Task Load Estimation & Mediation using Psychophysiological Measures

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Situated Interactions

Not meeting shared expectations
~ *inconsiderate*

→ Breakdown

Winograd & Flores

Research Question

How can we get multiple agents to interact without breakdown?

Overview

- Problem Space & Related Work
- Experiment 1: Distraction?
  - Data Collection and Model Building
- Experiment 2: Mediation
  - Model Validation
- Conclusion

Problems with Distracted Driving

Talking/Texting while driving is distracting:

- 26% of crashes involve drivers talking and texting

http://www.nsc.org/DistractedDrivingDocuments/Attributable-Risk-Summary-2012-Estimate.pdf

Texting vs. Notifications

2 way *1 way*

1. Are notifications distracting?

   Does modality play a role?

   Audio vs. Visual notifications

2. How to mediate distractions?

Related Work

- Rapidly changing workload

- Realtime Autonomous Mediation

- External (context) vs. Internal (physiology)
  - Potential advantages: domain independence, personalization, wearables

- Cheap, non-invasive task load estimation

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E1: Are notifications distracting — *Exp. Design*

Primary Driving Task

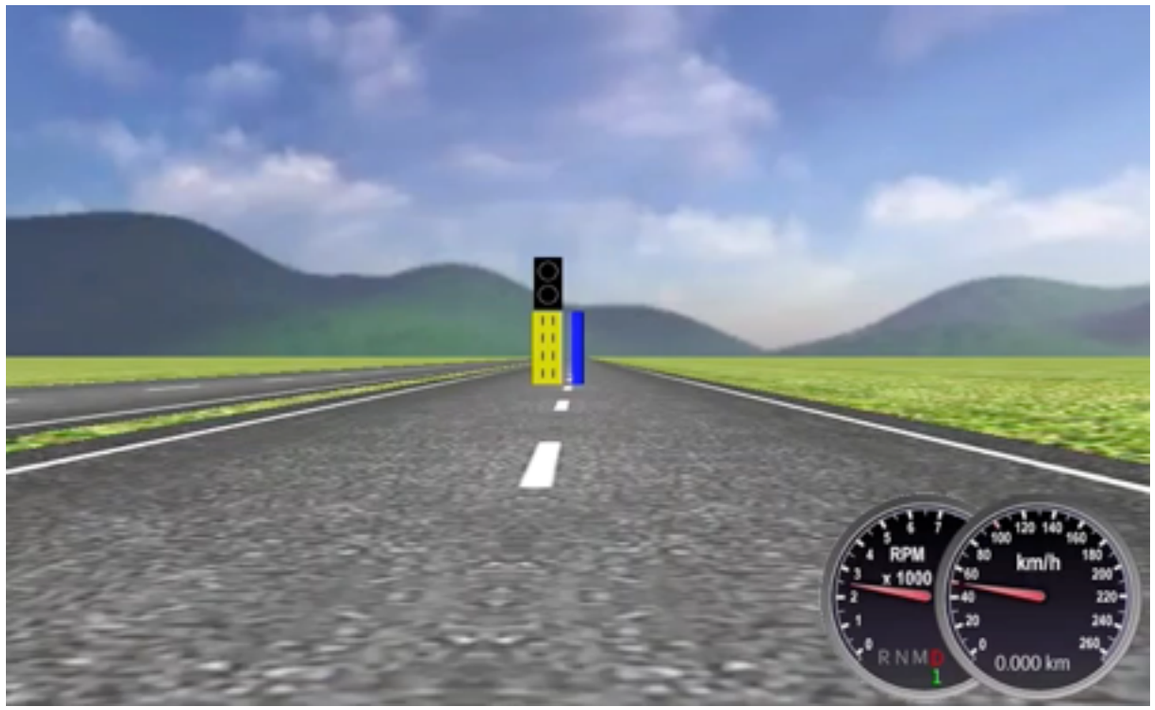
- Rapidly changing workload

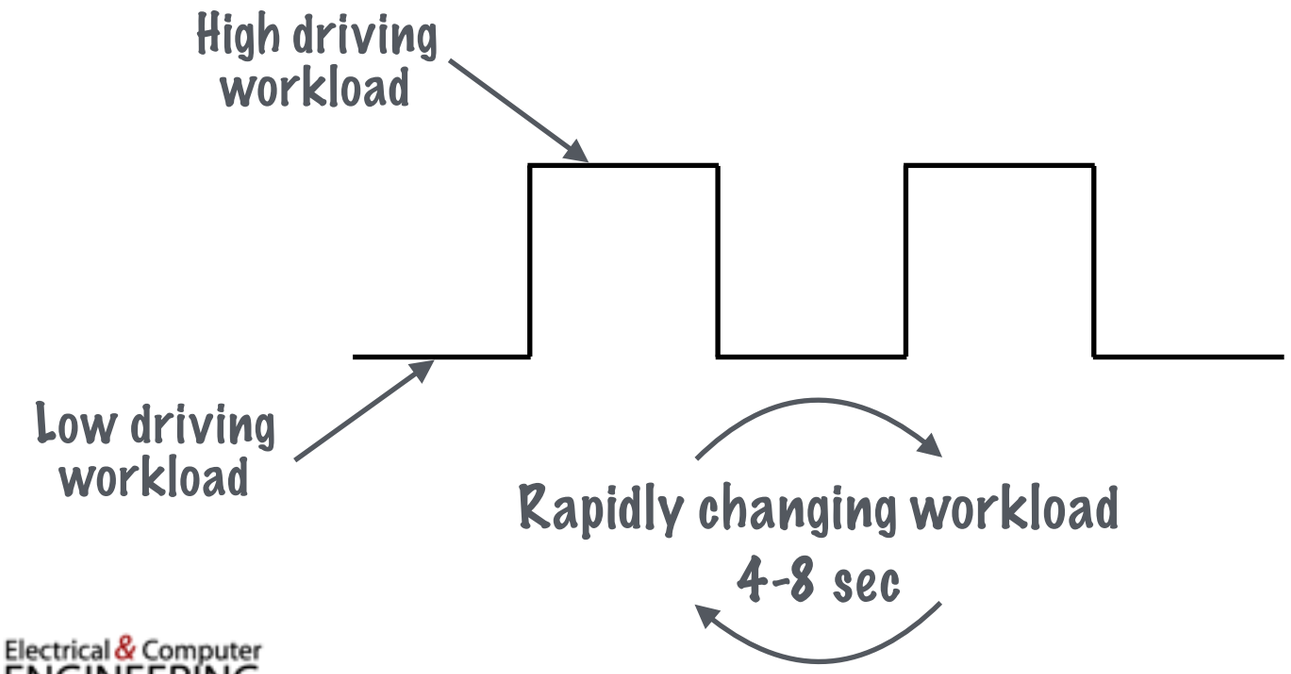
Cruising vs. Merging/Pedestrians

E1: Are notifications distracting — *Exp. Design*

OpenDS
ConTRe Task:

(Continuous Tracking and Reaction)





Control Condition:

Send notifications randomly *(non-mediated)*

Test Condition:

Send notifications during low workload *(mediated)*

E1: Are notifications distracting — *Exp. Design*

Primary Driving Task

- Rapidly changing workload

Cruising vs. Merging/Pedestrians

Secondary Notification Task

- *Attending* to notification

Notifications come in indiscriminately

"Hey want to get a drink tonight?"

- *Responding* to notification

Drivers moderate when they respond at a red light, traffic jam

"Can't tonight. How about tomorrow?"

E1: Are notifications distracting — *Exp. Design*

Secondary Task: Complex Span (Reading & Listening)

2/2 + 1 = 1	*False*	P
After yelling at the game, I knew I would have a tall voice	*False*	Q
3/1 + 3 = 6	*True*	F

