UCDAVIS
PLUG-IN HYBRID & ELECTRIC VEHICLE RESEARCH CENTER

Large Sample Ecodriving Experiment Preliminary Results

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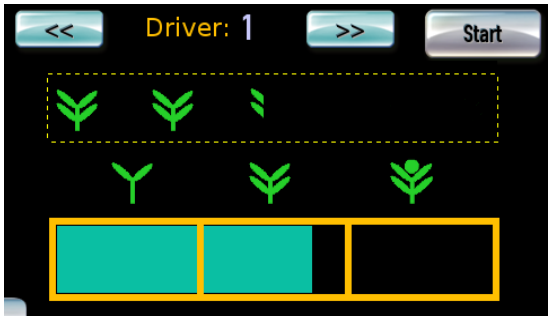
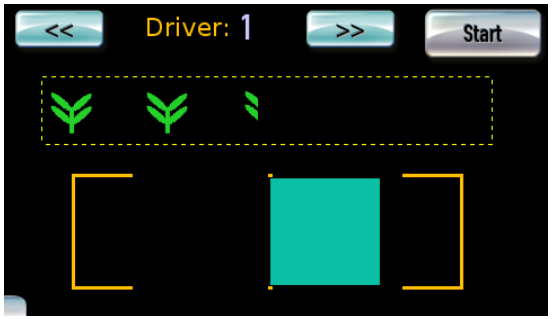
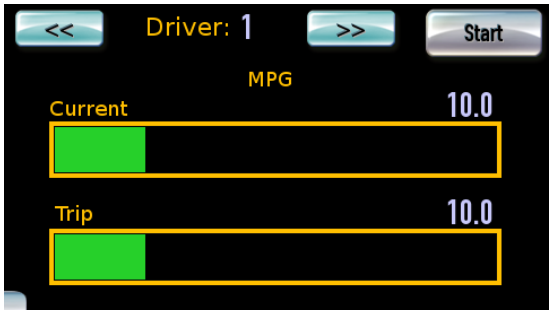
Summary

- A study of 3 driver feedback screens
  - One-month periods
  - Average 5.8% improvement
  - Range 4-7% improvement by screen type

