Optimizing the Value of Driving Simulators in Rehabilitation Practice by Increasing Behavioral Validity

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NMEDA Conference, Daytona Beach, Florida
March 6, 2018

The Main Question

How can driving simulation support or complement a comprehensive evaluation of fitness to drive, including clinical and on-road indicators?
Plan

• Q & A
• A process model of behavioral validity for driving simulation (video)
• Definitions - Vocabulary
• Factors that increase presence / behavioral validity
• Conducting a session for:
  • Fitness to drive eval (case study)
  • Habilitation (case study)
  • Rehabilitation (case study)
• Measuring presence (how and why)
• Summary & Discussion

Q & A

What are your perceptions / expectations of using a driving simulator in your practice?

• Prior experience with simulators?

(video)
Premise

“Any use of driving simulators should be preceded by questioning whether the simulator is sufficiently valid for the task or ability to be investigated.”

Kaptein et al., 1996. p. 31

Assumption #1

The value of driving simulator-based evaluations assumes behavioral validity.

Behavioral validity means that driver performance on the simulator matches driver performance on the same tasks in the real world, e.g. lane changes.
Assumption #2

A driving simulator’s look and feel, the “overall fidelity configuration”, needs to match the goals and content of the session, e.g. intersection gap judgment.

7-Step Model of Behavioral Validity
Steps 1 and 2

1. Driving Task
   - Lane keeping
   - Speed control
   - Brake reactions *
   - Turns at Y intersections

   All the above, except reverse parking, plus:
   - Lane changes with blind spot verifications **
   - Passing
   - Crossing and turns at all standard intersections ***
   - Expressway merges

2. Physical Fidelity & Task Fidelity
   - Gaming controls, restricted field of view.
   - Tasks limited to single lane roads without intersections.

   Real car cockpit, minimum field of view: 180° + mirrors + blind spots.

   Unlimited range of driving tasks.
Step 3 - Immersion

**Immersion** - The *process* by which information from the senses surrounds the driver (e.g., visual, auditory, kinesthetic & motion / vibration platform).

Through immersion, the driver’s attention begins to engage in the virtual world.

*continuous

Step 4 - Interactions

**Interactions**

Actions and reactions between the driver and the virtual environment (e.g., the driver brakes, his vehicle slows, the virtual vehicles behind slow in response).

Insert video 2:04
**Step 5 – Achieving Presence**

Through the continuous process of performing engaging and demanding driving tasks in the simulator (steps 3 and 4), the driver develops a state of psychological fidelity or presence.

*Presence* is a subjective mental state.

**Step 6 – Behavioral Validity**

*Presence* is considered to be a necessary condition for achieving behavioral validity.

Behavioral validity is the target or goal of using driving simulation.

Behavioral validity justifies our confidence in driving simulator-based assessments.
Step 7 - Validation (Testing)

Through research, confirm that driver performance on the simulator matches driver performance on the same tasks in the real world.

7-Step Model of Behavioral Validity

**1 DRIVING TASK**

**2 PHYSICAL AND TASK FIDELITY**

**3 IMMERSION**

**4 INTERACTIONS**

**5 PRESENCE**

**6 BEHAVIORAL VALIDITY**

**7 VALIDATION**
Factors that Increase Presence

<table>
<thead>
<tr>
<th>Factors</th>
<th>Definitions</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>External</td>
<td>Simulator hardware and software that generates the virtual world surrounding the driver’s visual, auditory, and kinesthetic senses</td>
<td>• Wider fields of vision • Increased graphic detail • Task fidelity of driving scenario</td>
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<td>Internal</td>
<td>Driver’s perception and interpretation of sensory data</td>
<td>• Personality, e.g. introversion *** • Predisposition to immersion</td>
</tr>
<tr>
<td>Interactive</td>
<td>Ease of driver’s interactions with and level of perceived control within the virtual world</td>
<td>• Acclimation of driver to simulator before formal training</td>
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</tbody>
</table>

Increasing Presence During a Simulation Session

Key points to respect:

• Reduce internal and external distractions;
• Clearly communicate task instructions and tangible outcomes, e.g. practical value of PowerPoint slides, and;
• Provide engaging exercises.

