Metrics for Identifying Fatigued Driving

Research Professor Mikael Sallinen
Rationale for developing metrics of driver fatigue

Valid metrics of driver fatigue

Sufficient knowledge of driver fatigue

Measures to alleviate the problem

Reduction in road traffic casualties
### Physiologic metrics

<table>
<thead>
<tr>
<th>Method</th>
<th>Metric</th>
<th>Reference standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>EEG</td>
<td>- alpha, theta &amp; beta power density&lt;sup&gt;1,2,3,4,5,6,7&lt;/sup&gt;</td>
<td>- response to fatigue-inducing factors while driving</td>
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<tr>
<td></td>
<td>- alpha spindle parameters&lt;sup&gt;3&lt;/sup&gt;</td>
<td>- self-rated sleepiness</td>
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<tr>
<td></td>
<td>- lane drifting</td>
<td>- lane drifting</td>
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<tr>
<td>EOG</td>
<td>- slow eye movements&lt;sup&gt;1,5,7&lt;/sup&gt;</td>
<td>- response to fatigue-provoking factors while driving</td>
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<tr>
<td></td>
<td>- blink duration, amplitude, density&lt;sup&gt;2,5,7,8&lt;/sup&gt;</td>
<td>- self-rated sleepiness</td>
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<tr>
<td></td>
<td>- lid closing and opening velocity&lt;sup&gt;5,8&lt;/sup&gt;</td>
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</tr>
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<td></td>
<td>- saccadic &amp; fixation parameters&lt;sup&gt;8&lt;/sup&gt;</td>
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</table>

## Behavioral metrics

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<thead>
<tr>
<th>Method</th>
<th>Metric</th>
<th>Reference standard</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Task-based methods</strong></td>
<td><strong>PVT</strong>: lapses, response speed&lt;sup&gt;1&lt;/sup&gt;</td>
<td>- response to fatigue-inducing factors</td>
</tr>
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<td></td>
<td><strong>Posturography</strong>: balance scores&lt;sup&gt;2&lt;/sup&gt;</td>
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<td><strong>Video-based methods</strong></td>
<td><strong>Perclos</strong>: the proportion of time eyes are 80–100% closed&lt;sup&gt;3,4,5&lt;/sup&gt;</td>
<td>- &quot;near crashes&quot;</td>
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<tr>
<td></td>
<td><strong>ORD</strong>: eye closures, facial tone, behavior, mannerisms&lt;sup&gt;3,4&lt;/sup&gt;</td>
<td>- self-rated sleepiness</td>
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<tr>
<td></td>
<td></td>
<td>- lane drifting</td>
</tr>
<tr>
<td><strong>Vehicle &amp; steering wheel-based methods</strong></td>
<td>lane variability&lt;sup&gt;6,7,8,9,10,11&lt;/sup&gt;</td>
<td>- self-rated sleepiness, vigilance performance</td>
</tr>
<tr>
<td></td>
<td>steering variability&lt;sup&gt;6,7,8&lt;/sup&gt;</td>
<td>- response to fatigue-inducing factors while driving</td>
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</tbody>
</table>

<sup>8</sup>Mattson Master's Thesis 2007.  
<sup>9</sup>Sandberg et al. IEEE Trasaction on Intelligent Transportation 2011, 12, 97-108.  
# Vehicle/steering wheel-based metrics

<table>
<thead>
<tr>
<th>Study</th>
<th>Driving conditions</th>
<th>N of metrics tested</th>
<th>Ref. standard</th>
<th>Most sensitive metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friedrics¹ (2010)</td>
<td>Real roads</td>
<td>31</td>
<td>Subj. fatigue (KSS)</td>
<td>Average <em>steering</em> angular velocity</td>
</tr>
<tr>
<td>Forsman⁴ (in press)</td>
<td>Simulator</td>
<td>87</td>
<td>Beh. &amp; subj. fatigue (PVT, KSS)</td>
<td>Combination of <em>lane variability</em> metrics (e.g., sd of lateral lane position)</td>
</tr>
</tbody>
</table>

## Subjective sleepiness and driving

<table>
<thead>
<tr>
<th>Subjective sleepiness (KSS)</th>
<th>Driving errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 extremely alert</td>
<td></td>
</tr>
<tr>
<td>2 very alert</td>
<td></td>
</tr>
<tr>
<td>3 alert</td>
<td></td>
</tr>
<tr>
<td>4 rather alert</td>
<td></td>
</tr>
<tr>
<td>5 neither alert nor sleepy</td>
<td></td>
</tr>
<tr>
<td>6 some signs of sleepiness</td>
<td>minor lane drifting markedly increases$^{1,2}$</td>
</tr>
<tr>
<td>7 sleepy, no effort to stay awake</td>
<td></td>
</tr>
<tr>
<td>8 sleepy, some effort to stay awake</td>
<td>major lane drifting (lane departures)</td>
</tr>
<tr>
<td>9 very sleepy, great effort to keep awake, fighting sleep</td>
<td>markedly increases $^{1,3,4}$</td>
</tr>
</tbody>
</table>

How can you choose the right metric(s)?

1) For the moment, there is no "silver bullet" to measure driver fatigue. Therefore, it is recommended using multiple methods/metrics.

2) The easiest way is to rely on introspection (subjective metrics). It is a quite valid/reliable and inexpensive method but sensitive to manipulation.

3) Vehicle/steering wheel and eye closure metrics are also among the first choices. They are unobtrusive and objective by nature.

4) Physiologic metrics are objective by nature but often obtrusive (electrodes) and expensive (analyses). However, they will become more feasible to use in the future along with the development of technology.
Truck driver sleepiness – an ongoing project at FIOH

1. How sleepy are long-haul truck drivers at the wheel?

2. Is it possible to improve their alertness through training?

Pre-intervention measurement
- 2 week measurement period including 3 days of intensive measurements

Intervention
- half-day fatigue management training
- self-made plan for fatigue management + feedback from the plan

Post-intervention measurement
- 2-week measurement period including 3 days of intensive measurements

52 long-haul truck drivers

Intervention group (N=32)

Fatigue management training (N=29)

Control group (N=20)

49 long-haul truck drivers


05 – 09/2011

11/2011 – 03/2012
Fig. 1. The proportion of shifts during which the drivers rated their sleepiness ≥ 6, ≥ 7 or ≥ 8 on the Karoliska Sleepiness Scale at least once. A total of 130 morning shifts, 38 day shifts, 85 evening shifts, and 222 night shifts have been included in the analysis.
Does fatigue management training reduce fatigue?

**Intervention Group**

- **Morning shift (n=74)**
  - Pre-intervention: 20.3%
  - Post-intervention: 15.2%

- **Day shift (n=26)**
  - 38.5%

- **Evening shift (n=39)**
  - 30.8%

- **Night shift (n=135)**
  - 45.2%

**Control Group**

- **Morning shift (n=54)**
  - 31.5%

- **Evening shift (n=40)**
  - 42.5%

- **Night shift (n=80)**
  - 47.5%

Fig. 2. % of "sleepy" shifts (KSS≥6 at least once) in the intervention and control groups.
Thank you!