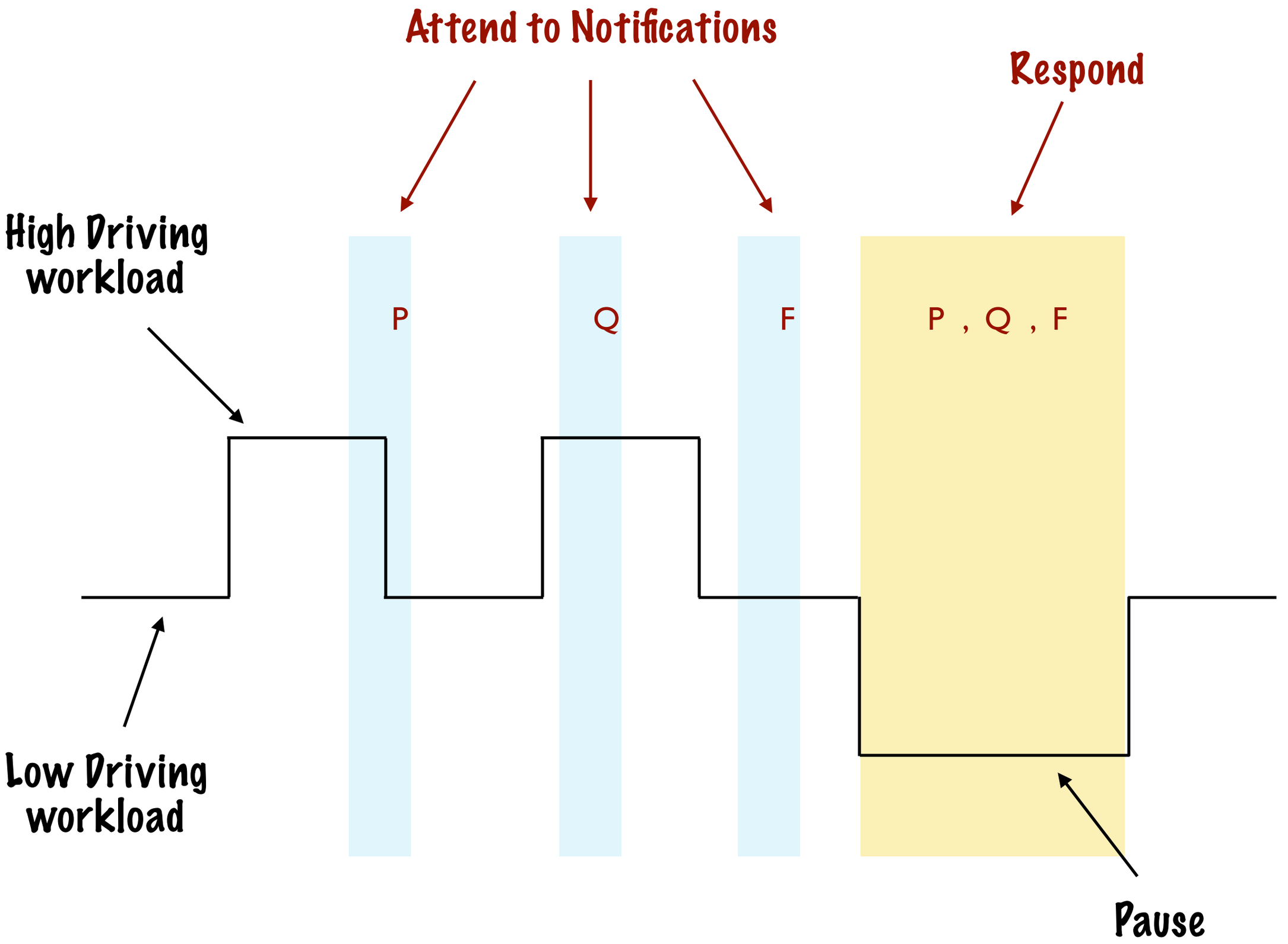
E1: Are notifications distracting — *Exp. Design*

Secondary Task: Complex Span (Reading & Listening)

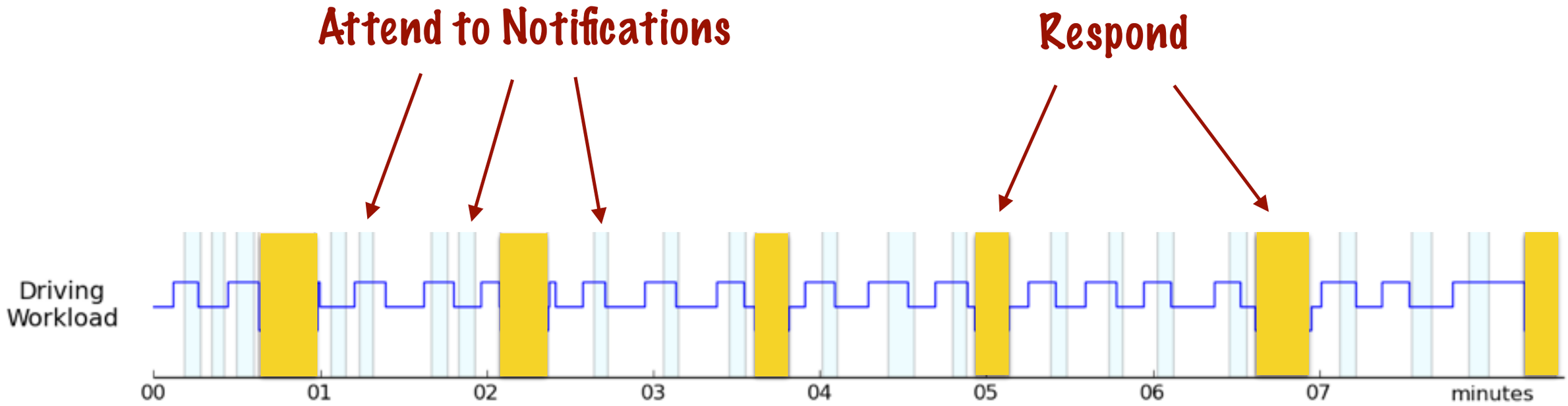
2/2 + 1 = 1	*False*	P
After yelling at the game, I knew I would have a tall voice	*False*	Q
3/1 + 3 = 6	*True*	F

Respond (Recall)

Attending (Processing)


Attend to Notifications
Respond
High Driving workload
P
Q
F
P , Q , F
Low Driving workload
Pause

