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 clip types 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 to date.

Background & Aims

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

Figure 1. A “Black box” Device

- A**im 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 (Treagar et al., 2009).

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

Specification	Trigger	Baseline	Ignition
Clip Duration	20s	20s	60s
Conditions that must be met to generate the clip	when g’s ≥ .35	every 15 min into the drive	ignition on
Targeted dimensions & contexts of performance	Safety (e.g. running red lights, turn errors, etc.), state, & exposure during g-events	Safety, state, & exposure in the absence of g-events	Safety, state, & exposure in well-practiced trips (e.g. home to work)

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.

Question 2. Do pre and post-pap measures of sleepiness from video clips correlate with 2 external validity measures: a) pap-adherence metrics for OSAs and b) symptoms of excessive daytime sleepiness pre and post-pap for all drivers?

Question 3. Is adherence to pap-therapy (>4 hrs of use per night) associated with driver state variables, safety, and exposure post-pap in drivers with OSA?

Methods

Subjects

- 37 OSA drivers (26M, mean 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 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:
  - o Safety (e.g., traffic sign violations, wide turns)
  - o Exposure (e.g., weather related variables, road culture)
  - o Driver State (e.g., distraction, fatigue, gaze movements)

Figure 2. Camera View

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 20s-segments from ignition clips, 6 20s-segments from baseline clips, and 4 20s-segments from trigger clips.

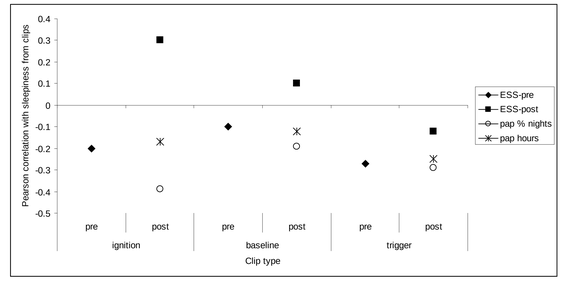
Aim1

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

	Ignition M (SD)	Baseline M (SD)	Trigger M (SD)	*p*-value for clip type main effect
Exposure				
Road culture				
Highway	.06 (.08)	.43 (.30)	.17 (.24)	<.001
Intersection	.44 (.11)	.23 (.23)	.79 (.25)	<.001
Rural	.04 (.09)	.03 (.07)	.03 (.10)	ns
City	.39 (.15)	.31 (.26)	.72 (.26)	<.001
Weather				
Visibility	.06 (.08)	.07 (.16)	.05 (.09)	ns
Dark	.26 (.20)	.29 (.27)	.18 (.20)	.004
Slippery (wet/ icy/ snowy) roadway	.21 (.25)	.17 (.23)	.15 (.21)	ns
Driver safety and state				
Safety errors	.04(.04)	.01 (.03)	.91 (.18)	<.001
Distraction	.58 (.28)	.51 (.46)	.35 (.27)	<.001
Driving related gaze movements	.65 (.13)	.38 (.22)	.71 (.24)	<.001
Sleepiness	4.57 (7.11)	7.82 (10.1)	4.79 (7.15)	.003

- 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.)

Aim 2



- Expected negative correlations with pap-use were ns ($p > .05$).
- Only 2 out of 6 correlations were in the expected positive direction with ESS.

Figure 3. Pearson correlations between sleepiness measures in three clip types with pap-adherence and subjective sleepiness ratings (Note that when $|r|>.32$, $p< .05$)

Aim 3

Table 3. Descriptive data for driver safety, state, and exposure for compliant vs. noncompliant OSA subjects

	Noncompliant M (SD)	Compliant M (SD)	p-value
Safety[a]	0.94 (.10)	0.99 (.31)	ns
Sleepiness[a]	8.52 (7.94)	2.18 (2.63)	.007
Distraction	0.40 (.25)	0.44 (.22)	ns
Driving related gaze	0.63 (.18)	0.54 (.09)	.085
Non-driving related gaze	0.57 (.22)	0.40 (.16)	.020
Visibility	0.13 (.27)	.11 (.23)	ns
Darkness	0.21 (.26)	.13 (.19)	ns
Precipitation	0.12 (.29)	.11 (.23)	ns
Slippery roads	0.19 (.29)	.27 (.30)	ns

N = 13 for noncompliant and N= 17 for compliant OSA participants.
[a] Measures reflect level obtained from post-pap trigger clips.
Remaining measures reflect average level from all three types of clips post-pap.

- 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.

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 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 RO1 HL091917, Real-World Driving Safety in OSA. We thank Michelle Nutting, Courtney Waite, Nicholas Heisermann, Kelsey Thompson, Katherine Read, and Bryan Fiscus for their diligence and endurance in coding video clips.

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