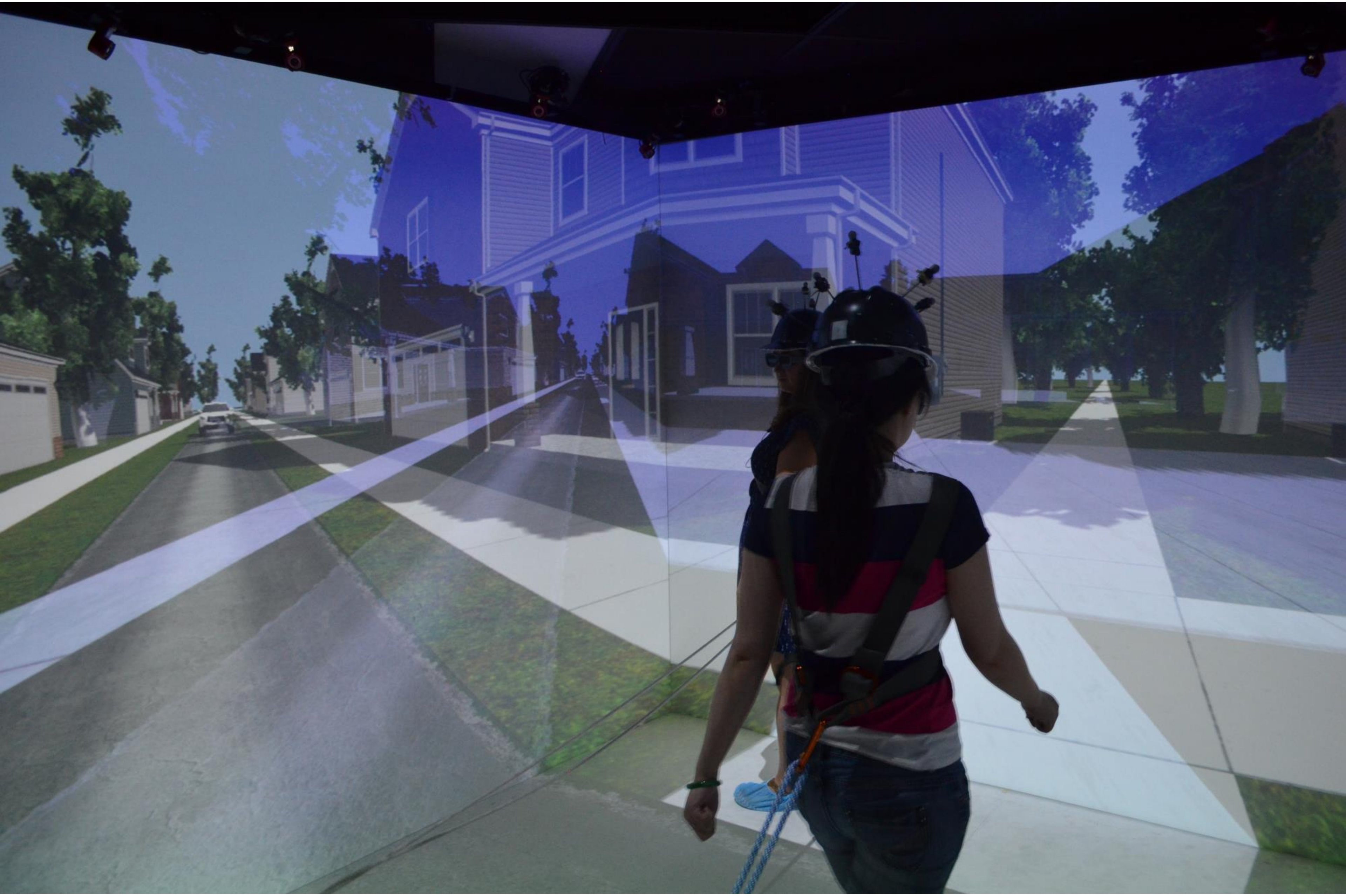
- Focused on the cell phone ~80% of the time
- Glance at traffic immediately before crossing

Gap selection

- High likelihood of crossing identified gaps

Timing

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



Joint Road Crossing

Pairs crossed together 75% of the time

Pairs tightly synchronized their movements

Road entry within .19 seconds of one another

Pairs selected larger gaps and timed crossing to accommodate joint crossing

What's next?