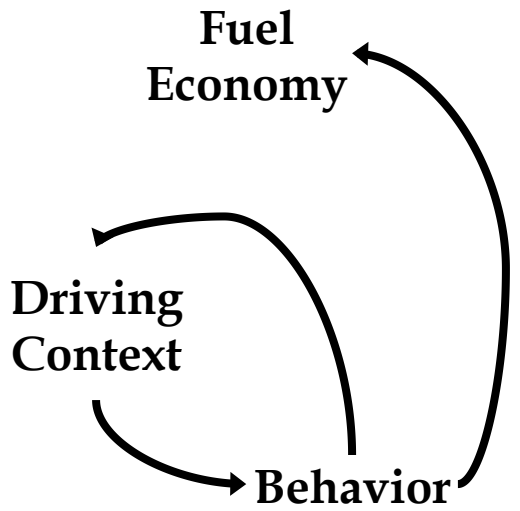






The HMI Feedback Loop

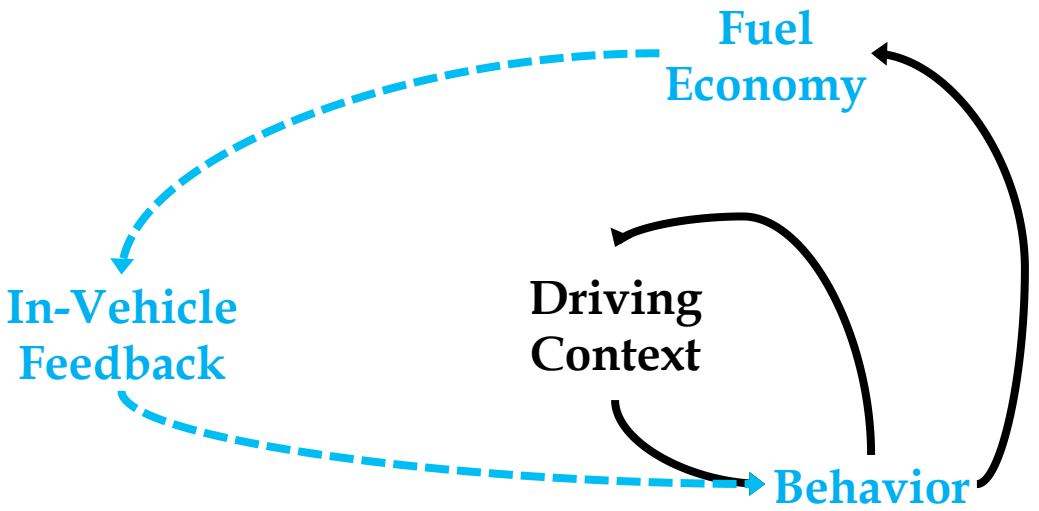
❶Context
❷HMI points of influence



A Broken Feedback Loop

The HMI Feedback Loop

❶Context
❷HMI points of influence



h0 : Feedback !-> MPG improvement

Past PH&EV Center Projects With Eco-driving Feedback

❶2009 Scangauge field test

(~6 drivers, 6 months).

❶

❷2008-9 Prius field test with V2Green Gridpoint website

(~60 households, 1 month each).

❷

Energy Monitor and Consumption screens of Prius. Accessed through "Info" button.

❸2009-10 UC Davis custom HMI

(~40 drivers, 1 month each)

❸

Notes on Methodology

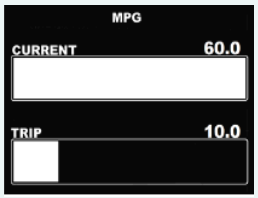
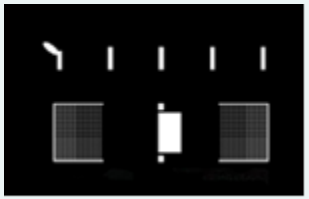
- Experimental design:
  - Natural driving
  - Avoid social biases
  - Randomization
  - Supplement measurement with surveys and interviews
  - Individual specificity

