Preliminary Evaluation of Real-time Steering Entropy for Monitoring Driver State

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- Real-time Steering Entropy(RSE)
- Naturalistic Driving Study and Previous Study
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Background

- Distraction and fatigue are of course contributing factors in vehicle crashes
- Countermeasure: driver state monitor
  - camera based
  - physiological based
  - driving behavior based
- These can challenge computational resources of embedded systems
- Real-time Steering Entropy (RSE) has been proposed as a feasible approach

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Purpose

- Two previous studies have clarified as follows:
  - The RSE method was demonstrated to detect various forms of driver distractions
  - The RSE method was found to be sensitive to calling behavior (incoming call and outgoing calls)

RSE performance was investigated for use in identifying periods of reduced alertness

1) in long-duration driving situations, and

2) at different times during the day

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Real-time Steering Entropy(RSE)

Rationale for Measurement

- Steering behavior is generally smooth for a driver who is concentrating on driving

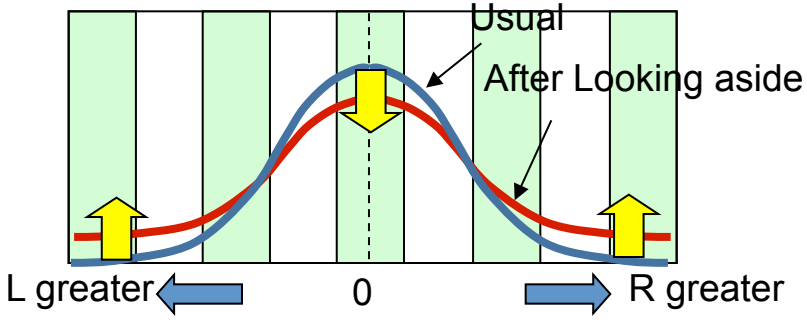
  ⇒ *PE (diff. btwn "actual steering angle" and "predict") is small*

  ⇒ *PE appears at the center on zero in P.D. of PE*

- Quick steering inputs indicate steering corrections and high workload (ex. after looking aside)

  ⇒ *PE gets great.*

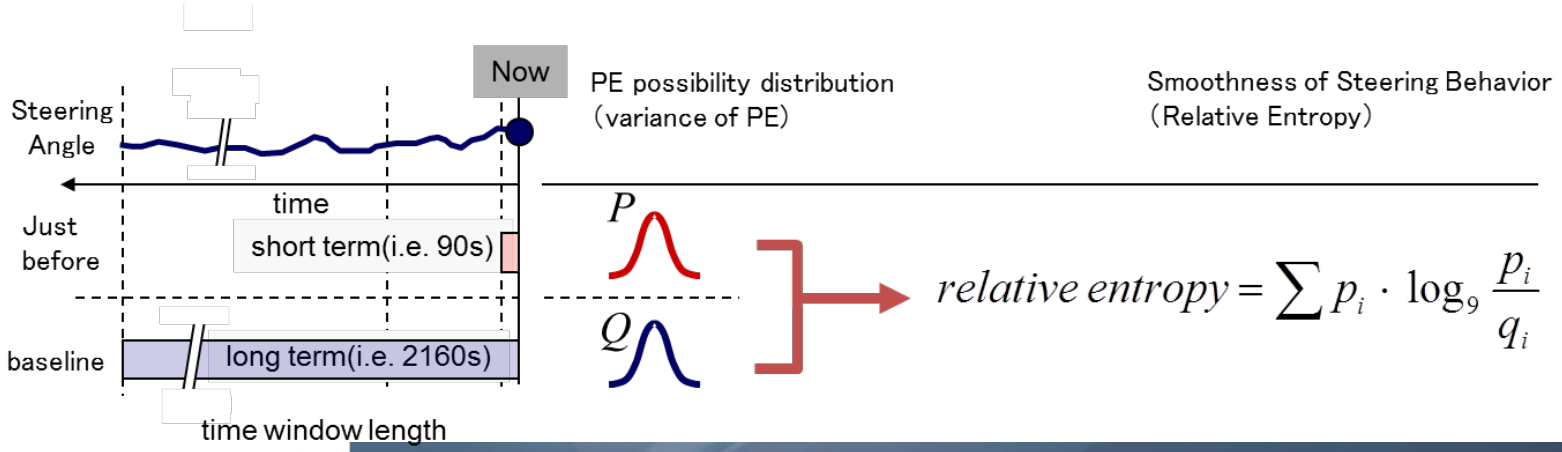
  ⇒ *Distribution of PE widens: Hp (measure of disorder) increases*



