A New Tool for Assessing Driver Behaviors at Intersections

Dr Pierro Hirsch
ADED Conference
Columbus, Ohio
August 16, 2016
Dr Pierro Hirsch
Research and Program Development
for
Virage Simulation
Plan

1. Defining the problem / challenge
2. How scientists fail practitioners
3. Defining solutions
4. Assessing a driver’s ability at safely cross uncontrolled intersections
5. Preliminary impressions
6. Summary
Defining the Problem of Driver Assessments
Driving is a complex task that requires adequate operational, cognitive and higher executive functions working together.  

Driving skills are what individuals need to execute driving tasks. 

Is it logical to *train* skills that are not tested, assessed or evaluated?

Is it fair to *assess* skills that cannot be trained?

Is it professional to neglect to *research* the validity of training or testing process?
If driving is to be taught successfully .... then a **systematic theory of driving** is needed which can be verified by observation and experimentation.”

How scientists fail practitioners
Scientific Progress – 1938 to 2016

THEORY OF DRIVING

DRIVER ASSESSMENT
A brief history of how scientists have failed to help professionals involved in driver assessment and training.
Safe driving is:

- the *outcome* of a sequence of events and their interactions occurring at the person, vehicle, and environment levels.
- can be characterized by the *absence of* near misses, errors, violations, crashes, and crash-related injuries or deaths.
- measured by examining citation or violation *history*, crash rates, and crash-related morbidity and mortality rates.

Centers for Disease Control and Prevention, (2007); NHTSA, 2008)
There is no single, widely accepted, authoritative theory or model to explain how automobile collisions occur. ¹

1. McKenna (1983); Ranney, (1994); Wilde 2001).
Researchers are unable to specify precisely and exhaustively which driving behaviors are safe\textsuperscript{1} or risky \textsuperscript{2}.

2. Simpson, 1995
Experts in 2013

Safe driving is operating a motor vehicle in a reasonable and expected manner. “ *

* Conclusion of 21 experts led by James Foley, Senior Principal Engineer at Toyota Technical Center, presented at the PROCEEDINGS of the Seventh International Driving Symposium on Human Factors in Driver Assessment, Training, and Vehicle Design (2013).
Peter A. Hancock, D.Sc., Ph.D. is the University Pegasus Professor and Provost Distinguished Research Professor and the author of over six hundred (600) refereed scientific articles and publications.

Reputedly, he is the most often cited human factors scientist in the world.
To "attack a straw man" is to create the illusion of having refuted a proposition by replacing it with a superficially similar yet unequivalent proposition (the "straw man"), and to refute it, without ever having actually refuted the original position.
“IS PERFECT [DRIVING] PERFORMANCE POSSIBLE?
...you are ...approaching an intersection having a signal light...
Where is the driver to look? If you look at the light to see a possible change, you cannot look at the intersection and vice versa. ...However, the simple fact is that driving presents many such ambiguous situations in which, whatever "correct" action one is actually accomplishing, there is another equally "correct" action that one must neglect.”

Citing Hancock, a research expert on distraction, Michael Regan (2011) writes:

“(I)t is only with the benefit of hindsight that one is able to identify retrospectively what are activities critical for safe driving in a particular situation, and hence to what a driver should have attended.”
In an email to Regan, I proposed that his conclusion:

(1) Is based on the absence of evidence, **not** on a tested scientific hypothesis

(2) Implies, at its logical limit, that it is **impossible** to:

   a) *predict* what are the safety-critical elements of any driving scene

   b) establish the content validity of any driver training curriculum

   c) establish the validity of the evaluation criteria of or the methods for testing the safety of any driver (novice, aging, etc.)
"It is true that we don't know from moment to moment exactly what people should/should be attending to – but, as you suggest, this is because of a lack of serious thought about, and research on, this issue."

Regan, Personal communication (2013)
Lack of Serious Thought...
On-road Assessments

The “gold standard” for assessing driving ability. ¹

1. Kraft, Amick et al. (2010)
After reviewing over 1,500 papers, Molnar, Byszewski et al. (2005) report that they did not find any evidence-based information to help physicians make decisions regarding medical fitness to drive.
7 Problems with On-Road Assessments

1. Safety and costs
2. Stress
3. Standardization of evaluation routes
4. Replication of traffic events
5. Subjectivity of on-road scoring methods
6. Consistency and reliability among multiple examiners
7. Road test performance pass rates have no demonstrated association with crash risk \(^1\)

---

Many of the problems with on-road assessments can be addressed with driving simulator assessments.