E1: Are notifications distracting — *Test Setup*



10 Math & 10 Sentence
notifications interspersed

E1: Are notifications distracting — *Study & Results*

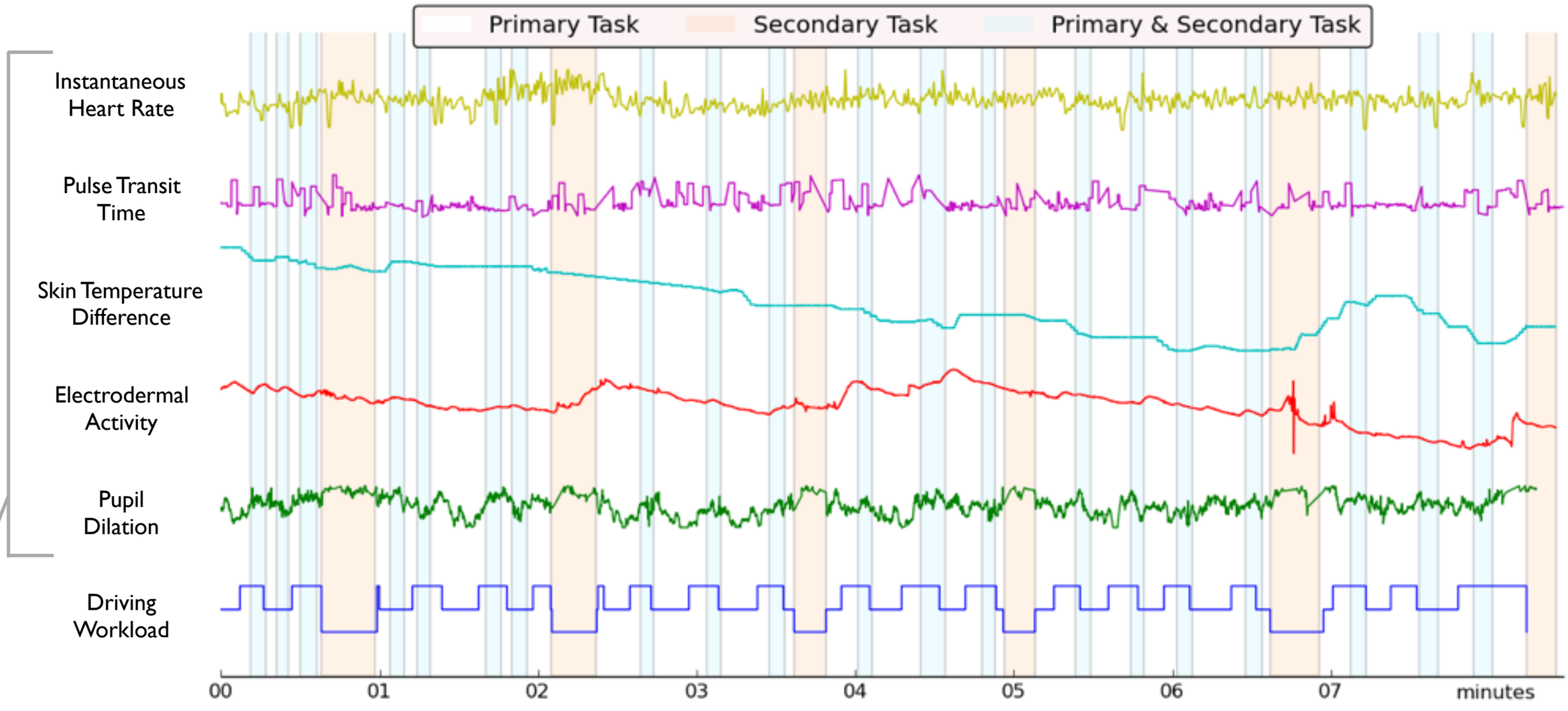
- **Wizard-of-Oz Study:**
  - 2 (Audio/Video) X 2 (Mediated/Non-mediated)
  - 20 Participants (10M, 10F)
  - Within-subject; counter-balanced; repeated measures

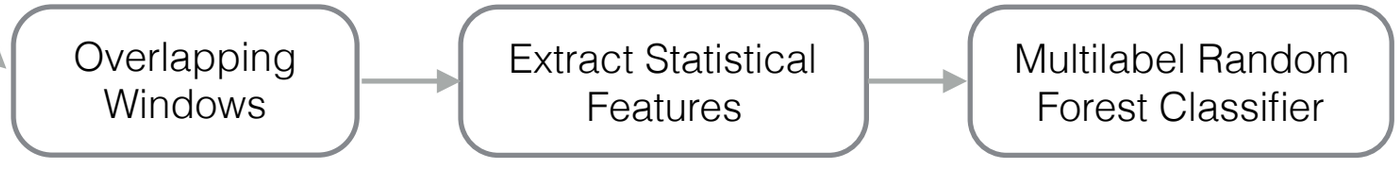
	Mediated	Non-mediated
Audio		
Video		

- **2-Way Multivariate ANOVA**
  - *Mediation effect is very significant (F=25.47, p<.001)*
  - Modality effect is not significant

