Validation of driving simulation to assess on-road performance in Huntington disease

H. Devos, A. Nieuwboer, W. Vandenberghe, M. Tant, W. De Weerdt, E. Uc

Introduction

• Neurodegenerative
• Hereditary
• Motor, cognitive, behavioral
• Age of motor onset: 35 – 44
• Disease duration: 5 – 20 years
• Prevalence: 4 – 7/100,000
• ? 35,000 in US
• + 150,000 at risk

Symptoms of HD

Involuntary movement

CHOREA/DYSTONIA

Voluntary movement

GAIT

Spaces

Changes in driving behavior

• Motor, cognitive and behavioral symptoms
• Driving is the most self-reported change
• About 70% continue driving after motor onset
• Higher risk of car crashes
• 26% of drivers are advised to stop driving

Driving simulator performance

• Comparison of HD with healthy controls

<table>
<thead>
<tr>
<th>Computerized measures of driving simulation</th>
<th>Drivers with HD</th>
<th>Healthy drivers</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variable</td>
<td>N = 29</td>
<td>N = 30</td>
<td></td>
</tr>
<tr>
<td>Tickets, n</td>
<td>1 (1 – 2)</td>
<td>0 (0 – 1)</td>
<td>0.0001</td>
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Driving simulator performance

• Comparison of HD with healthy controls

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<tr>
<td>Variable</td>
<td>N = 29</td>
<td>N = 30</td>
<td></td>
</tr>
<tr>
<td>Car crashes, n</td>
<td>2 (1 – 3)</td>
<td>0 (0 – 1)</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>
Driving simulator performance

• Comparison of HD with healthy controls

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<tr>
<td>N = 29</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Divided attention</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Correct responses, n</td>
<td>16 (12 – 19)</td>
<td>19 (19 – 20)</td>
<td>0.0003</td>
</tr>
<tr>
<td>Response time, s</td>
<td>3.37 (2.04 – 5.34)</td>
<td>1.58 (1.82 – 2.31)</td>
<td>0.0002</td>
</tr>
</tbody>
</table>

Introduction

TRIP

• Test Ride for Investigating Practical fitness to drive

• Clinical evaluation of driving skills

• 4 point ordinal scale

Introduction

TRIP - 13 items

Hierarchic levels of driving skill

Operational maneuvers

Item 1: Lateral position on the road at low speed

Item 2: Lateral position on the road at high speed

Item 3: Mechanical operations

Tactical maneuvers

Item 4: Speed adaptations at low speed

Item 5: Speed adaptation at high speed

Item 8: Lane position change

Visuo-integrative maneuvers

Item 9: Quality of traffic participation

Item 10: Visual behavior and non-verbal communication

Item 11: Anticipation and perception of road signs and traffic signals
Mixed maneuvers

Item 12: Turning left

Item 13: Joining the traffic stream

Aim

• To assess the concurrent validity of our driving simulator scenario against road testing in patients with Huntington disease
  - Correlation of TRIP scores assessed in the driving simulator and on the road
  - Correlation of computer generated simulator measures with TRIP on the road

Participants

• 29 drivers with manifest symptoms of HD
• 2 locations and days, median 7 (2 – 24) days
• Random order

Road test

Simulation @ University Hospitals

Road test @ Belgian Road Safety Institute

Introduction

TRIP

Validity

Reliability

Content

Construct

Criterion

Discriminant

Convergent

Predictive

Concurrent

Fitness to drive experts

Healthy – impaired

Pass – fail

Visuospatial skills

Executive skills

Attention

Car crashes

Withaar, 2000; PhD dissertation
De Raedt, Acc Anal Prev, 2001;

Methods

• 29 drivers with manifest symptoms of HD
• 2 locations and days, median 7 (2 – 24) days
• Random order

Road test @ Belgian Road Safety Institute

Simulation @ University Hospitals

26/06/2013
Introduction

Methods

- STISIM Drive, STI Inc
- 4 practice drives of 2 km
- 15 km evaluation scenario
- Simulated 12/13 TRIP road events
- Unexpected road hazards and divided attention

Driving simulation

- Overtaking and DA
- Stop at cross walks
- Unexpected road hazards
- Turning left
- Child crossing
- Negotiating curves

Results

Correlations computer measures with total on-road TRIP

<table>
<thead>
<tr>
<th>Measure</th>
<th>Correlation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of traffic tickets</td>
<td>p = 0.06</td>
<td>0.76</td>
</tr>
<tr>
<td>Number of crashes</td>
<td>p = -0.58</td>
<td>0.001</td>
</tr>
<tr>
<td>Divided attention</td>
<td>p = -0.56</td>
<td>0.002</td>
</tr>
</tbody>
</table>

Correlations operational maneuvers

<table>
<thead>
<tr>
<th>Measure</th>
<th>Correlation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral position on the road at low speed</td>
<td>p = 0.62</td>
<td>0.0004</td>
</tr>
<tr>
<td>Lateral position on the road at high speed</td>
<td>p = 0.59</td>
<td>0.0008</td>
</tr>
<tr>
<td>Mechanical operations</td>
<td>p = 0.67</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

Correlations tactical maneuvers

<table>
<thead>
<tr>
<th>Measure</th>
<th>Correlation</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed adaptations at low speed</td>
<td>p = 0.38</td>
<td>0.06</td>
</tr>
<tr>
<td>Speed adaptation at high speed</td>
<td>p = 0.50</td>
<td>0.0006</td>
</tr>
<tr>
<td>Lane position change</td>
<td>p = 0.47</td>
<td>0.0009</td>
</tr>
<tr>
<td>Gap distance at low speed</td>
<td>p = 0.12</td>
<td>0.53</td>
</tr>
<tr>
<td>Gap distance at high speed</td>
<td>p = 0.32</td>
<td>0.0008</td>
</tr>
</tbody>
</table>

26/06/2013
Correlations visuo-integrative maneuvers

<table>
<thead>
<tr>
<th>Quality of traffic participation</th>
<th>$p = 0.49; p = 0.002$</th>
<th>moderate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual behavior and non-verbal communication</td>
<td>$p = 0.36; p = 0.06$</td>
<td>moderate</td>
</tr>
<tr>
<td>Anticipation and perception of road signs and traffic signals</td>
<td>$p = 0.32; p = 0.009$</td>
<td>moderate</td>
</tr>
</tbody>
</table>

Correlations mixed maneuvers

| Turning left | $p = 0.55; p = 0.007$ | strong |

Correlations total TRIP score

| $p = 0.72; p < 0.0001$ | strong |

Introduction

Methods

Results

Conclusion

• Strongest correlation in overall performance
• Cumulative simulator score is a valid index of global on-road driving performance

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