Notes on Methodology

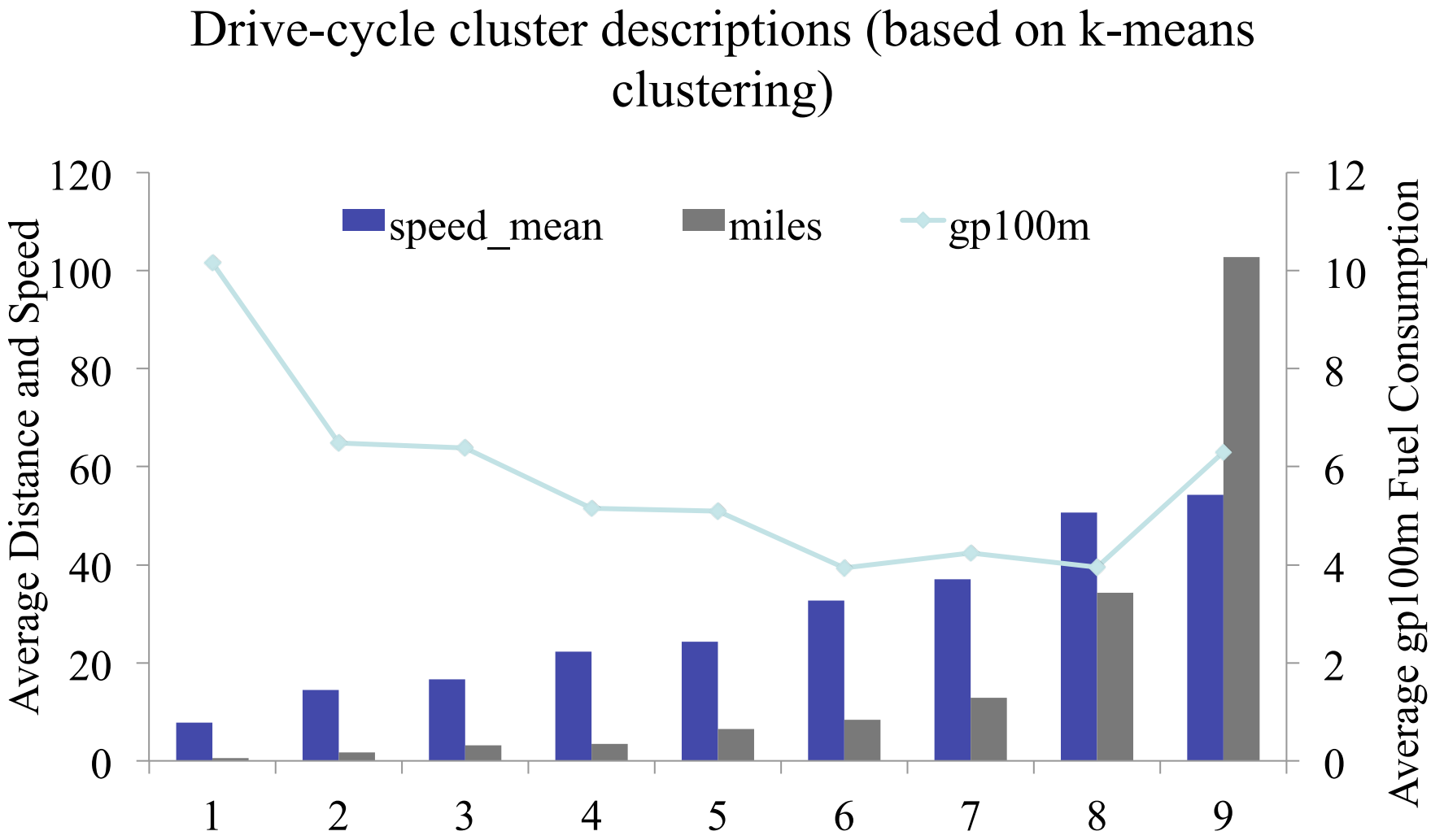
- Analysis
  - Model-based analysis
    - Presumes trip-patterns are constant – looks for changes within trip types
    - Mixed-effects models makes individual-level estimates using trips as repeated observations
    - Predictive model trained on baseline driving predicts neutral outcome in treatment phase based on trip-specific factors.
      - Prediction residual = behavior change + error.
      - Primary model factors are distance, drive-cycle, weather (temperature), vehicle