Notifications are distracting

E1: Are notifications distracting — *Model Building*





Pupil measure can detect when user is multitasking with AUC ROC of 0.85

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E2: Autonomous Mediation — *Experiment Design*

Primary Task: ConTRe

- Rapidly changing workload

Secondary Task: Gear Change

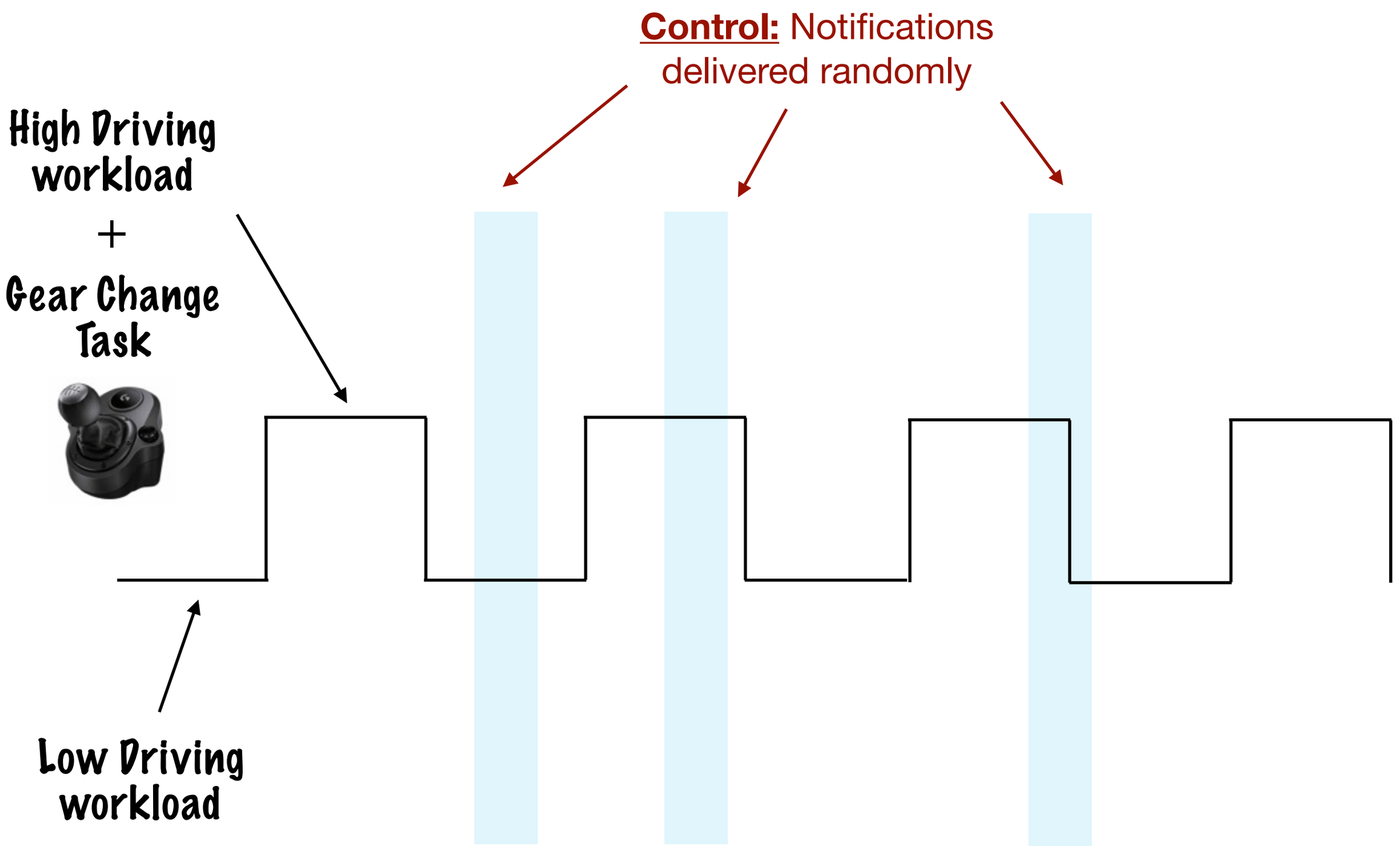
- Change gear to number displayed

Mediation Task: Notifications

- Attend to *aural* notifications