However, simulator-based driving scores predicted crash risk five (5) years after.*

* Hoffman & McDowd (2010).
Fitness to drive: A characteristic of the driver, defined by the absence of any functional (sensory/perceptual, cognitive, or psychomotor) deficit(s) or medical condition(s) that significantly impairs such an individual’s ability to fully control the vehicle while conforming to the rules of the road and obeying traffic laws, and/or that significantly increases crash risk.

(Brouwer & Ponds, 1994).
What actions significantly increase crash risk?
Defining solutions

Starting with the basics
Driving is predominantly a visual task (Sivak, 1996)
Intersections

About 40% of all injury crashes reported to the police occur at intersections (Elvik and Vaa, 2004),
Goal - Identify the driving simulator scenarios desired by certified driver rehabilitation specialists (CDRS)

Method - Questionnaire consisting of 22 driving scenario situations answered by 164 CDRSs

Results - Three factors emerged:
• (1) Intersections,
• (2) Roadway and Traffic Conditions, and
• (3) Environmental Conditions.

Yuen et al. 2012
Collision statistics report the high frequency of intersection crashes both for novice and aging drivers.

Choi (2010)
Drivers aged 65 and above are significantly more likely to be involved in crashes at intersections, stop signs, while turning against oncoming traffic and changing lanes.

* McGwin & Brown (1999); Ryan et al. (1998); Hakamies-Blomqvist (1993); Cooper (1990)
Drivers at intersections are required “to scan left, and right looking for potential hazards and checking for traffic”. (p. 14-11)

Stoner, Fisher, & Mollenhauer (2011)
A Sample Driver Assessment

Driver Assessment Form
Driver Name: ______________________ Driver’s Licence # __________________ Company: ___________________________
Date and Time : ___________________ Weather: ___________________________
Vehicle Type: ______________________

Assessor / Evaluator: Observation
Eye lead time
Left - Right / scanning / shoulder checks Mirrors / tracking traffic

Space Management

Speed Control

General

Total Score (out of 40)
Route: 
Score
Comments
Final Comments:
Ratings:
PASS_______ FAIL_________

Driver Assessment Form (Mar 2014) Last Revised: Mar 2014
Hypothetical Tale of Two Moms

Which one of these two loving Mothers would be more reluctant to tell her story in public?
How much realism is needed in a driving simulator for a driver assessment?
“The functional requirements of the simulator should match the training programs objective.” p. 8

Goode, Salmon, & Lenné (2013)
The driving simulator’s “overall fidelity configuration [need] to match the goals and content of the rehabilitation session. p. i55

Driving simulations should provide the driver with the critical sensory information needed to perform the driving task in the same manner as in the real world. *

Logical Deduction

Careful assessment by driving evaluators of the safety and the fitness to drive criteria of looking both ways before crossing would suggest the need for a driving simulator with a true 180-degree forward FOV.
## Simulator Configurations & Driving Skills

<table>
<thead>
<tr>
<th>Simulator type</th>
<th>Operational skills</th>
<th>Tactical / Strategic</th>
</tr>
</thead>
</table>
| **Desktop:** Gaming controls, restricted field of view | ▪ Lane keeping  
▪ Speed control  
▪ Brake reactions  
▪ Turns at Y intersections | Limited to single lane roads and routes without intersections.                        |
| **High Fidelity:** Real car cockpit, minimum field of view: 180° + mirrors + blind spots. | ▪ All of the above, except reverse parking, plus:  
▪ Lane changes with blind spot verifications  
▪ Crossing and turns at all standard intersections  
▪ Expressway merges | The full range* of tactical and strategic skills.  
* Except for intersection configurations greater than 90° |
180-Degree FOV – True or False?

Some simulators compress a 180-degree FOV into computer screens 120 degrees wide. This is not a true 180-degree FOV.

In driving simulator with true 180-degree FOV systems, pedestrians and vehicles in the intersection will appear, relative to the driver’s head, exactly where they would appear in real life.

