Situated Interactions

Not meeting shared expectations
~ *inconsiderate*

→ Breakdown

Winograd & Flores

Research Question

How can we get multiple agents to interact without breakdown?

Effects of Mediating Notifications Based on Task Load

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Overview

- Problem Space

- Experiment 1: Are Notification Distracting?
  - Data Collection and Model Building

- Experiment 2: Autonomous Mediation
  - Model Validation

- Conclusion

Problem Space: Distracted Driving

http://exchange.aaa.com/wp-content/uploads/2013/06/Distracted-Driving-Teens-Cell-Phone-Use-AAA.jpg

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?

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E1: Are notifications distracting — *Exp. Design*

Primary Driving Task

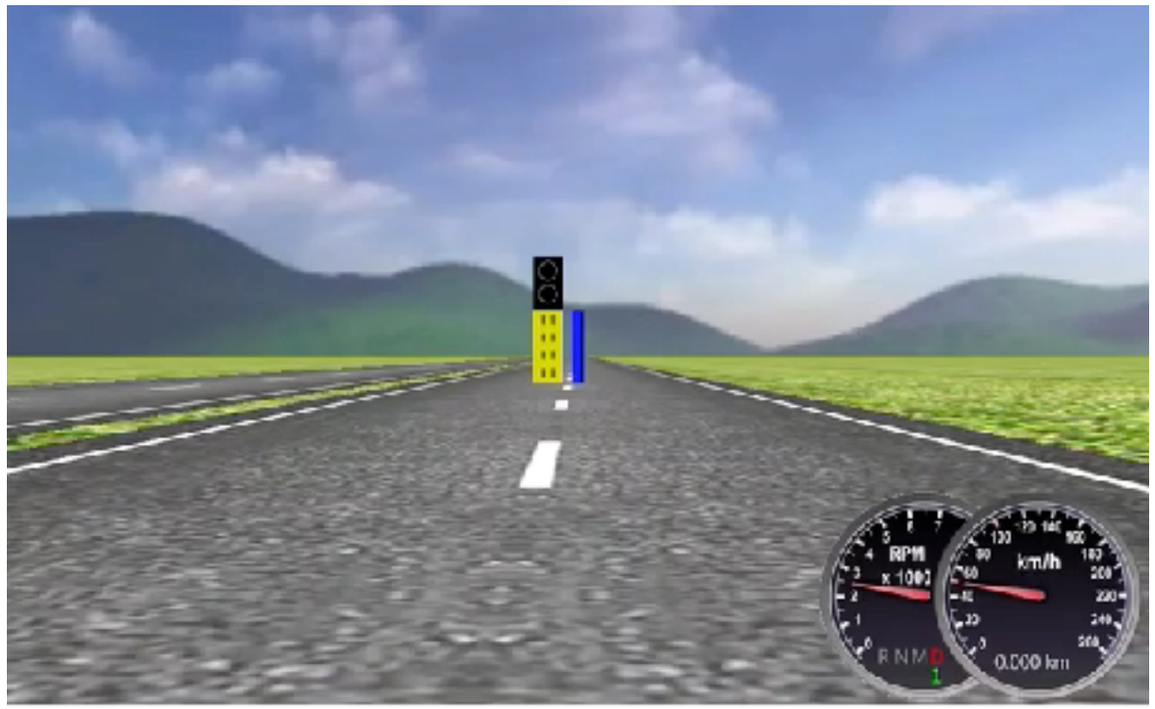
- Rapidly changing workload

Cruising vs. Merging/Pedestrians