Real-time Steering Entropy(RSE)

Measurement

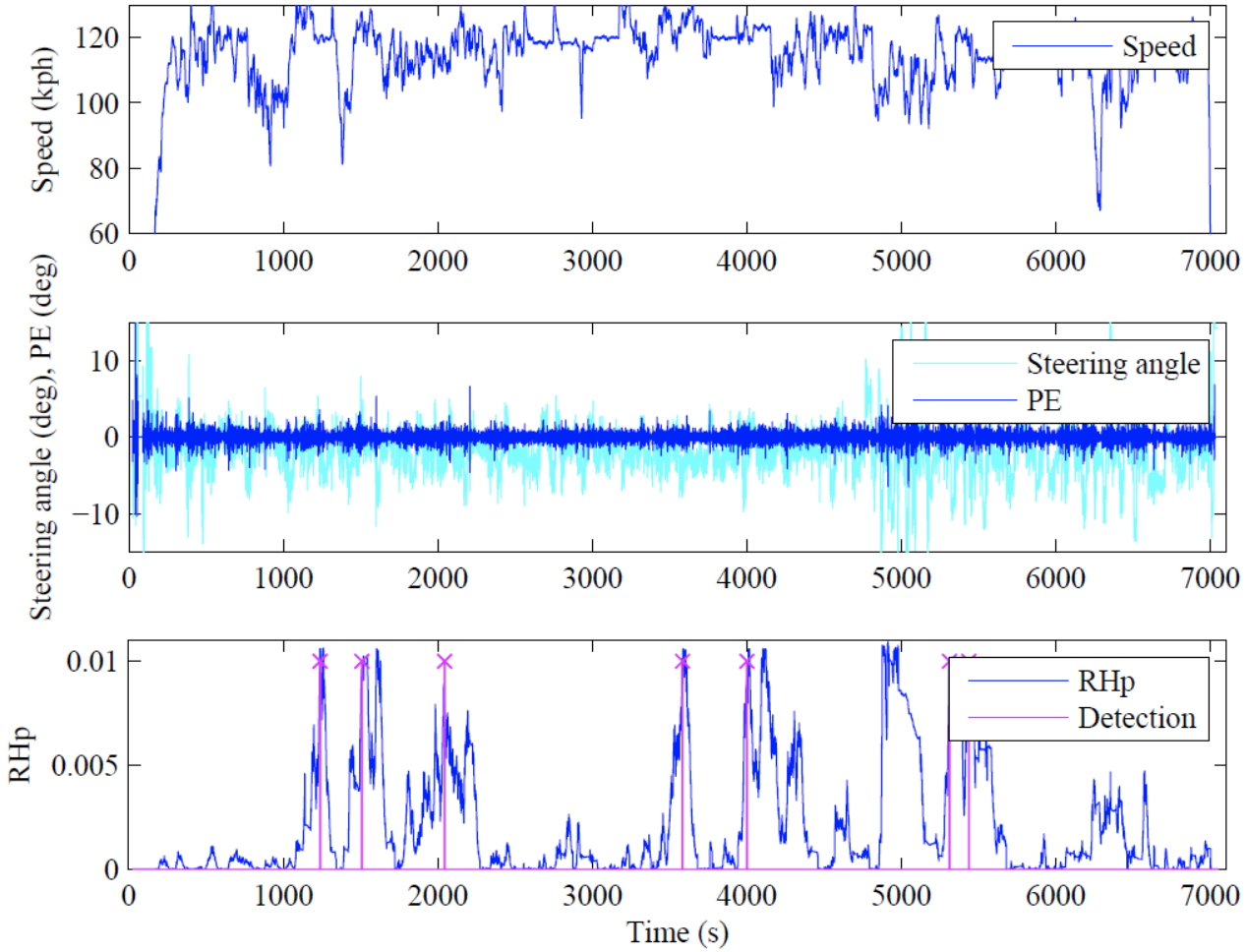
1. Uses a comparison instantaneous measures to long-term measures (driver characteristics)
2. RSE computation needs time to learn and identify individual steering characteristics
3. Relative entropy is applied to quantify both measures.