Ecodrive I-80 Study

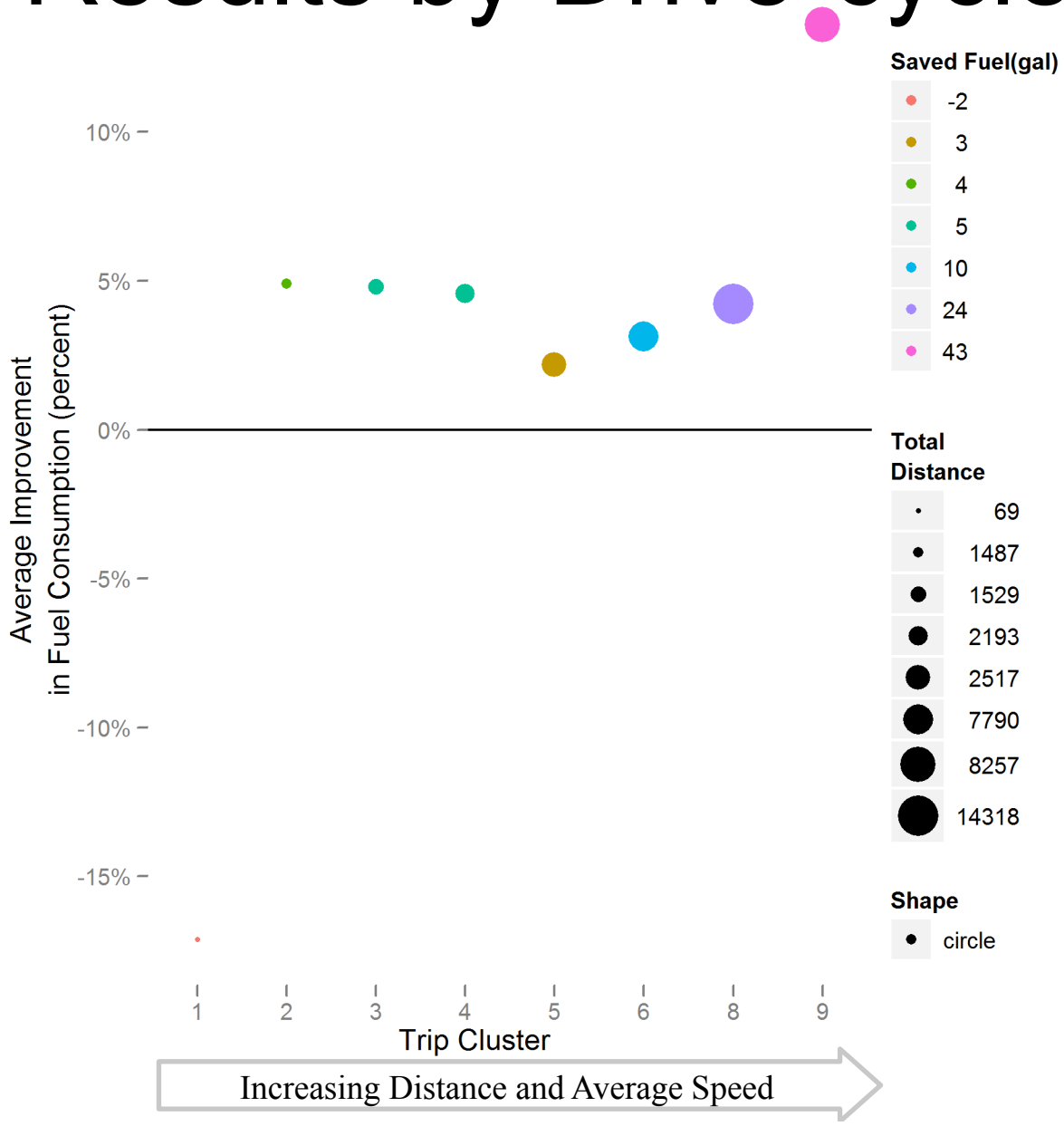
- ORNL/DOE Study of 150 drivers along the San Francisco-Reno I-80 Corridor ending in early 2013.
  - Internal Controls based on 1 month off/on design
  - Experimental Comparison of three feedback metrics developed from NHTSA*:
  - Currently 72 drivers, 95,000 miles in 3000 hours of driving.