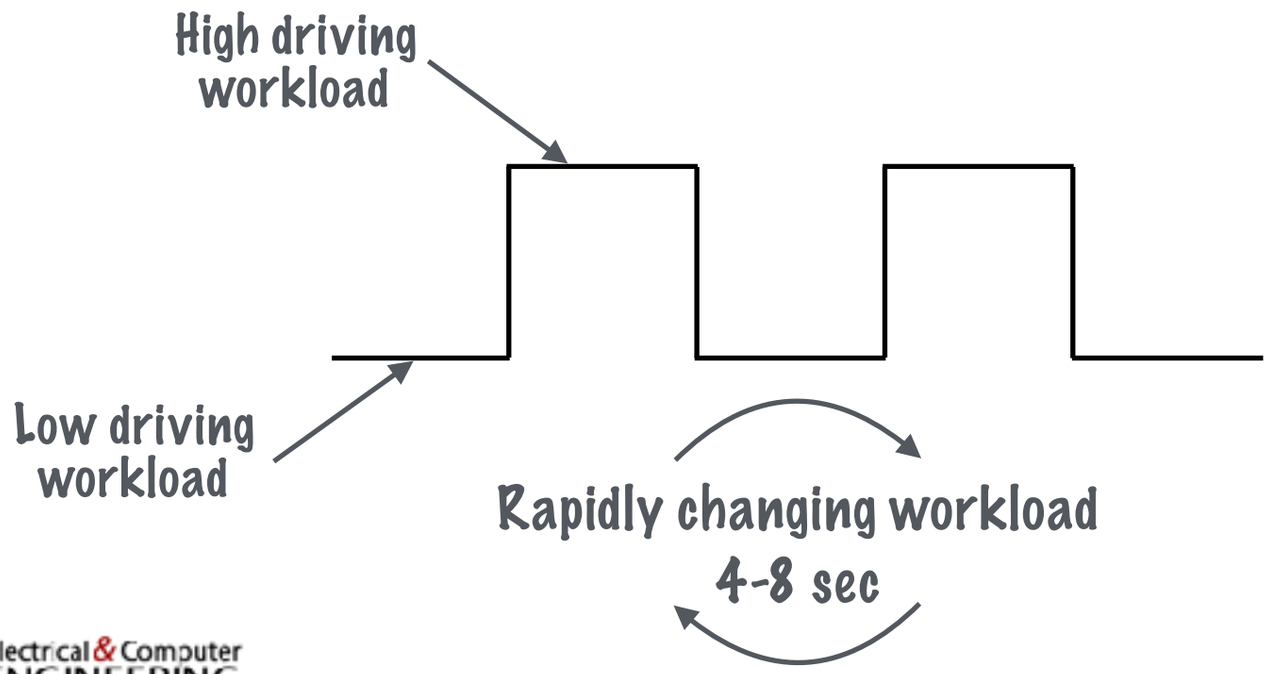
E1: Are notifications distracting — *Exp. Design*

OpenDS
ConTRe Task:

(Continuous Tracking and Reaction)



Mahr, A., Feld, M., Moniri, M. M., & Math, R. (2012). The contre (continuous tracking and reaction) task: A flexible approach for assessing driver cognitive workload with high sensitivity. AutomotiveUI, Portsmouth. ACM.



<u>Control Condition:</u>

Send notifications randomly *(non-mediated)*

<u>Test Condition:</u>

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)

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

Conway, A. R., Kane, M. J., Bunting, M. F., Hambrick, D. Z., Wilhelm, O., & Engle, R. W. (2005). Working memory span tasks: A methodological review and user's guide. Psychonomic bulletin & review, 12(5), 769-786.

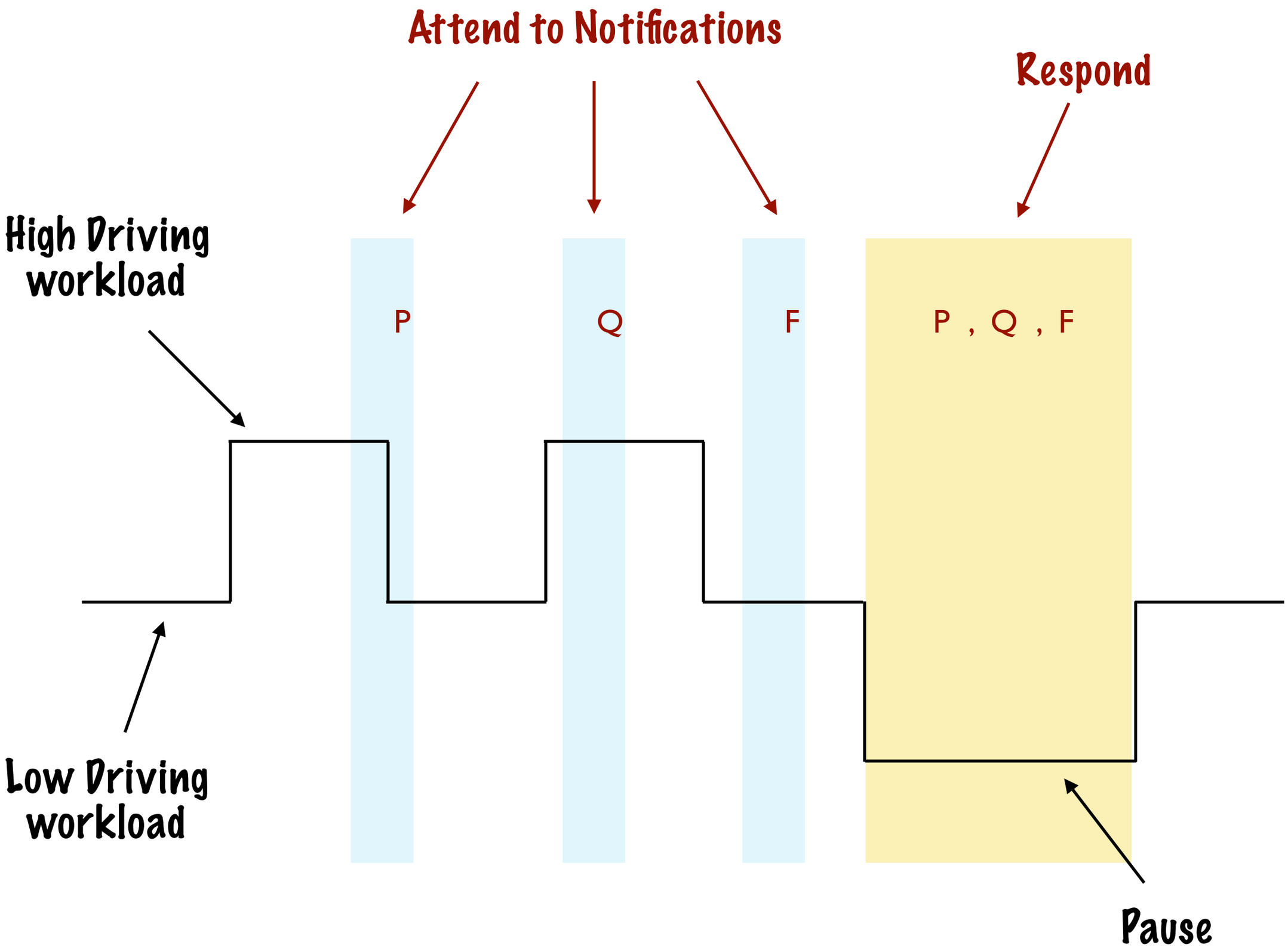
E1: Are notifications distracting — *Exp. Design*

