The Lane Change Task as a tool for driver distraction evaluation

Stefan Mattes

DaimlerChrysler AG
Research & Technology
Developed within the Project ADAM (DaimlerChrysler, BMW)

Goal: Develop a method to evaluate driver distraction. Consider:
- Reliability
- Validity
- Objectivity
- simple
- low-cost
Strategy in method development: combine the advantages of classical approaches.

Dual task paradigm (work on two tasks simultaneously, performance in task 1 is index for capacity affordance of tasks 2)

**Probe reaction time paradigm.** Response to additional stimulus. Reaction time is index for cognitive capacity. (RT with secondary task vs. RT without secondary task).

**Driving simulation.** Drive in a more or less realistic scenario. Driving performance is an index for cognitive capacity. (Performance with secondary task vs. performance without secondary task).
Lane Change Task

Reaction time paradigm
+ condition exactly reproducible
+ condition under control
+ high frequency of measurements

= Reliability

Driving simulation
+ features of primary task resemble driving (cognitive, motoric, posture etc.)

= Validity

Standard consumer equipment
PC+Monitor
Game steering wheel

= low cost

Standardized test plan
+ simple experimental plan
+ short testing
+ standardized analysis

= simple
Lan Change Task - Experimental design (1)

Dual-task situation.
The subjects have to drive in the simulated driving task while they perform a secondary task.
Lane Change Task - Experimental design (2)

“Change your lane immediately as soon as you recognize the next sign.”
Lane Change Task - Experimental design (3)

„Change your lane immediately as soon as you recognize the next sign.“

Velocity: constant 60 km/h
Distance between signs: M=150 (140-188 m, exponentially distr.)
Duration: ~3 min.
Lane Change:

```
From lane | 1 | 2 | 3
-----------|---|---|---
      1    | 3 | 0 | 3
      2    | 3 | 0 | 3
      3    | 3 | 3 | 0
```
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Lane Change Task - Experimental Design (4)

Lane Change Task

Start

crash barrier

Part 1

Part 2

(etc.)

3000m

150m

Car onset 1

Car onset 2
Lane Change Task - Example
## Lane Change Task - Procedure

<table>
<thead>
<tr>
<th></th>
<th>Primary Task</th>
<th>Secondary Task #1</th>
<th>Secondary Task #1 + Primary Task</th>
<th>Secondary Task #2</th>
<th>Secondary Task #2 + Primary Task</th>
<th>Secondary Task #3</th>
<th>Secondary Task #3 + Primary Task</th>
<th>Secondary Task #4</th>
<th>Secondary Task #4 + Primary Task</th>
<th>Secondary Task #4 + Primary Task</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Primary Task</td>
<td>Secondary Task #1</td>
<td>Secondary Task #1 + Primary Task</td>
<td>Secondary Task #2</td>
<td>Secondary Task #2 + Primary Task</td>
<td>Secondary Task #3</td>
<td>Secondary Task #3 + Primary Task</td>
<td>Secondary Task #4</td>
<td>Secondary Task #4 + Primary Task</td>
<td>Secondary Task #4 + Primary Task</td>
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<td></td>
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<td>3 min</td>
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<td>3 min</td>
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</tbody>
</table>

n = 45 subjects

8 out of 12 secondary tasks per subject

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Position on the lane is recorded.

First approach:
1. fit model to measure “RT”
2. count missed signs
3. measure lane keeping performance
4. combine all measures

→ effortful and complicated
Lane Change Task - Analysis (1)

Position on the lane is recorded.
A simple normative model is used to assess driving performance

Note that all parameters of this model are fixed. That is, no fitting of the model to the behavioral data is necessary. The only parameters of the model are the onset of lane change (distance to sign) and the slope. These parameters can be set more or less arbitrary.
Area indicates driving quality.

The area is sensitive to:
• Perception (missed sign)
• Reaction
• Manoeuvre
• Lane keeping

This comparison of the behavioral data to the normative model provides one single index of performance which allows automatic and objective analysis.
Lane Change Task - Analysis (4)

Response: impact on area

Early response
= small area

Late response
= big area
Lane Change Task - Analysis (5)

Manoeuvre: impact on area

Good manoeuvre
= small area

Bad manoeuvre
= big area
Lane Change Task - Analysis (6)

Lane keeping: impact on area

Good lane keeping
= small area

Bad lane keeping
= big area
Lane Change Task - Analysis (7)

Perception (missed sign): impact on area

Response to sign
= small area

Missed sign
= big area
Lane Change Task - Result (Principle)

Area increase:

- Area with secondary task
- Area without secondary task
Lane Change Task - area increase

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Moving base driving simulator Berlin  
\( n = 85 \) subjects  
Same 12 secondary tasks

<table>
<thead>
<tr>
<th>Measure</th>
<th>Workload</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Subjective rating</td>
</tr>
<tr>
<td>Glance Behavior</td>
<td>Percentage glances outside</td>
</tr>
<tr>
<td>Lateral Control Behavior</td>
<td>Error Direction (max, sd), Lateral Acceleration (max, sd), Steering Wheel Angle (sd), TLC (min, mn, sd), Yaw Velocity</td>
</tr>
<tr>
<td>Longitudinal Control Performance</td>
<td>TTC (min), speed (sd, difference before-during ST), amount events distance to leading vehic &lt; 5 sec,</td>
</tr>
</tbody>
</table>

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Basics of Lane Change Task and Peripheral Detection Task
Lane Change Task

Lane-Change-Task

Peripheral-Detection-Task

Randomly one of three stimulus locations;
Stimulus duration: 2 s
Inter-Stimulus-Interval: 2-4 s (random)
Response: foot pedal press
Visual task

Find brown „X“ or blue „O“

Feature search

Conjunction search

easy
difficult

Details:

• Subject responds by saying „X“ or „O“. Reaction time is recorded.

• Experimenter marks response with keypress (X or O); about 500 ms

• Next screen immediately after experimenters input.

• Duration 3 minutes.
Cognitive task

„Count from [...] forwards in steps of 2“
„... 178 180 182 184 ...“

easy

„Count from [...] backwards in steps of 7“
„... 178 171 165 oops! 164? ...“

difficult
Motor task

Put stick clockwise in every hole and turn it without looking at the board!
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Peripheral-Detection-Task

<table>
<thead>
<tr>
<th>Secondary Task</th>
<th>Deviation [m]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>600</td>
</tr>
<tr>
<td></td>
<td>700</td>
</tr>
<tr>
<td></td>
<td>800</td>
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<tr>
<td></td>
<td>900</td>
</tr>
</tbody>
</table>

Mean Reaction Time [ms]

- **replication**: p < .001
- **visual**: n.s.
- **cognitive**: p < .001
- **motoric**: n.s.
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Peripheral-Detection-Task

Rate of misses differentiates easy and hard visual task whereas Reaction Time does not.
Conclusions

! LCT is a simple and efficient tool for driver distraction evaluation.

! LCT is especially sensitive to visual and cognitive distraction.

! Recommendation: prefer continuous measurement to special events approach.

! For method evaluation use secondary tasks with logical rank order.

Free copies of Lane Change Task simulation-and analysis software for research purposes are available upon request: stefan.mattes@daimlerchrysler.com