Direct Fuel Economy Value	
Symbolic "Leaf" representation	
Acceleration level	

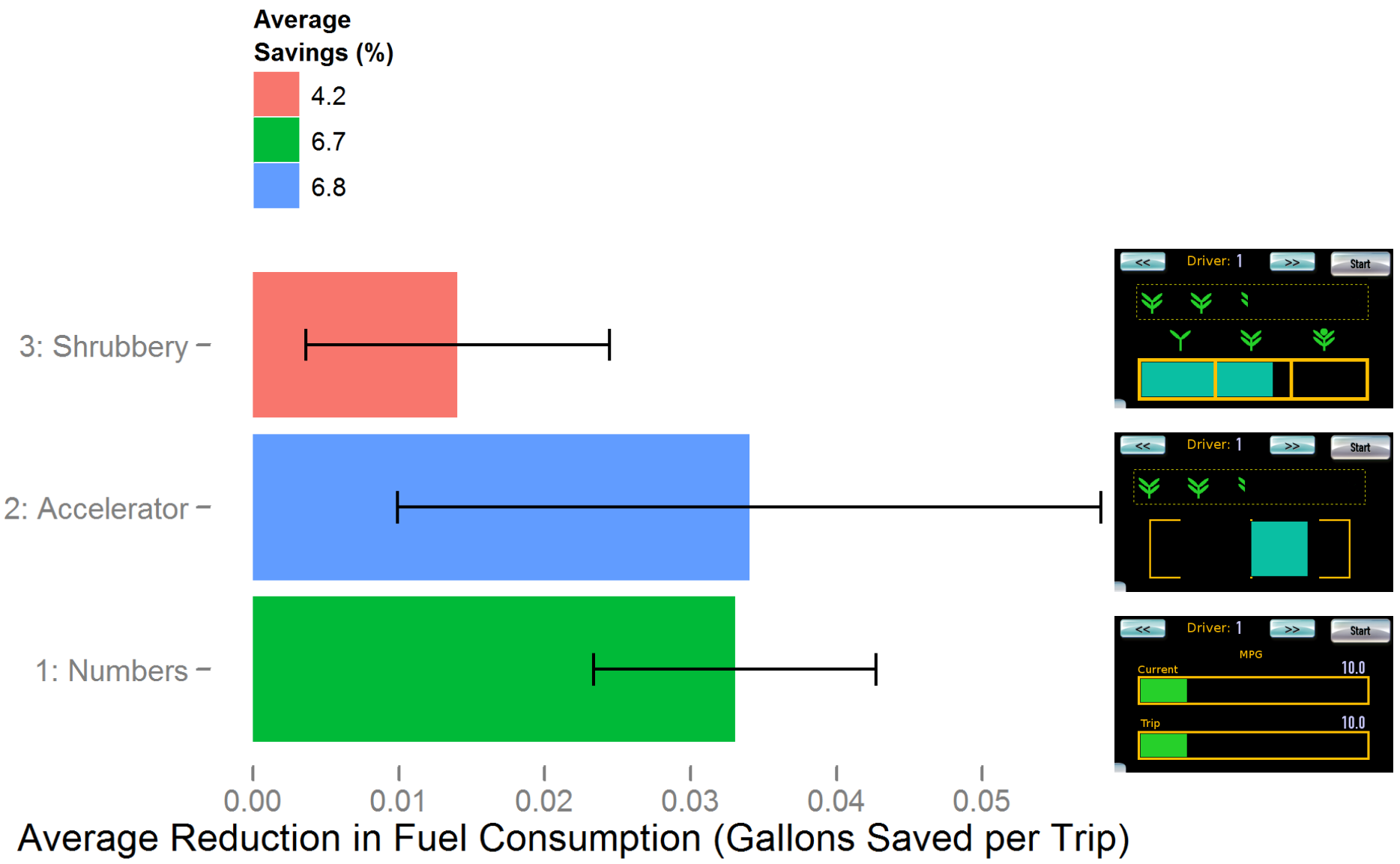
Trip-types


Drive-cycle cluster descriptions (based on k-means clustering)
speed_mean
miles
gp100m
Average Distance and Speed
Average gp100m Fuel Consumption
120
100
80
60
40
20
0
12
10
8
6
4
2
0
1
2
3
4
5
6
7
8
9

Results by Drive-cycle



Results by Interface Design



Conclusions

This is a 50% dataset

- Feedback has a significant influence on consumption
  1. Large variation by trip-type - low efficiency trips have higher effects
  2. Moderate variation by interface style (50% improvement between interfaces)
  3. Average reduction of 5.8% overall in 38k miles of driving with the interface on.

Future Directions

- Investigating changes over time, and mechanisms to keep drivers engaged
- Collaborations with municipal agencies (carbon reduction strategies)
- Inclusion of behavioral strategies into state/ federal policy

Thank you.
Questions?