Secondary Task: Complex Span (Reading & Listening)

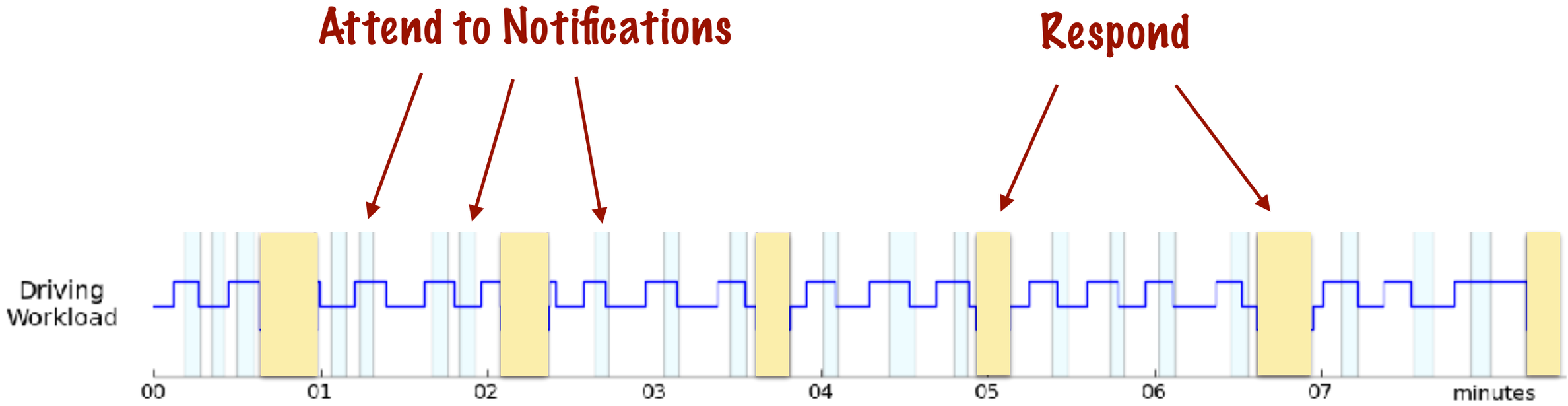
2/2 + 1 = 1	*False*	P
After yelling at the game, I knew I would have a tall voice	*False*	Q
3/1 + 3 = 6	*True*	F

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*

- **User 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

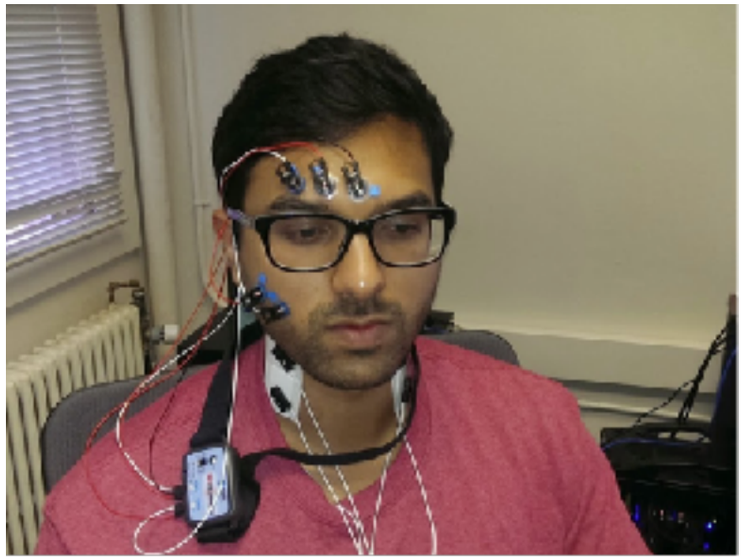
E1: Are notifications distracting — *Model Building*