2/2 + 1 = 1 *False*

E2: Autonomous Mediation — *Test Setup*



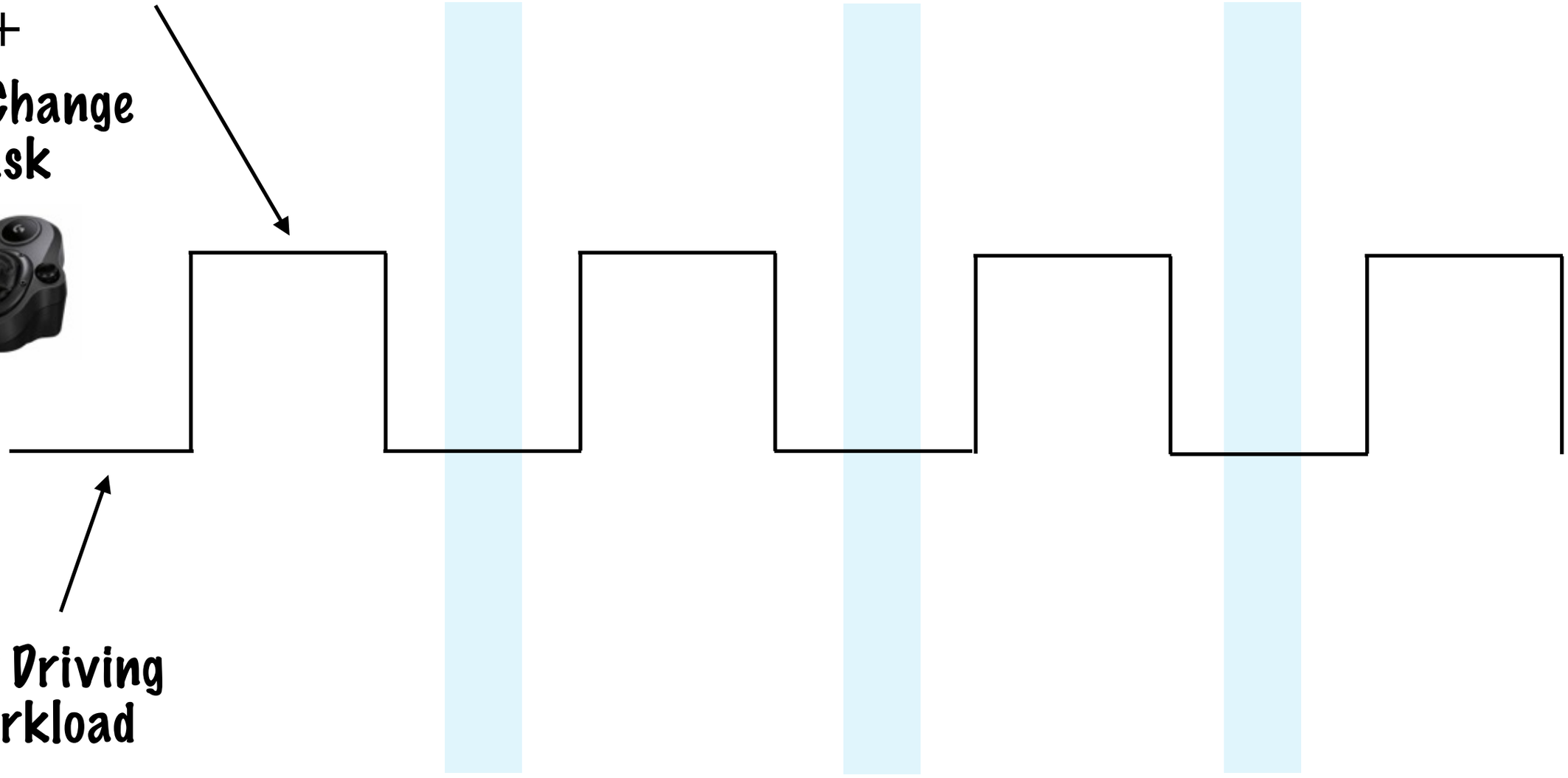
E2: Autonomous Mediation — *Test Setup*

Goal: Delay notifications till *low workload*

High Driving workload

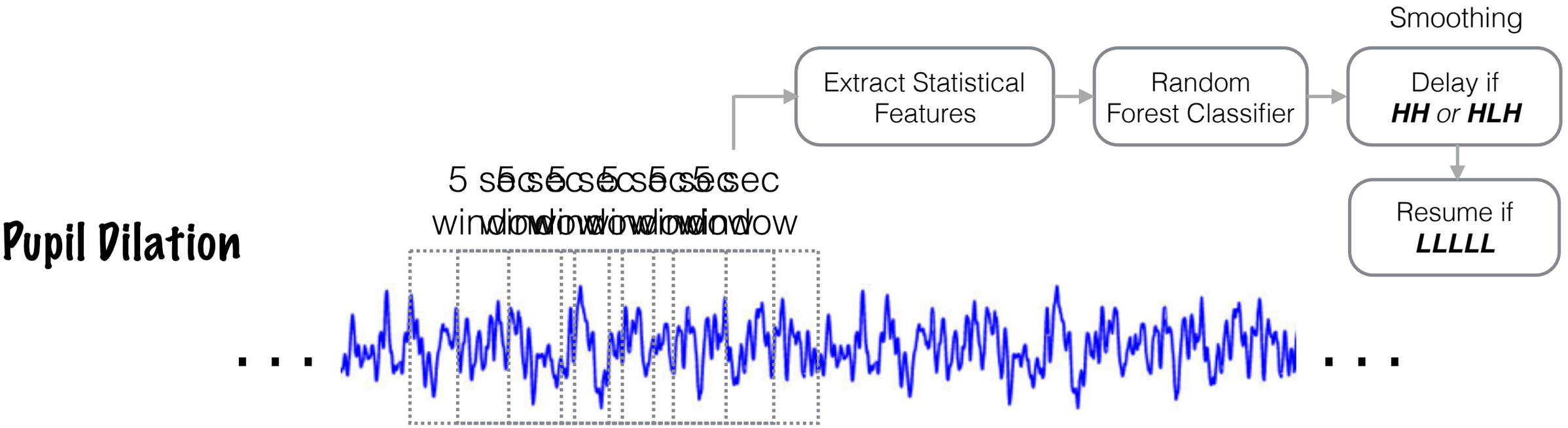
+

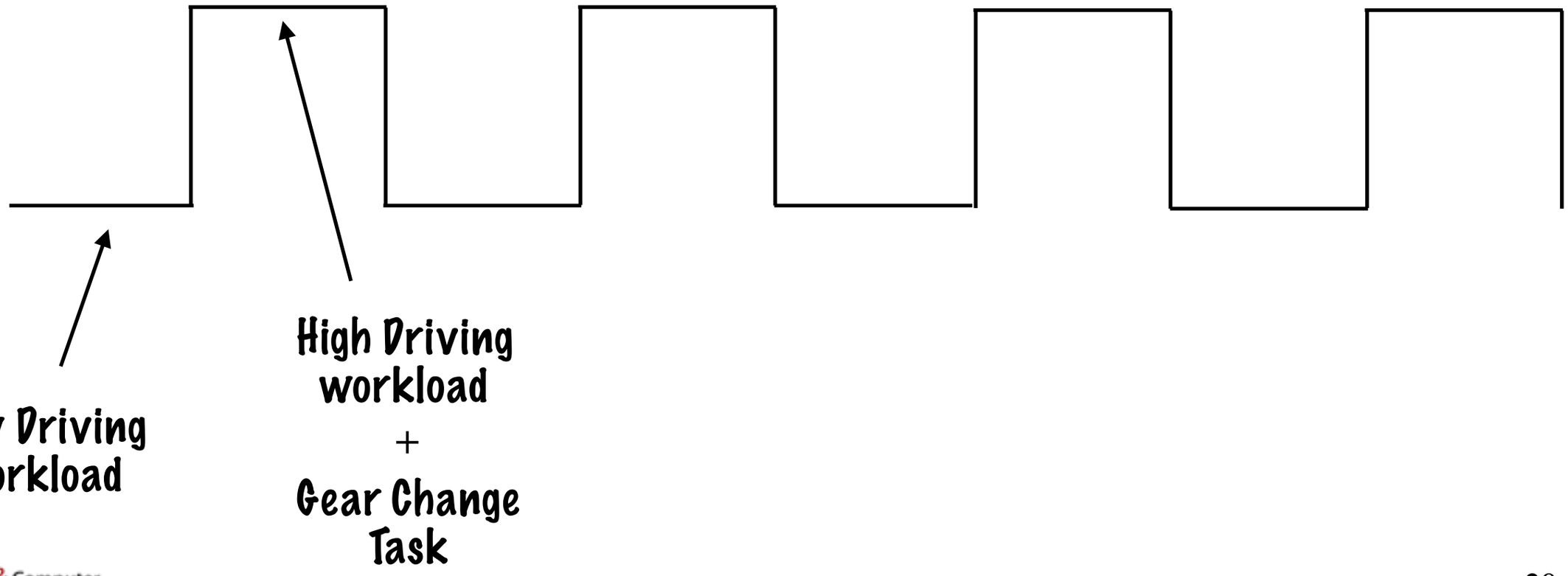
Gear Change Task



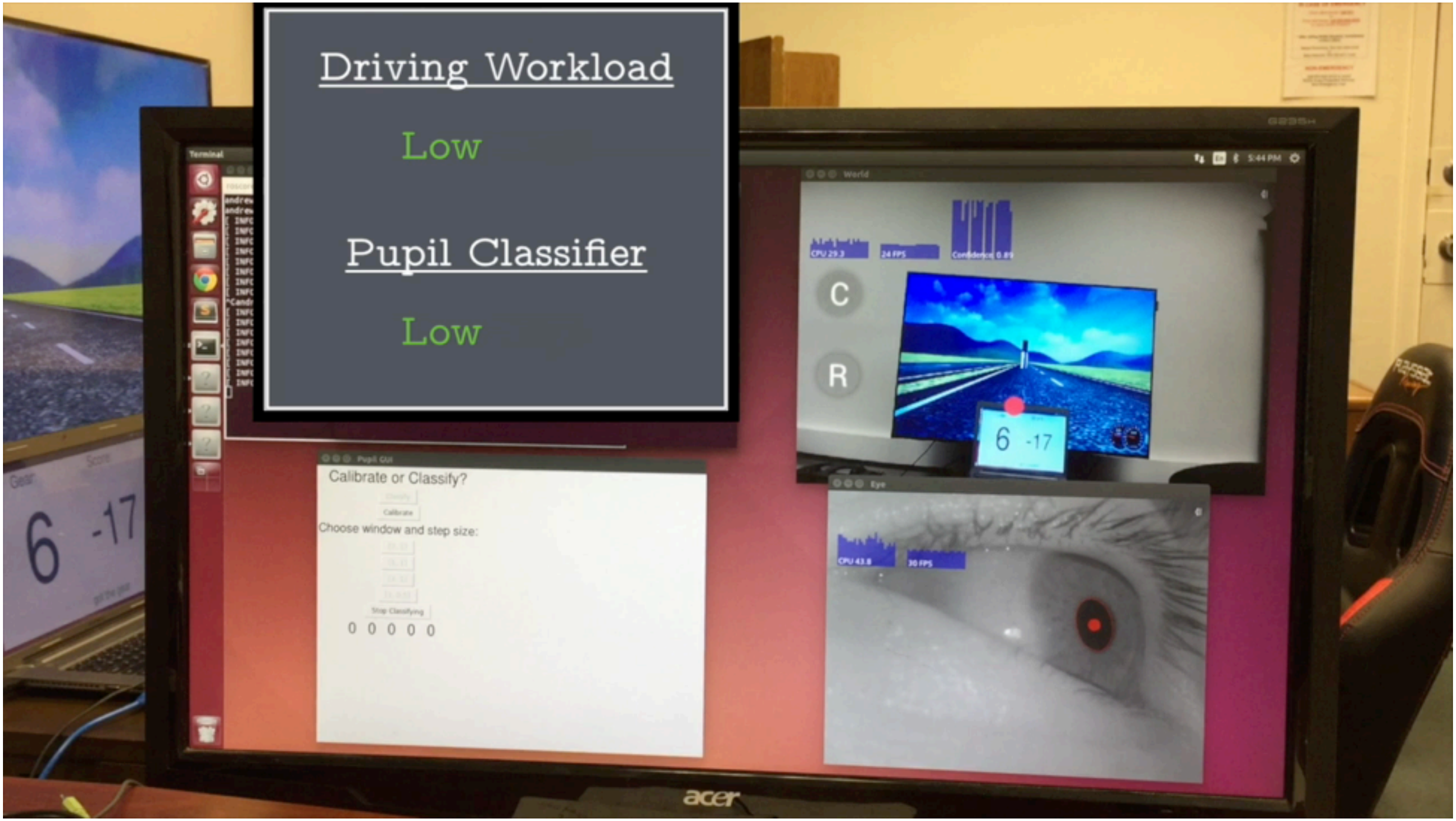
Low Driving workload

E2: Autonomous Mediation — *Algorithm*





E2: Autonomous Mediation — *Demo*



E2: Autonomous Mediation — *Study & Results*

- **User Study:**
  - Control: Non-mediated; Test: Mediated autonomously
  - 10 Participants
  - Within-subject; counter-balanced; repeated measures

- **Was mediating agent successful?**

  ★ **User performance:**
  - No significant difference in primary driving task
  - Significant difference in secondary gear changing task

  ★ **Agent performance:**
  - Accuracy was 63% (for HH or HLH)
  - If HHH pattern was used, accuracy would be 71%

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Conclusion

- **Problem:** Distracted driving from notifications
- **Goal:** Rapid task load estimation to mediate notifications
- **Experiment 1:**
  - Notifications are distracting regardless of modality
  - Simultaneously collected data to build models
  - Success with pupil dilation measures
- **Experiment 2:**
  - Demonstrated realtime autonomous mediation
  - Investigated user and agent performance

Questions?