Real-time Steering Entropy(RSE)

RHp Behavior in Driving

- Examples of changes in one trip



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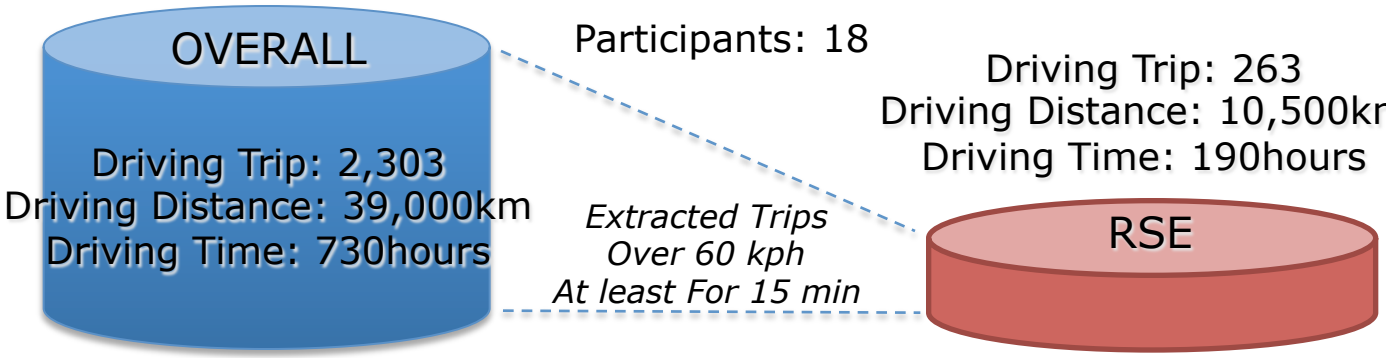
NDS and Previous Study

NDS Summary

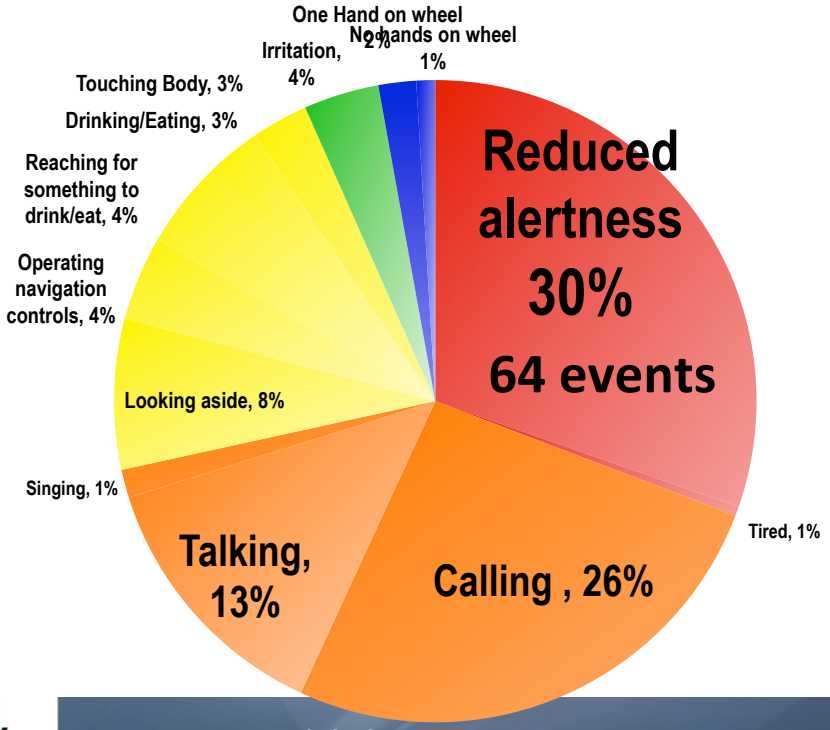
- Collected in collaboration with VTTI
- Approval(#10-624) from IRB of VT to analysis



NDS and Previous Study

Observed Driver Condition

- 30% (64 events): Reduced alertness
- 39% (83 events): Cell phone, Talking to passenger
- 22% (46 events): Looking aside, Reaching for something to drink/eat