Raw

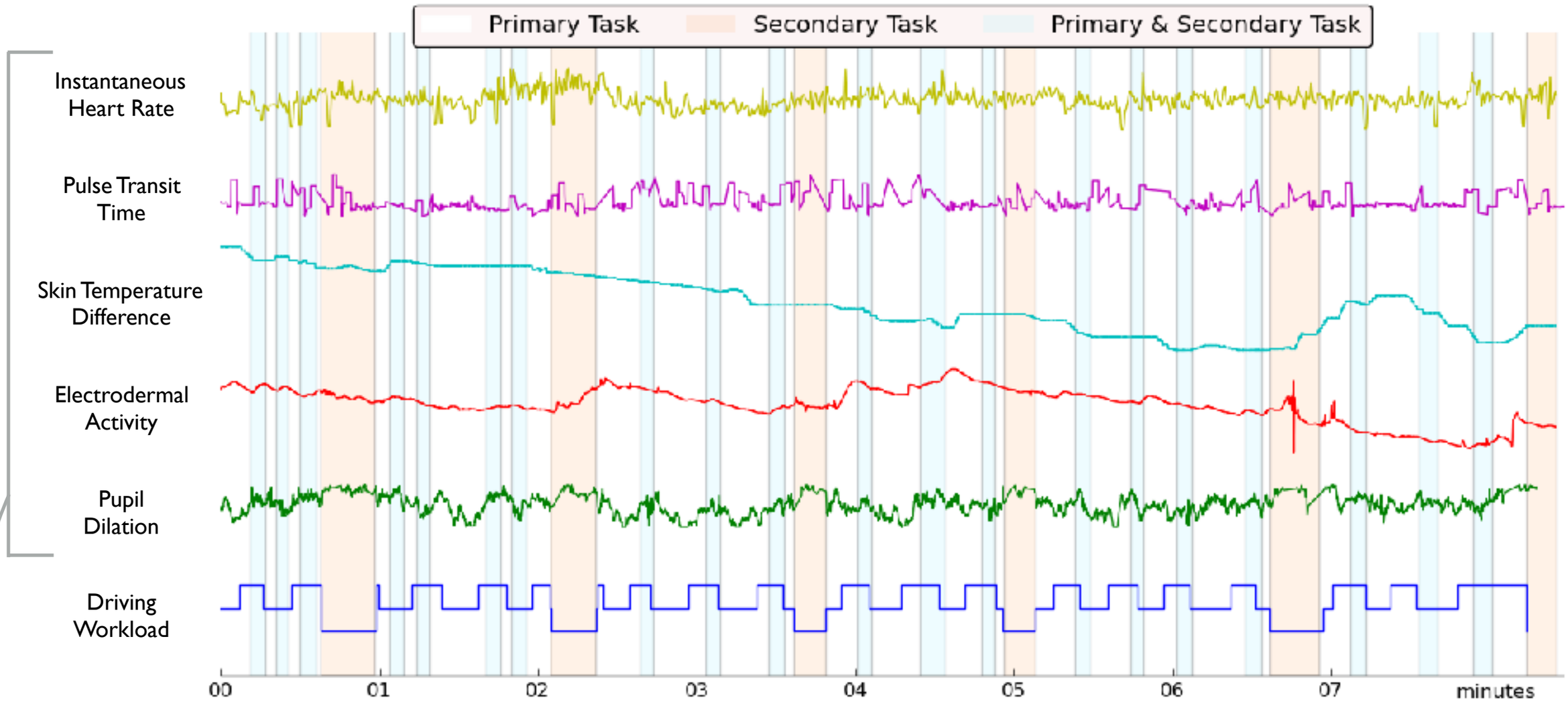
1. Electrocardiogram (ECG)
2. Photoplethysmograph (PPG)
3. Impedance Cardiography(ICG)
4. Respiration
5. Electrodermal Activity (EDA)
6. Skin Temp. Nose (SKT A)
7. Skin Temp. Cheek (SKT B)
8. Electromyography (EMG)
9. Pupil Dilation
10. Eye Gaze