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Evaluation of Fitness to Drive

Population: Everyone

Benefits of simulation:
• Complements clinical / on-road tests
• Standardized routes and events
• Objective measures for baseline and follow up scores
• Safe context to test potentially problematic behaviors
  • Visual field cut, anxiety, impulsivity, decreased proprioception/tactile sensation of lower extremities

Case 1 - Rita

Age: 36

Diagnosis: Mild CVA with residual L visual field cut

Evaluation: OT DORA and selected simulations
### Driving tasks

<table>
<thead>
<tr>
<th>Driving tasks</th>
<th>Skills addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crossing an uncontrolled intersection (vehicles from L, R, B, with and without pedestrians; impatient driver behind)</td>
<td>Scanning complete environment, judgment and decision making</td>
</tr>
<tr>
<td>Lane changes - expressway</td>
<td>Scanning complete environment, blind spot checks, lane integrity/position, judgment decision making, vehicle maneuvers/control</td>
</tr>
</tbody>
</table>

### Driving Simulation - Habilitation

**Population:**
- Individuals with developmental disabilities and no prior “legal” driving experience

**Benefits of simulation:**
- Safe context for practice, prior to on-road with a parent
- Identify potentially problematic behaviors/skill deficits
- Opportunity to practice “driving” before obtaining a learner’s permit. Aids in learning road laws/signs.
Case 2 - Mary

Age: 19

Diagnosis: Mild intellectual disability

Permit/License: Studying for learner’s permit

Intervention: 45-minute training session 1x/week with OT

<table>
<thead>
<tr>
<th>Driving tasks</th>
<th>Skills addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptation to simulator</td>
<td>Pre-driving checks: seat adjustment, mirrors, seat belt</td>
</tr>
<tr>
<td></td>
<td>Pre-operational tasks: ignition, parking brake, gear selector</td>
</tr>
<tr>
<td>Graded lane changes (different roads)</td>
<td>Acceleration, operation of secondary controls in motion (turn signals), vehicle</td>
</tr>
<tr>
<td></td>
<td>maneuvers/control, blind-spot checks, gap acceptance, lane integrity/position</td>
</tr>
<tr>
<td>Right and left turns (multiple configurations)</td>
<td>Braking, acceleration, turning, operation of secondary controls in motion, gap</td>
</tr>
<tr>
<td></td>
<td>acceptance, lane integrity/position, attention and concentration, processing speed,</td>
</tr>
<tr>
<td></td>
<td>planning, time and space management, communication (turn signals), judgement, self-regulation of behavior</td>
</tr>
</tbody>
</table>
Case 3 - Winthrop

Age: 18

Diagnosis: Down Syndrome

Permit/License: None

Intervention: 45-minute training session 1x/week with OTS

Winthrop

<table>
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<tr>
<td>Adaptation to simulator</td>
<td>Pre-driving checks: seat adjustment, mirrors, seat belt Pre-operational tasks: ignition, parking brake, gear selector</td>
</tr>
<tr>
<td>Basic vehicle control - Preparation for lane changes</td>
<td>Acceleration, braking at stop signs, lane integrity/position, operation of secondary controls in motion (graded progression: maintain speed, identify turn signal “up” or “down” verbally with instruction for R or L lane change, operate turn signal with no lane change (maintain speed and forward gaze), operate turn signal and perform lane change while maintaining speed</td>
</tr>
<tr>
<td>Right and left turns (multiple configurations)</td>
<td>Braking, acceleration, turning, operation of secondary controls in motion with use of L hand only, lane integrity/position, attention and concentration, processing speed, planning, time and space management, communication (turn signals), judgement, self-regulation of behavior (tolerance of correction/instruction)</td>
</tr>
</tbody>
</table>
## Driving Simulation - Rehabilitation