What are the most effective ways to communication information to texting pedestrians?

How does the avatar fidelity influence joint action?

Appearance

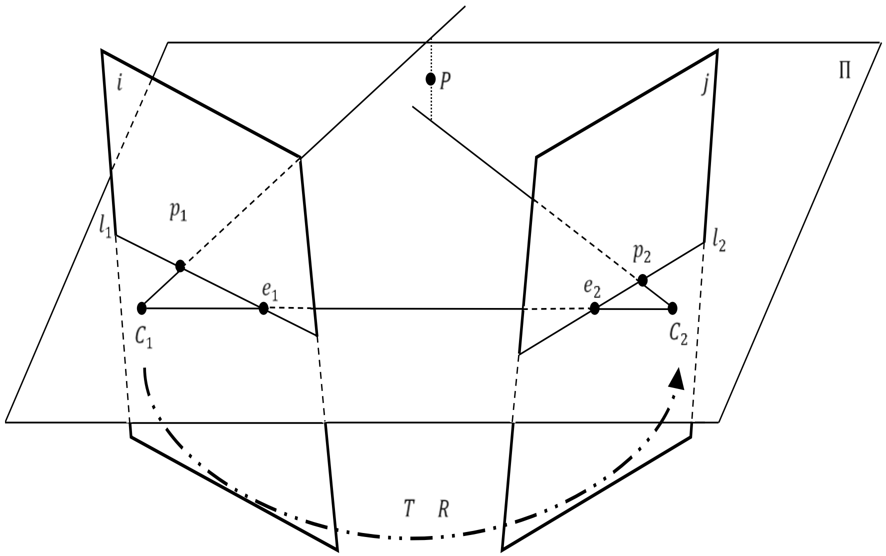
Motion

Pedestrian Avatar

Carl and Carly

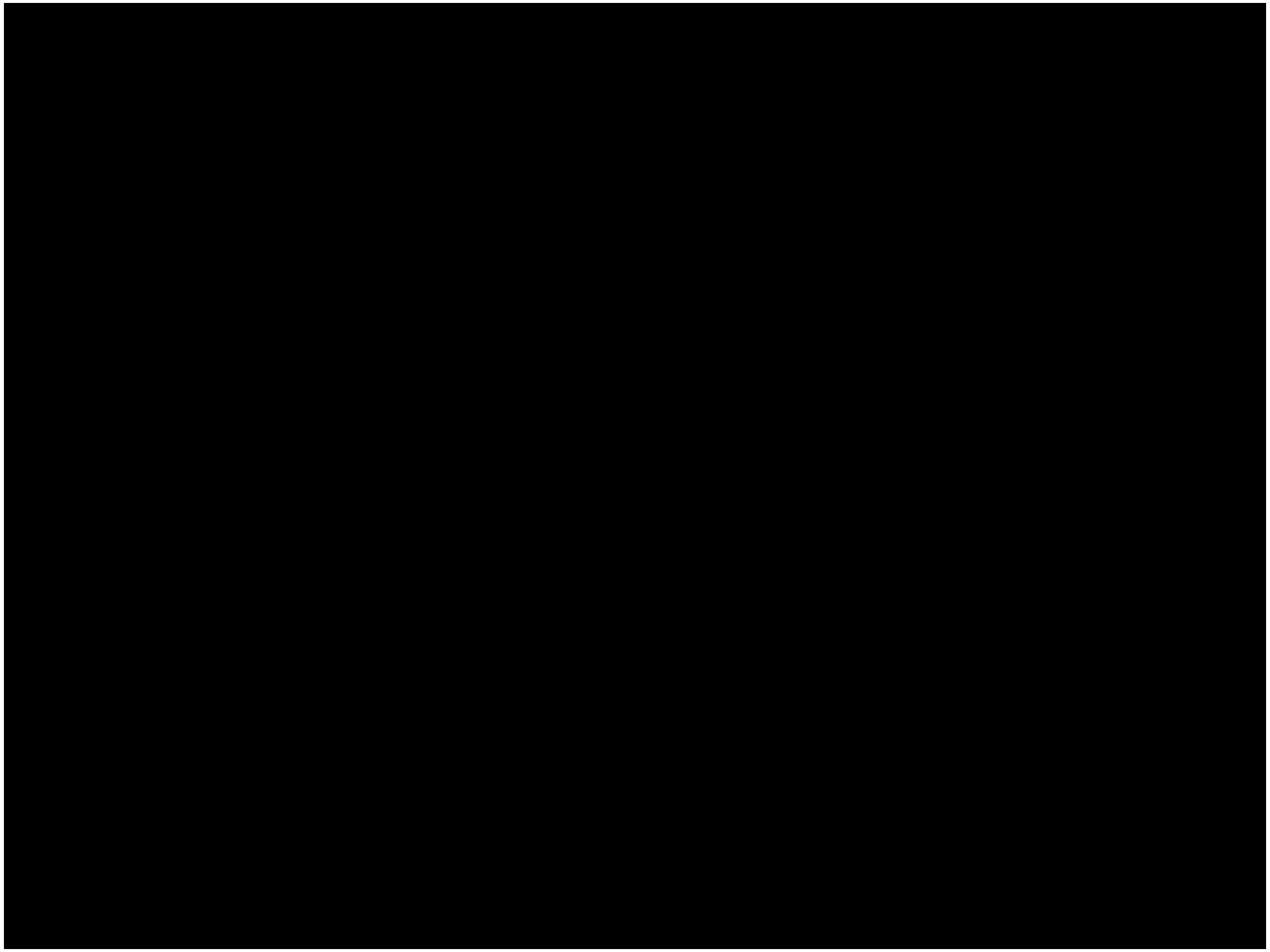
Stereoscopic display (Does it matter?)

- Driving simulators are non-stereo (mostly)
- Cue strongest in near field (personal space)
  - Falls off as square of distance
  - Effective range in real world ~ 1 km
  - Effective range in VE ~ 44 m
- Possible contributions
  - Judging gap size
  - Time movements
- Natural experience
  - Close one eye
  - Drivers without stereo



Display type (HMD vs. Large Screen)

+ Large field of regard
+ Portable
+ Low cost, modest infrastructure
- Low field of view (typically)
- Encumbrance
- Sickness from tracking latency



Grechkin, T. Y., Plumert, J. M., & Kearney, J. K. (2014). *Dynamic affordances in embodied interactive systems: The role of display and mode of locomotion.* **Visualization and Computer Graphics, IEEE Transactions on**, *20*(4), 596-605.

Collaborators

- *Co-Director of the Hank Lab:*

  Jodie Plumert
- *Lab Manager:*

  Calvin Bryant
- *Students:*

  Katie Brown, Yuanyuan Jiang, Zhimao Liu,
  Elizabeth O'Neal, Pooya Rahimian, Paul Yon
- *A host of others:*

  Sab Babu, Ben Chihak, Jim Cremer, Luke Franzen,
  Tim Grechkin, Megan Mathews, Quinn Montgomery,
  Dat Nguyen, Geb Thomas, Christine Ziemer, Tyler Zeken

Thanks to our sponsors

NIH *Eunice Kennedy Shriver* National Institute of Child Health and Human Development

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The University of Iowa
IPRC Injury Prevention Research Center