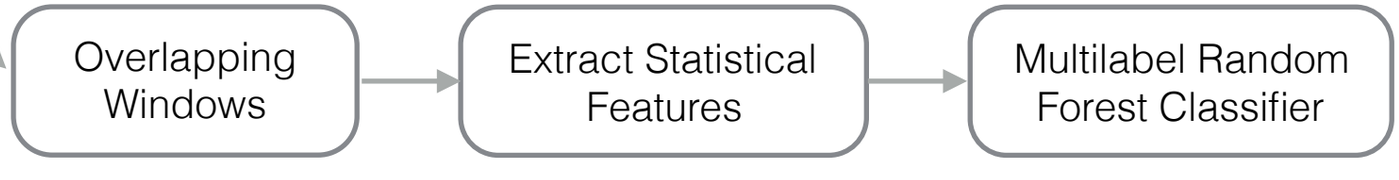
Derivative

1. Pulse Transit Time (PTT)
2. Inst. Heart Rate (IHR)
3. SKT B – SKT A (SKT)



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

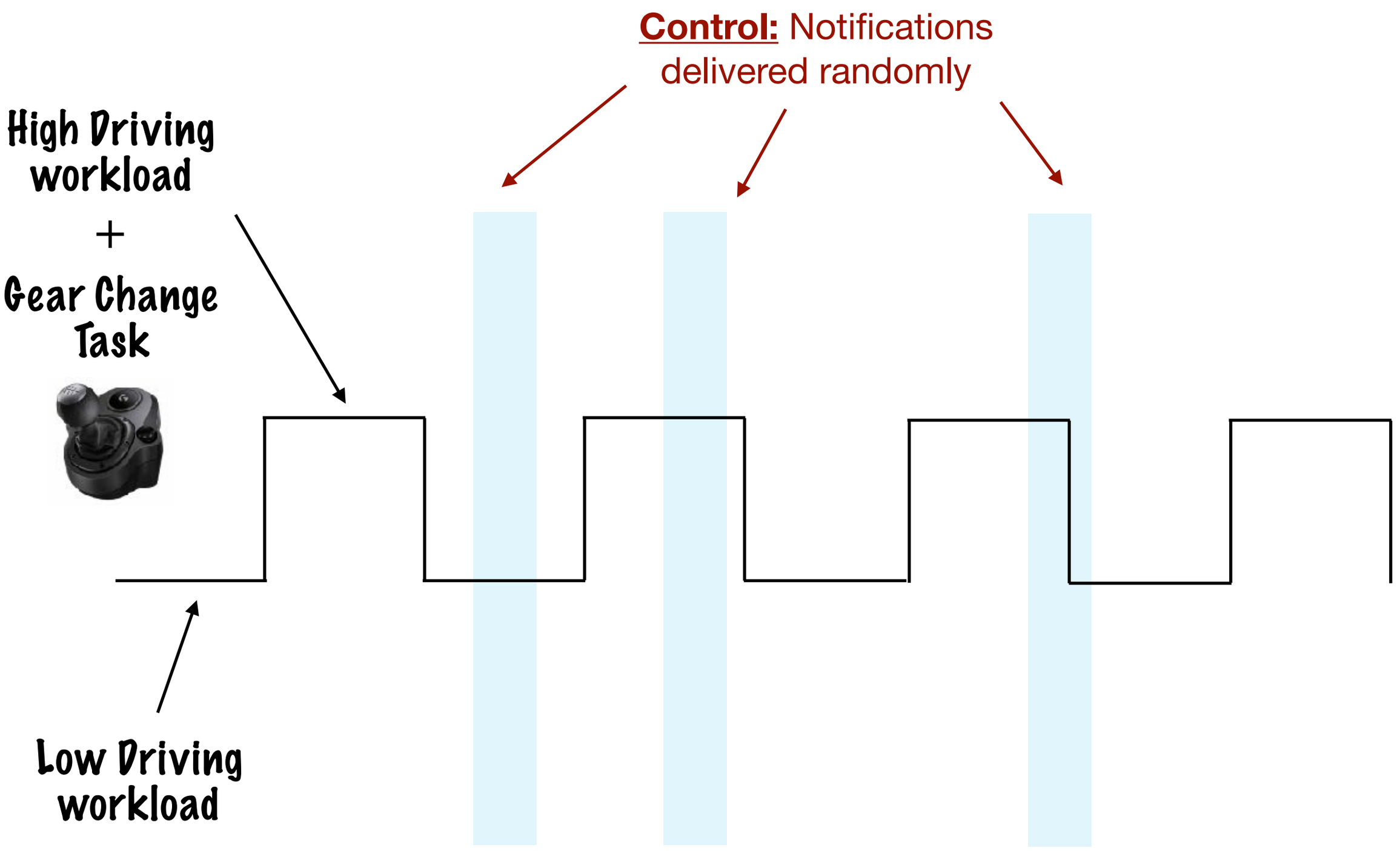
- Change gear to number displayed

Notifications

- Attend to *aural* notifications

2/2 + 1 = 1 *False*

E2: Autonomous Mediation — *Test Setup*



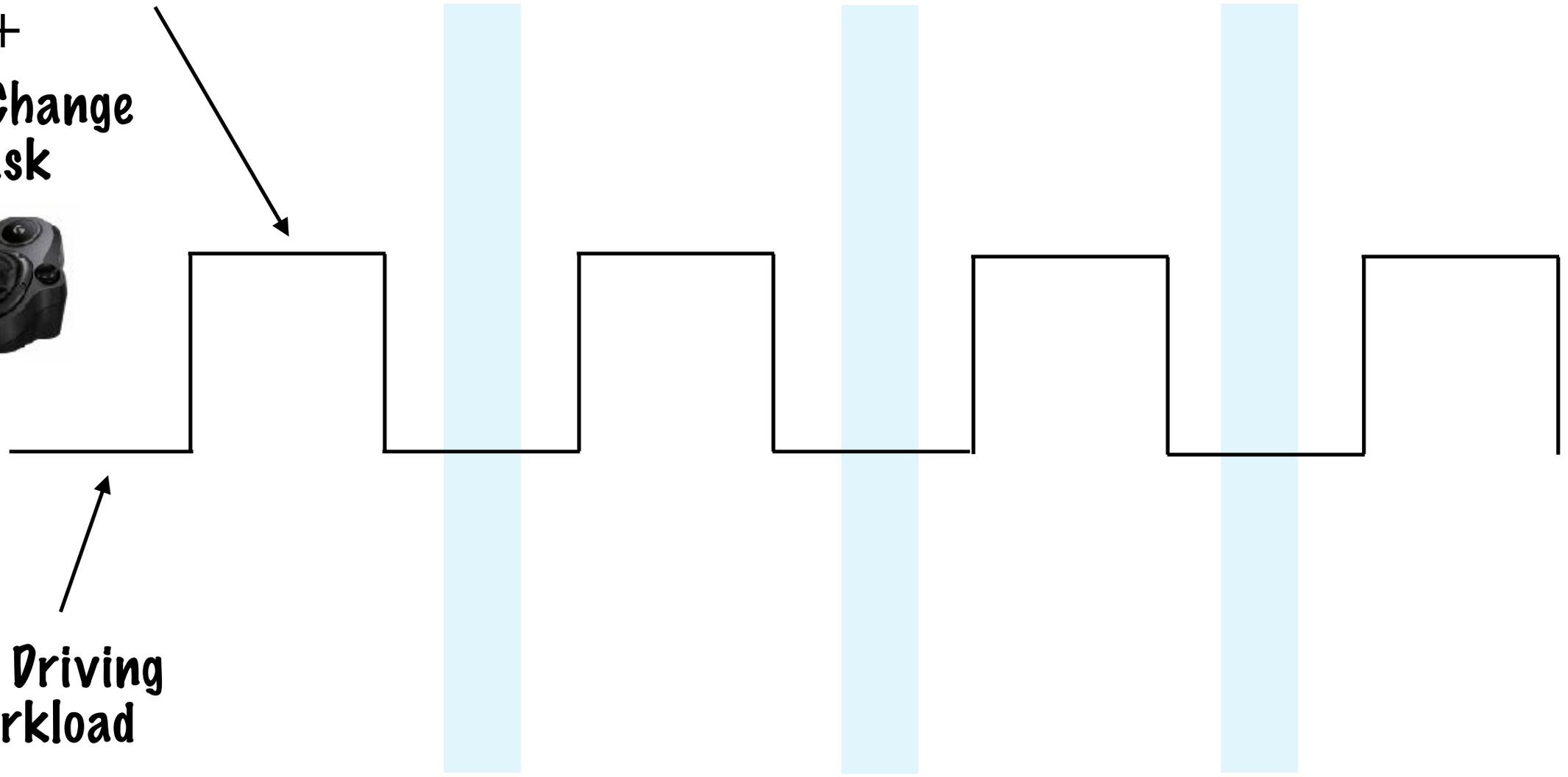
