CAN INTERMITTENT VIDEO SAMPLING CAPTURE INDIVIDUAL DIFFERENCES IN NATURALISTIC DRIVING?

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Abstract
We examined the utility and validity of intermittent video samples from “black box” devices for capturing individual difference variability in real-world driving performance in an ongoing study of obstructive sleep apnea (OSA) and community controls. Video clips were coded along dimensions of driver safety, exposure, and state. Preliminary findings showed that clips type captured variability along targeted dimensions such as highway vs. city driving, driver state (such as distraction and sleepiness), and safety. Sleepiness metrics were meaningfully associated with adherence to PAP (positive airway pressure) therapy. OSA drivers who were PAP adherent showed less sleepiness and less non-driving related gaze movements than the non-adherent. Simple differences in sleepiness did not readily translate to improvements in driver safety, consistent with epidemiologic evidence date to.

Background & Aims
- “Black box” devices are increasingly employed to study real-world driving performance and safety (e.g. Blanchard et al., 2010; Critelle et al., 2011). Video samples are necessary to contextualize & classify driver actions but are there storage & analysis challenges.

Aim 1 was to examine the utility of an intermittent video sampling protocol (Table 1) to capture individual differences in driver safety, exposure, and state in drivers with OSA who are at increased risk for vehicle crashes (Tregear et al., 2009).

Table 1: Intermittent video sampling protocol in each drive defined by ignition-on to ignition-off cycles.

<table>
<thead>
<tr>
<th>Specification</th>
<th>Trigger</th>
<th>Baseline</th>
<th>Ignition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clip Duration</td>
<td>20s</td>
<td>20s</td>
<td>60s</td>
</tr>
<tr>
<td>Conditions that must be met</td>
<td>when g is &gt; 0.35 every 15 min ignition on to generate the clip</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Targeted dimensions</td>
<td>Safety (e.g. running), Safety, state, &amp; contexts of performance Safety, state, &amp; light intensity, turn errors, &amp; exposure exposure in well-lit, &amp; drivers present&lt;br&gt;practiced trips during previous trips of parents (e.g. home to work)</td>
<td></td>
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</tr>
</tbody>
</table>

Question 1. Do the rates of safety errors, exposure, and driver state show expected mean differences across clip types?

Aim 2 and Aim 3 were to examine driver safety, state, and exposure in relation to PAP adherence data and self-reports of excessive sleepiness.

Methods
Subjects
37 OSA drivers (28M, mean age 48 years, SD = 6.79) met ICSD-2 clinical criteria for OSA and had a Respiratory Distress Index (RDI) ≥ 15.
20 Controls (10 male, mean age 45 years, SD = 8.03) had no sleep complaints & RDI < 5.

Controls were matched with OSA drivers on gender, age within 5 y, education within 2 y, and county of residence for rural vs. urban driving.

Procedure
Subjects were observed driving their own vehicles using a black box device for 2-weeks before and after PAP & 2-weeks after PAP.

Measures
- Nightly PAP use data and monthly tracking of symptoms of excessive daytime sleepiness (EDS) were obtained from OSA drivers.

- Performance was evaluated in 20s segments in 3 domains:
  a) Safety (e.g., traffic sign violations, wide turns)
  b) Exposure (e.g., weather related variables, road culture)
  c) Driver State (e.g., distraction, fatigue, gaze movements)

Results
Descriptive Data
- On average, OSA participants used PAP >4 hours/night on 58% of days.
  EDS symptoms improved from pre to post-PAP for OSA but not controls (p < .05 for the interaction effect).

- Average daily data showed 14 segments from ignition clips, 6 20s- segments from baseline clips, and 4 trigger clips from trigger clips.

Aim 1

Table 2: Descriptive statistics on coded dimensions in each clip type pre-PAP for OSA & Control Drivers

<table>
<thead>
<tr>
<th>Measure</th>
<th>Ignition</th>
<th>Baseline</th>
<th>Trigger</th>
<th>p-value for clip type main effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>.03 (.10)</td>
<td>.02 (.06)</td>
<td>.02 (.09)</td>
<td>.003</td>
</tr>
<tr>
<td>Sleepiness</td>
<td>.72 (.26)</td>
<td>.72 (.27)</td>
<td>.72 (.29)</td>
<td>.001</td>
</tr>
<tr>
<td>Distraction</td>
<td>.39 (.15)</td>
<td>.39 (.16)</td>
<td>.39 (.17)</td>
<td>.004</td>
</tr>
<tr>
<td>Driving related gaze</td>
<td>.29 (.23)</td>
<td>.29 (.24)</td>
<td>.29 (.25)</td>
<td>.001</td>
</tr>
<tr>
<td>Slippery roads</td>
<td>.19 (.29)</td>
<td>.19 (.30)</td>
<td>.19 (.30)</td>
<td>.001</td>
</tr>
</tbody>
</table>

- Trigger clips contained greater rates of intersection negotiation and city driving. Baseline clips contained greater rates of highway driving.

- None of the weather exposure rate variables differed across clip types.

- Trigger clips sampled lower levels of light compared to others.

- In terms of driver safety and state, findings suggested the presence of self-regulatory influences (e.g., trigger clips had elevated safety error rates coupled with lower distraction, sleepiness, and higher rates of driving related gaze movements.)

Conclusions
- Findings support the rationale and utility of the video protocol for systematically capturing variability in driver safety, exposure and state.

- PAP-adherent OSA drivers showed less sleepiness and non-driving related gaze movements than the noncompliant OSA patients. However, those differences did not translate to significant improvements in safety. Findings indicate that the association of driver safety with observer measures of excessive sleepiness is complex and highly situational.

- The canonical view that distracted & sleepy driving is directly linked to declines in driver safety was not supported by the current naturalistic driving data. Self-regulatory (supervisory executive control) processes may attenuate or reverse expected associations. For example, distracted drivers may choose the timing and location of distracted driving (e.g. conversations by cell phone or with passengers) to mitigate crash risk. Sleepy drivers may take similar precautions by reducing speed, increasing headway distance, and other tactics.

Acknowledgment
The study was supported by R01 HD059377, Road-World Driving in Adults with Obstructive Sleep Apnea, K08 HD070401, K08 HD069790, and K12 NS083957. K08 HD069790 & K12 NS083957 supported post-doctoral fellows, respectively. The research was conducted with support from the Program in Human Factors and Ergonomics, University of Iowa, Iowa City, Iowa, U.S.A.

References
Blanchard KD, Myers AM, Ferber E, et al. (2010). Differences in driving patterns in older drivers compared to an age-matched control group: Preliminary findings of the Program in Human Factors and Ergonomics, University of Iowa, Iowa City, Iowa, U.S.A.

Figure 1. A ‘Black Box’ Device

Figure 2. Camera View

Figure 3. Pearson correlations between sleepiness measures in three clip types with PAP-Adherence and subjective sleepiness ratings (Note that when r is < 0.05, p is > 0.5).

PAP-adherent OSA patients showed less sleepiness and non-driving related gaze movements than the nonadherent OSAS.

However, those differences in sleepiness did not translate to significant improvements in safety.