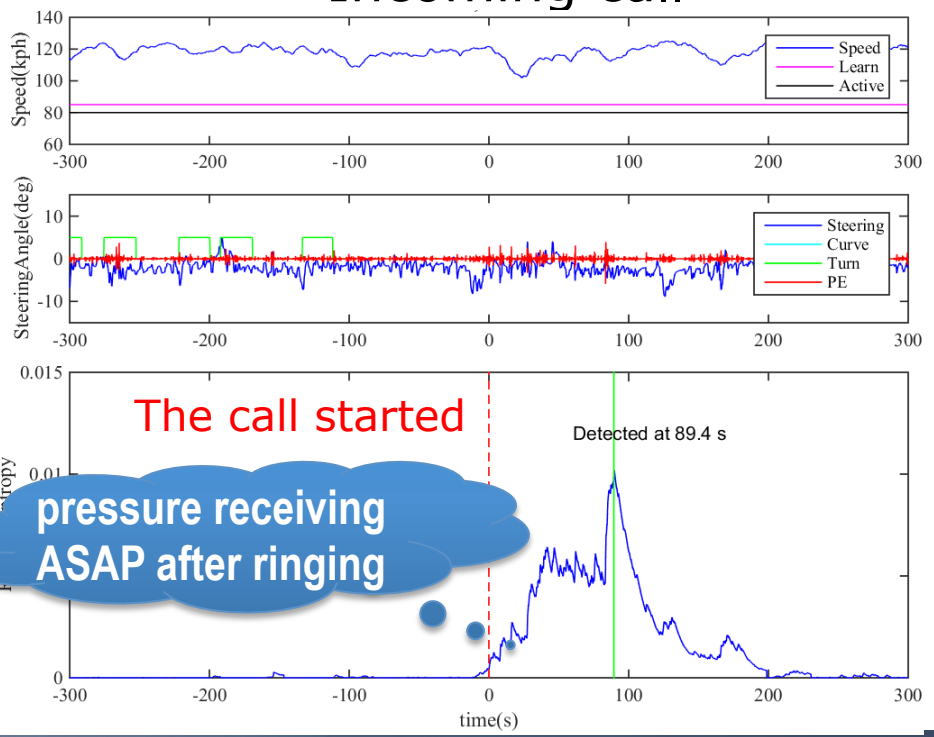
NDS and Previous Study

Typical RHp behavior in Calling Events

- RHp appears to follow onset of distraction
  - Outgoing call: Increases before the call started
  - Incoming call: Increases after the call started

Outgoing call

Incoming call



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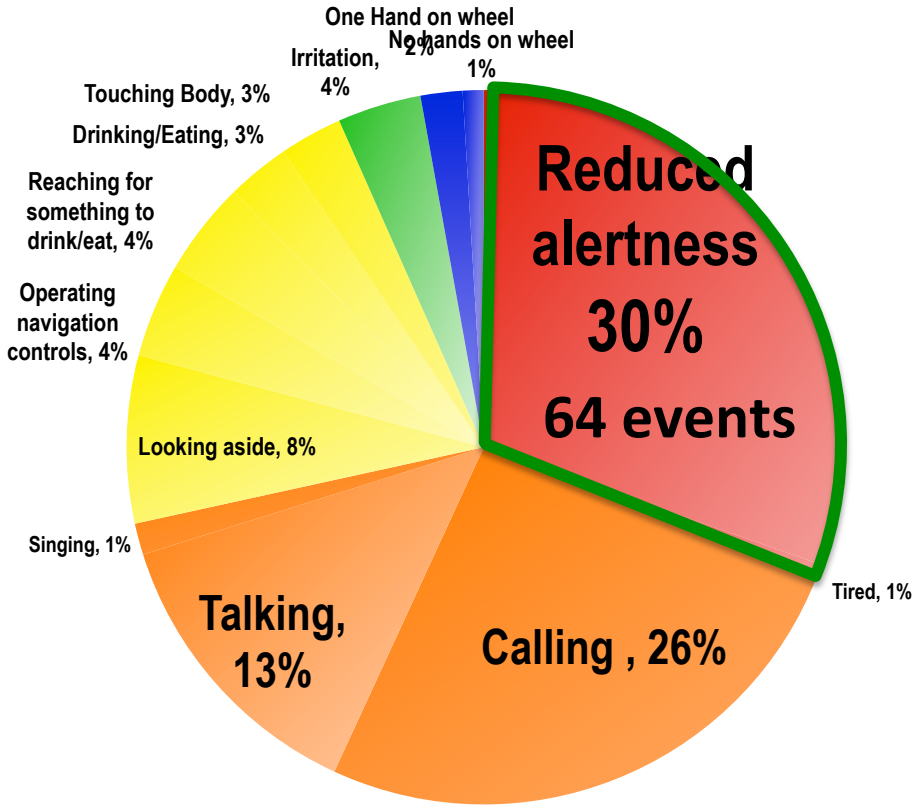
Results