E2: Autonomous Mediation — *Test Setup*

Goal: Delay notifications till *low workload*

High Driving workload

+

Gear Change Task

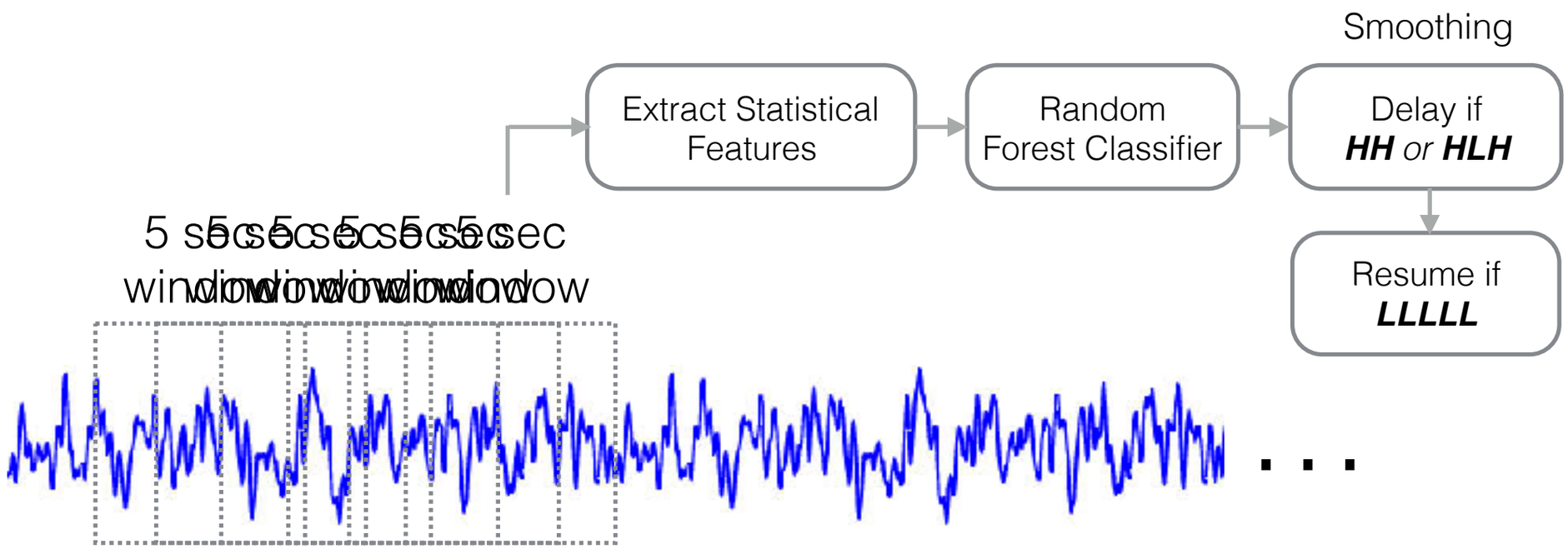


Low Driving workload

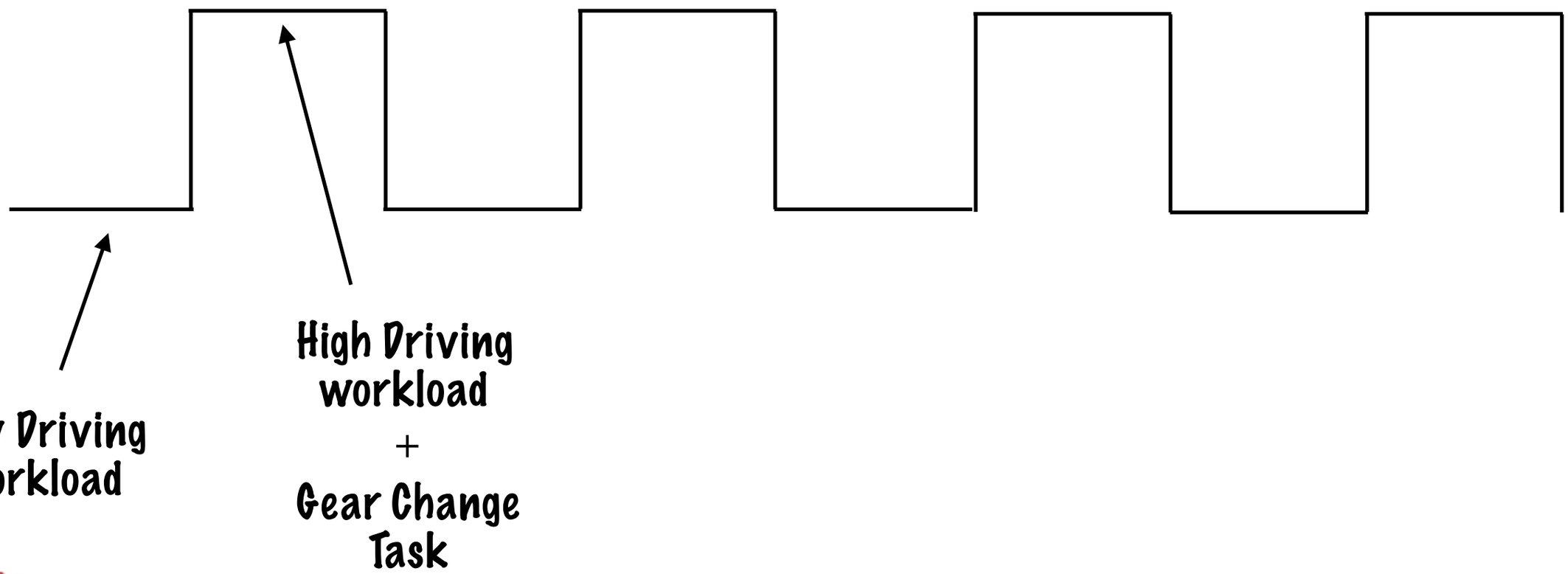
E2: Autonomous Mediation — *Algorithm*

Pupil Labs

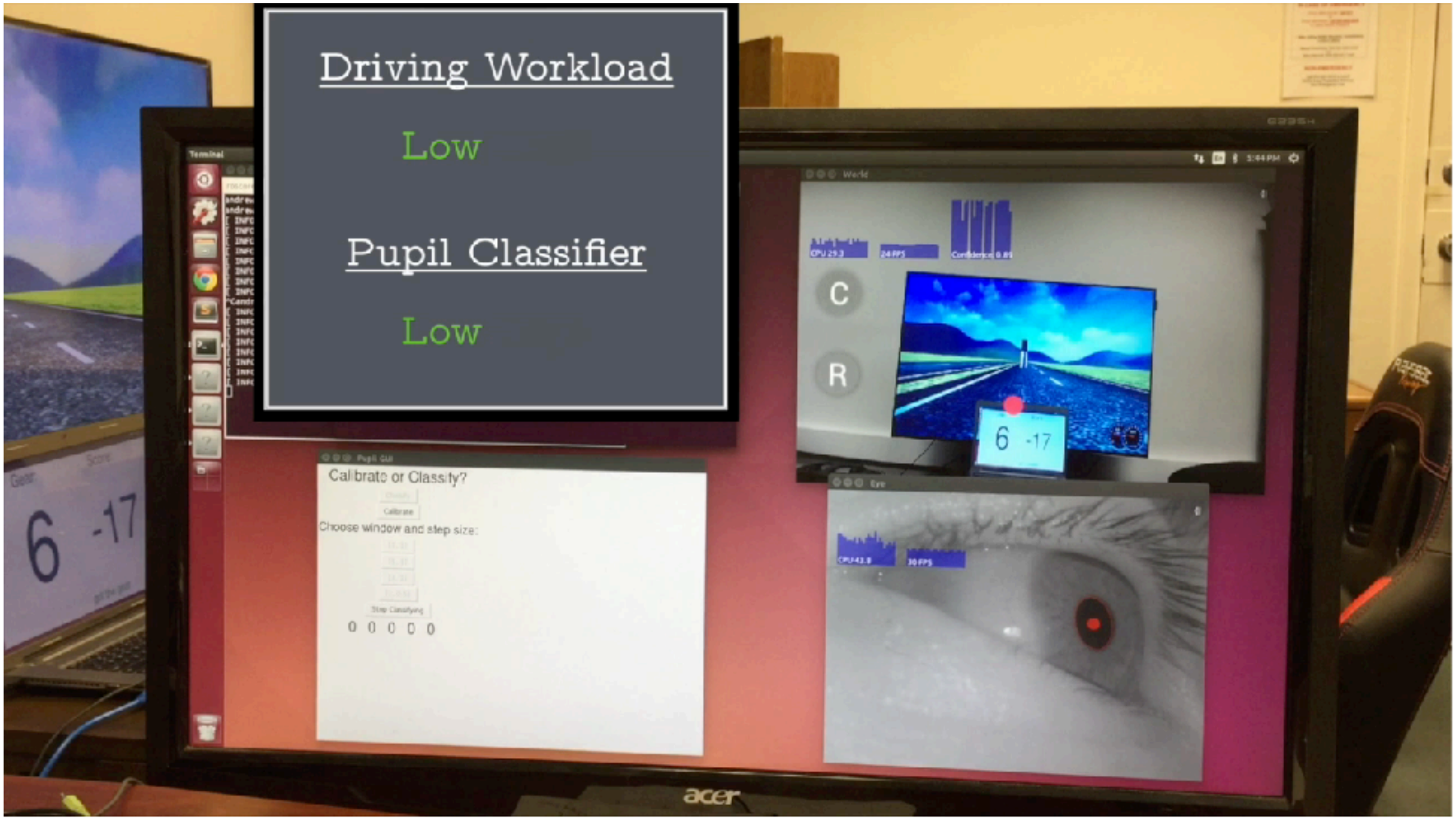
Pupil Dilation . . .



. . .



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:
    - Significant difference in secondary gear changing task, not in primary
  - ★ Agent performance:
    - Accuracy was 63% (for HH or HLH)
    - If HHH pattern was used, accuracy would be 71%

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Conclusion

- **Problem:** Notifications while driving
- **Goal:** Mediate notifications if distracting
- **Experiment 1: Are notifications distracting?**
  - Notifications are distracting regardless of modality
  - Simultaneously collected data to build models
  - Success with pupil dilation measures
- **Experiment 2: Autonomous mediation**
  - Demonstrated realtime autonomous mediation
  - Showed improvement in user performance
  - Analyzed agent performance

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Backup

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