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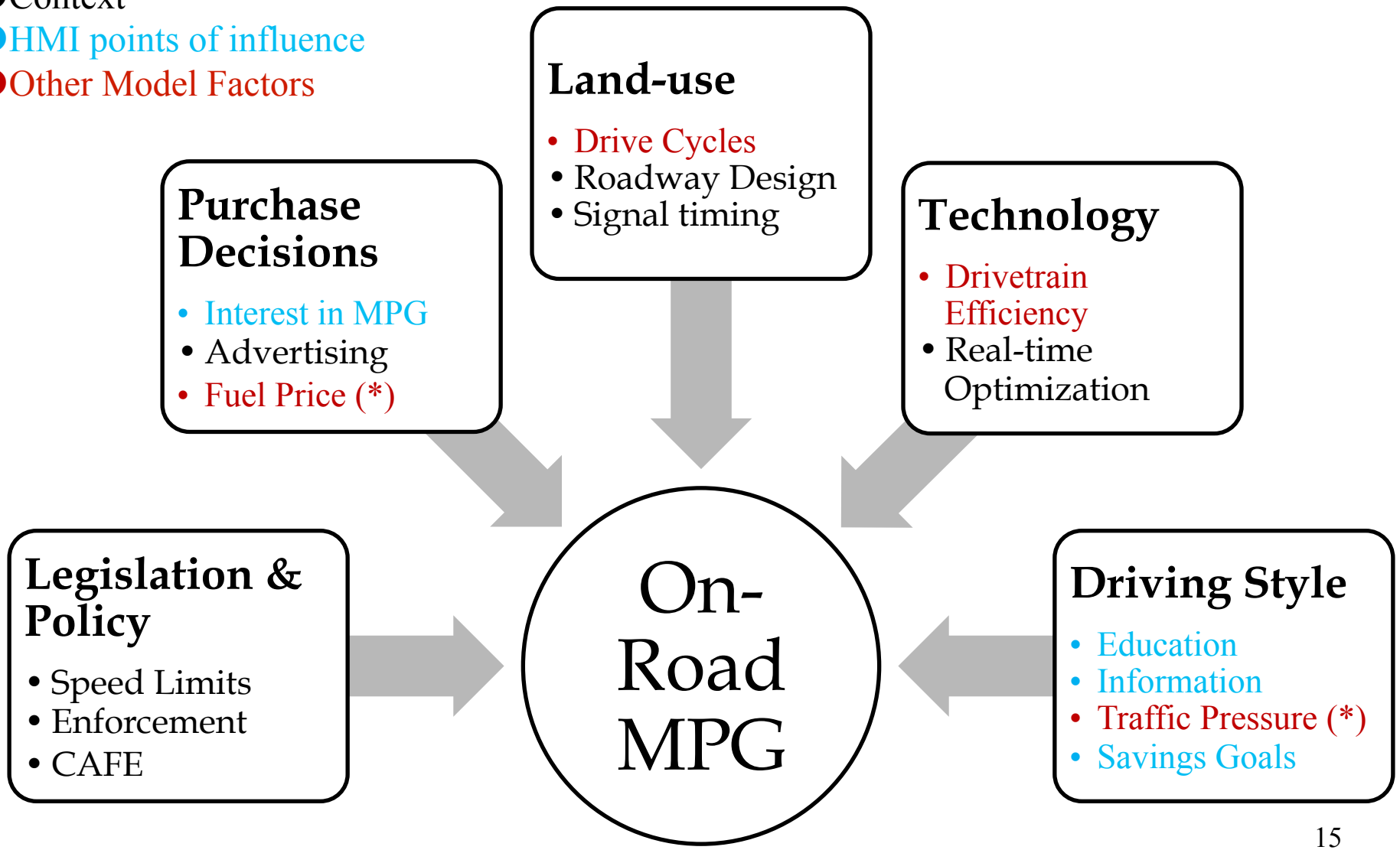
Acknowledgement:
DOE/Oak Ridge National Lab
UC Sustainable Transportation Center
AAA Northern California