Figure 1: True vs. false 180 degrees

Figure 2: How much head turning is required in real life?
A New Tool

Assessing of a driver’s ability at safely cross intersections
Insert videos
# Crossing Uncontrolled Intersection Scenario

<table>
<thead>
<tr>
<th>Traffic Direction</th>
<th>L to R</th>
<th>R to L</th>
<th>Both</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Duration (min/sec)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total acceptable gaps presented</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Acceptable gaps taken</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Forced crossing(s)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Near crash(es)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Crash(es)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Variables of interest

Acceptable gap - A gap in the traffic (3 s left to right, 4 s right to left) that allows drivers to cross the intersection without forcing other vehicles to slow down and without passing too close to other road users.

Safe crossing - Driver crosses to the other side of the road without forced crossings, near crashes or crashes.

Forced crossing - While crossing the intersection, the driver enters the crash avoidance space of other vehicles forcing other drivers to slow down) or blocks pedestrians path

Near crash - Driver crosses intersection but forces other drivers to brake abruptly or forces pedestrians to run out of the way

Crash - Contact
## Sample Scores

### SEGMENTED TESTS

- **Driver:** MORNING, READINESS (1)
- **Group:** Default Group
- **Trainer:** NO, INSTRUCTOR
- **Vehicle:** Red car
- **Date and time:** 2016-06-25, 11:36:59

### General results

**Number of segments:** 10
**Duration:** 11m 08s

<table>
<thead>
<tr>
<th>Traffic direction</th>
<th>Total gaps presented</th>
<th>L to R</th>
<th>R to L</th>
<th>Mix</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total gaps presented</strong></td>
<td>186</td>
<td>64</td>
<td>59</td>
<td>63</td>
<td>14</td>
</tr>
<tr>
<td><strong>Acceptable gaps not taken</strong></td>
<td>33</td>
<td>14</td>
<td>11</td>
<td>8</td>
<td>1</td>
</tr>
<tr>
<td><strong>Safe crossing</strong></td>
<td>9</td>
<td>5</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>** Forced crossing (Vehicle)**</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Near crash(es) (Vehicle)</strong></td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Crash(es) (Vehicle)</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>** Forced crossing (Unprotected road users)**</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Near crashes (Unprotected road users)</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Crashes (Unprotected road users)</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Total Duration:** 6m 56s

Compares to: Default Group, N = 40

---

All rights reserved, Virage Simulation
## Sample Scores

### SEGMENTED TESTS

**Driver:** -- MORNING, READINESS -- (1)  
**Group:** Default Group  
**Trainer:** -- NO, INSTRUCTOR --  
**Vehicle:** Red car  
**Date and time:** 2016-06-25, 10:34:36

<table>
<thead>
<tr>
<th>General results</th>
<th>-- MORNING, READINESS --</th>
<th>Compare to: Default Group</th>
<th>N = 40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of segments</td>
<td>10</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Duration</td>
<td>3m 07s</td>
<td>6m 56s</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Traffic direction</th>
<th>L to R</th>
<th>R to L</th>
<th>Mix</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total gaps presented</strong></td>
<td>25</td>
<td>13</td>
<td>27</td>
<td>65</td>
</tr>
<tr>
<td><strong>Acceptable gaps not taken</strong></td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>13</td>
</tr>
<tr>
<td><strong>Safe crossing</strong></td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td><strong>Forced crossing (Vehicle)</strong></td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><strong>Near crash(es) (Vehicle)</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Crash(es) (Vehicle)</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Forced crossing (Unprotected road users)</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Near crashes (Unprotected road users)</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Crashes (Unprotected road users)</strong></td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

**Total:** 147.7

All rights reserved, Virage Simulation
Preliminary Impressions
<table>
<thead>
<tr>
<th>Potential Clients</th>
<th>Assessment Targets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stroke &amp; TBI</td>
<td>Analytical abilities; decision-making; the presence of impulsivity or behavioral disorders; tolerance to frustration, and the detection of visual neglect.</td>
</tr>
<tr>
<td>Right tibial prosthesis</td>
<td>Verification that foot position on pedals is adequate, especially when attention demanded</td>
</tr>
<tr>
<td>New drivers</td>
<td>Operational and tactical driving skills</td>
</tr>
</tbody>
</table>
Complements current driving assessment methods

Supports diagnostic judgments

Supports specific rehabilitation training

Serves as a reliable research platform
Sphygmomanometer

An instrument for measuring blood pressure, typically consisting of an inflatable rubber cuff that is applied to the arm and connected to a column of mercury next to a graduated scale, enabling the determination of systolic and diastolic blood pressure by increasing and gradually releasing the pressure in the cuff.
Summary

Clinical

Driving Simulator

On-road
Thank you

Questions?