Summary of Reduced alertness

- Reduced alertness was found for 30% of events
- This is the largest category of events

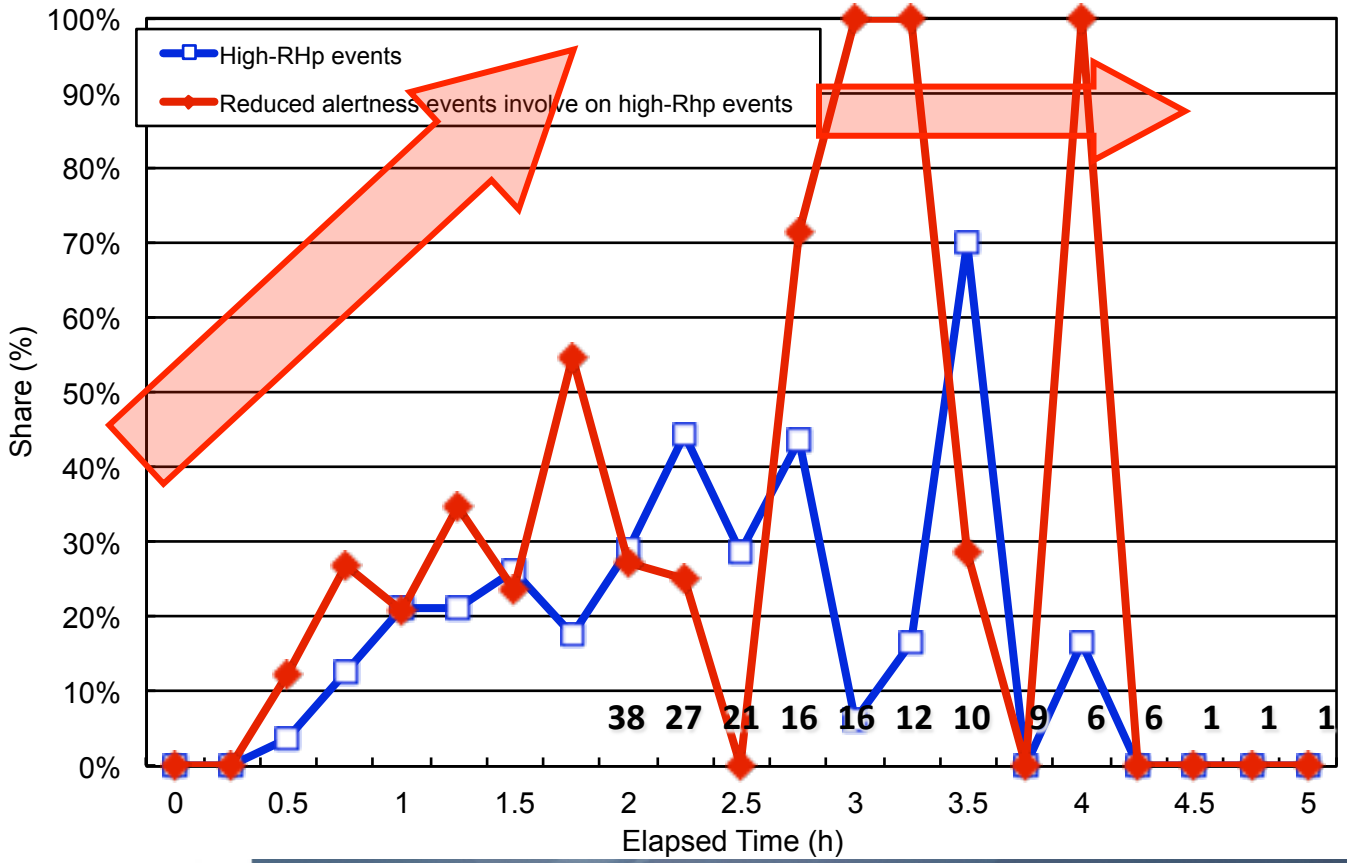
- Additional information was collected for each of these events
  - elapsed time
  - time of day