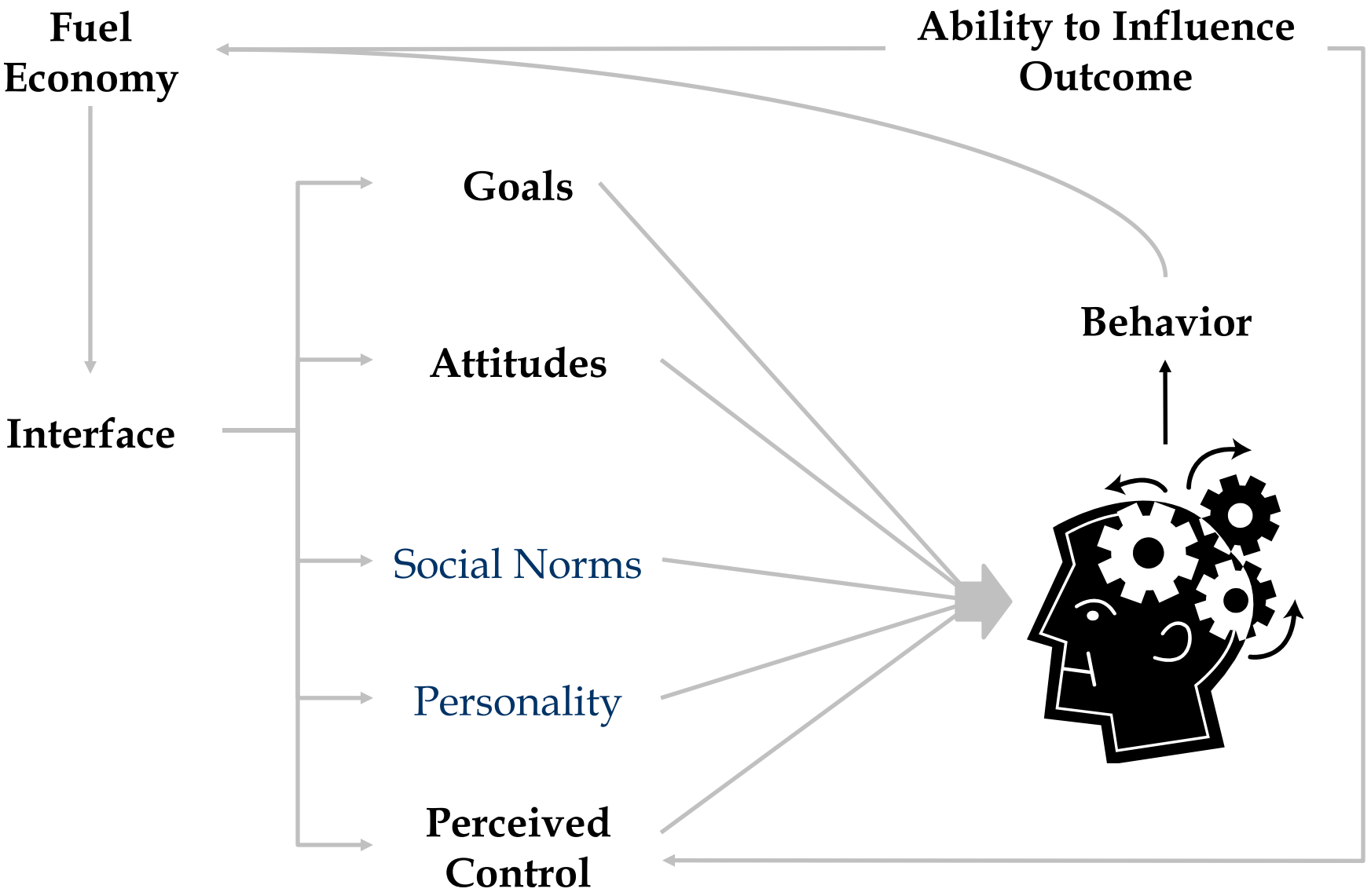
Fuel Economy in Context

❶Context
❷HMI points of influence
❸Other Model Factors



(*) Not currently in the driving model

Applied Behavioral Model (TPB, EMGDB)