**Population:**
- Individuals with an acquired disability that were previous drivers

**Benefits:**
- Practice driving skills impacted my motor/cognitive deficits in a safe context
- Ability to practice skills repetitively
- Ability to “design” the environment to challenge skill deficits

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## Case 4: Bill

**Age:** 48

**Diagnosis:** L CVA with R hemiparesis

**Intervention:** 45-minute training session 1x/week with OT
## Driving tasks

<table>
<thead>
<tr>
<th>Static practice: foot pedal control</th>
<th>Skills addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing speed, reaction times, braking, motor control (dorsiflexion and inversion adequate to clear the brake pedal; force grading)</td>
<td></td>
</tr>
</tbody>
</table>

| Expressway driving with required lane changes | Acceleration, operation of secondary controls in motion (turn signals), vehicle maneuvers/control, blind-spot checks, gap acceptance, lane integrity/position |

| Right and left turns at intersections; Crossing at an uncontrolled intersection | Braking, acceleration, turning, operation of secondary controls in motion with use of L hand only, lane integrity/position, attention and concentration, processing speed, planning, time and space management, communication (turn signals), judgement, self-regulation of behavior |

## Factors that Increase Presence

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<th>Definition</th>
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| External | Simulator hardware and software that generates the virtual world surrounding the driver’s visual, auditory, and kinesthetic senses | • Increased graphic detail  
• Wider fields of vision  
• Task fidelity of driving scenario |
| Internal | Driver’s perception and interpretation of sensory data | • Personality, e.g. introversion ***  
• Predisposition to immersion |
| Interactive | Ease of driver’s interactions with and level of perceived control within the virtual world | • Acclimation of driver to simulator before formal training |
How to Measure Presence

Subjective Reporting (Questionnaires):

1. I felt like I was part of the simulation world
2. The simulated world triggered my emotions (e.g. anger, satisfaction, sadness, anxiety)
3. Driving in the simulated world was satisfying for me
4. While driving in the simulated world, I forgot for the time being that I was in a driving simulator
5. Driving in the simulation world was boring to me
6. While driving, I was thinking deeply about the simulation world

*Likert scale 1-5 (strongly disagree → strongly agree)*

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Questionnaire Results

<table>
<thead>
<tr>
<th>Question</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Felt part of sim world</td>
<td>4</td>
</tr>
<tr>
<td>2. Sim triggered emotions</td>
<td>4</td>
</tr>
<tr>
<td>3. Forgot I was in a sim</td>
<td>3</td>
</tr>
<tr>
<td>4. Thought deeply about sim</td>
<td>2</td>
</tr>
<tr>
<td>5. Simulation world was boring</td>
<td>1</td>
</tr>
<tr>
<td>6. Driving in sim was satisfying</td>
<td>0</td>
</tr>
</tbody>
</table>

*1= strongly disagree → 5= strongly agree*
### An interesting comparison

<table>
<thead>
<tr>
<th>Question</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Driving in sim was satisfying</td>
<td>Q.6</td>
</tr>
<tr>
<td>5. Simulation world was boring</td>
<td>Q.5</td>
</tr>
<tr>
<td>4. Thought deeply about sim</td>
<td>Q.4</td>
</tr>
<tr>
<td>3. Forgot I was in a sim</td>
<td>Q.3</td>
</tr>
<tr>
<td>2. Sim triggered emotions</td>
<td>Q.2</td>
</tr>
<tr>
<td>1. Felt part of sim world</td>
<td>Q.1</td>
</tr>
</tbody>
</table>

1= strongly disagree → 5= strongly agree

### Why Measure Presence?

To learn more about how to optimize the value of driving simulators in rehabilitation practice by increasing behavioral validity.
Summary & Discussion

Thanks

For follow-up questions or comments:

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