Results

Elapsed time

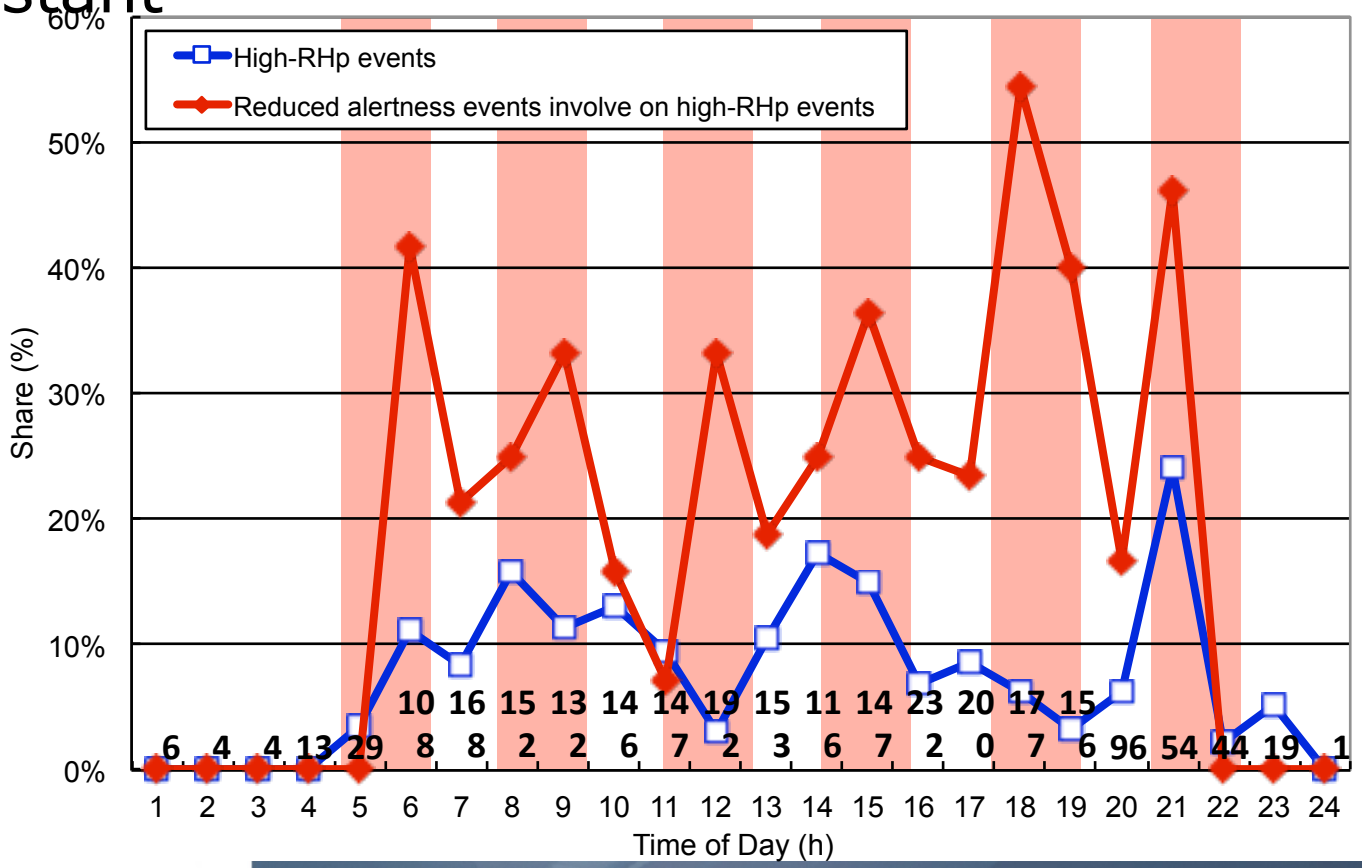
- Longer driving leads to higher possibilities of drowsiness



Results

Time of Day

- The peaks of reduced alertness appear cyclical (~1.5~2 hours), even though the rate of overall is constant



Results

Discussion

- Longer periods of driving correspond with more frequent periods of reduced alertness.

- The peaks in percentage of high-RHp events where reduced alertness was observed were found to be approximately three hours apart.
  - It may show “Ultradian Rhythm”

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Conclusion

- Applying RHp to NDS was successful in finding periods of reduced alertness.
- These periods appeared to be

  1) in long-duration driving situations

  2) at different times during the day

RSE approach has the potential to reliably detect higher-risk driving conditions

Thank you for your attention

Possibilities of RSE

- **A good index of various driver states and even phases of tasks (e.g., sensitivities related to cell use)**
- **Good for processing big databases: SHRP2 etc**
- **Application to known long distance drivers: Truck, Coach, Rideshare**