Upcoming MTC 'Smart Driving' Study

- MTC-funded study of 250 Bay Area drivers for 1 year.
  - Safety + Efficiency
  - Real-time dashboard extensions using Android phones
  - 4 distinct feedback designs to be tested
  - Remote data collection

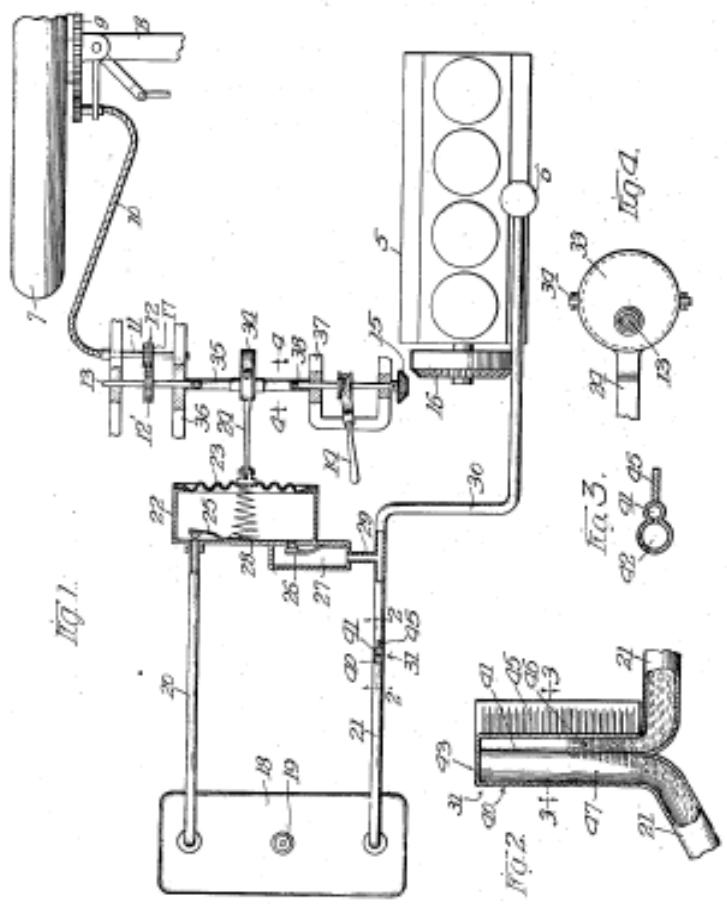
Predictive Model Code

- Using R
- Packages: nlme, ggplot2
- Estimated a Random effects model using the person-vehicle unit as the grouping factor

```
168
169     p0 <- clustData[clustData$phase=="p0" & clustData$miles >0.25  & clustData$grade < 1  & clustData$grade >-
        1,]
170     p1 <- clustData[clustData$phase=="p1" & clustData$miles >0.25  & clustData$grade < 1  & clustData$grade >-
        1,]
171
172         lmep0 <- lme(gp100m ~abs(72-temp_est)+as.factor(trip) + grade,data= p0, random=~1|as.factor(combo))
173             summary(lmep0)
174                 p1$gp100m_p <- predict(lmep0,p1)
175                     p1$gp100m_r <- p1$gp100m-p1$gp100m_p #predicted savings (negative residual = saved gp100m)
176                     summary(p1$gp100m_r)
177
```

The First Real-Time Feedback Device - 1915

Early mechanical MPG indicator designed for vehicle maintenance and fuel quality concerns.



For example, the driver of a motor car can tell by a glance at an indicator on the dash whether his car is operating at its normal rate of eighteen miles per gallon of gasolene, or at only fifteen miles per gallon, which latter reading would instantly tell him that some condition of operation required attention. For instance his last supply of gasolene might have been of a poor grade, the carbureter might require adjustment, the valves need grinding or some other part require attention that would cause a lowering of the fuel efficiency of the engine.