ACTUAL RESULTS WILL VARY

Ken Kurani

Angela Sanguinetti

Hannah Park

Graphics by Suhaila Sikand

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**National Center
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Transportation**

FIVE QUESTIONS

1. Why eco-driving?
2. What are eco-driving behaviors?
3. How much do they save?
4. How are they promoted?
5. What is a policymaker to do?

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1. WHY ECO-DRIVING?

- **Social Goals**
  - Fuel economy
    - U.S. Corporate Average Fuel Economy (CAFE) standards
  - Emissions: Clean air and climate
    - Local attainment plans
    - Zero emission vehicle credits
  - Safety
    - Social cost of traffic accidents
- **Private Goals**
  - Private cost: Fuel, accidents
  - Self-identity: Efficient, thrifty, environmentally-conscious

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2. WHAT ARE ECO-DRIVING BEHAVIORS?

Premise: Behaviors excluded by US CAFE test procedures

- Sources of variation in "Actual results will vary"?

- What do we mean by "behavior"?
  - A behavior analytic approach
    - *Function*: its effect/what it does (most important)
    - *Topography*: its observable form/what it looks like
    - *Context*: who emits the behavior, when, and where

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CATEGORIES OF ECO-DRIVING BEHAVIOR

Category	Function: Why	Topography: What	Context: Who, when, where
Driving	Operate the vehicle to provide mobility services	Accelerating; cruising; decelerating; waiting; parking	Driver, en route, in-vehicle
Cabin Comfort	Comfort, communications, entertainment	Using HVAC, windows, auxiliary electronics	Driver and passengers; en route; in vehicle
Trip Planning	Routing from point A to point B	Selecting travel routes and time (road type, grade, right turns, congestion, trip-chaining	Driver; pre-trip and en route; in vehicle
Load Management	Be prepared for cargo and passengers	Managing cargo weight and aerodynamics (racks, etc.)	Driver or surrogate; pre-trip; home
Fueling	Fuel vehicle	Selecting fuel; preventing evaporation; PEV charging (frequency, level, and source)	Driver or surrogate; pre-trip(s); gas or charging station
Maintenance	Maintain vehicle	Changing oil; selecting oil; inflating tires; selecting tires; getting engine tuned	Driver, surrogate, or professional; intervals based on use; auto shop

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$$I = \sum_k (t_k * p_k n_k)$$

I = impact
t = technical potential (savings impact of the behavior)
p = behavioral plasticity: proportion of population that can be induced to take the action
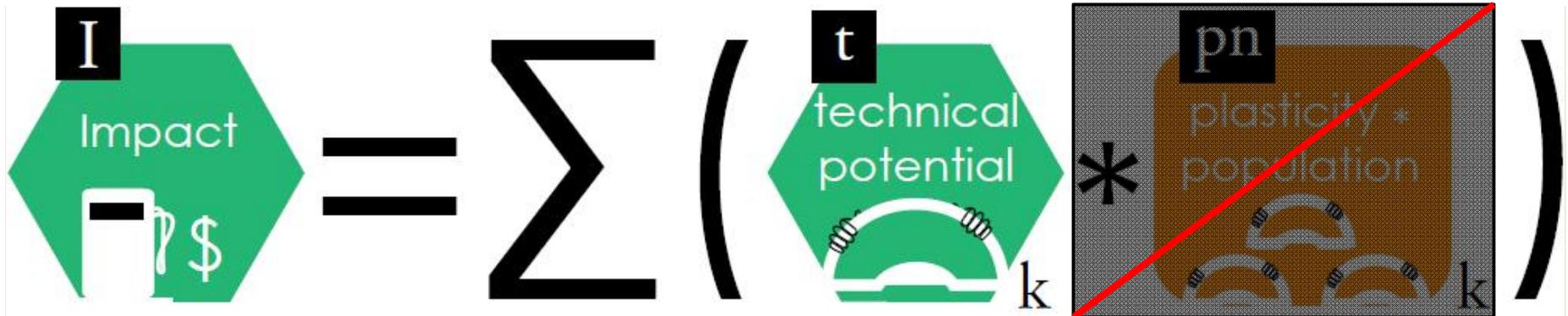n = total population that could possibly take the action
k = each eco-driving behavior

Adapted from Stern, 2011, *American Psychologist*

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HOW MUCH CAN ECO-DRIVING SAVE?

$$Impact = \sum \left(technical\ potential_k * plasticity * population_k \right)$$

Sivak and Schoettle, 2012, *Transport Policy*
- Estimates *technical potential (t)* for multiple behaviors ($k > 1$)
- *Neglecting* eco-driving = 45% *decrease* in fuel economy
  - Most influential behaviors: ***Driving***
    - "Aggressive driving"
      - Including frequency + intensity of pedal use; not using cruise control
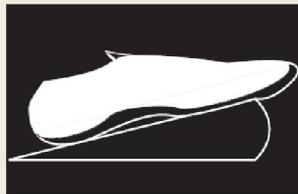 - Cruising speed (particularly excessively high speeds)

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HOW MUCH CAN ECO-DRIVING SAVE?

Our review of 40 empirical studies of eco-driving, *driving behavior*
- Average impact of eco-driving interventions = **9%** increase in fuel economy
  - Estimate better reflects *plasticity*, but only for a subset of behaviors (k)
    - Three most commonly measured (variously operationalized):
      1. Accelerating 2. Cruising 3. Decelerating

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HOW MUCH CAN ECO-DRIVING SAVE?

$$Impact = \sum \left(technical\ potential_k * plasticity * population_k \right)$$

The path to better savings estimates
- Define and measure eco-driving *behavior*!
  - 32/40 studies measured fuel economy
  - Only 24/40 studies measured behavior
- Define and measure eco-driving behaviors consistently across studies
- More research on network level impacts in different contexts
 - Alam & McNabola, 2012, *Transport Policy*

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4. HOW IS ECO-DRIVING PROMOTED?

- Most research targets **_driving_** behaviors
- Most common strategy: In-vehicle feedback
  - 27/40 studies reviewed
    - Average 5.6% improvement in fuel economy
- Other strategies include:
  - Training
    - In-vivo coaching
    - Verbal instruction

ECO

eco level

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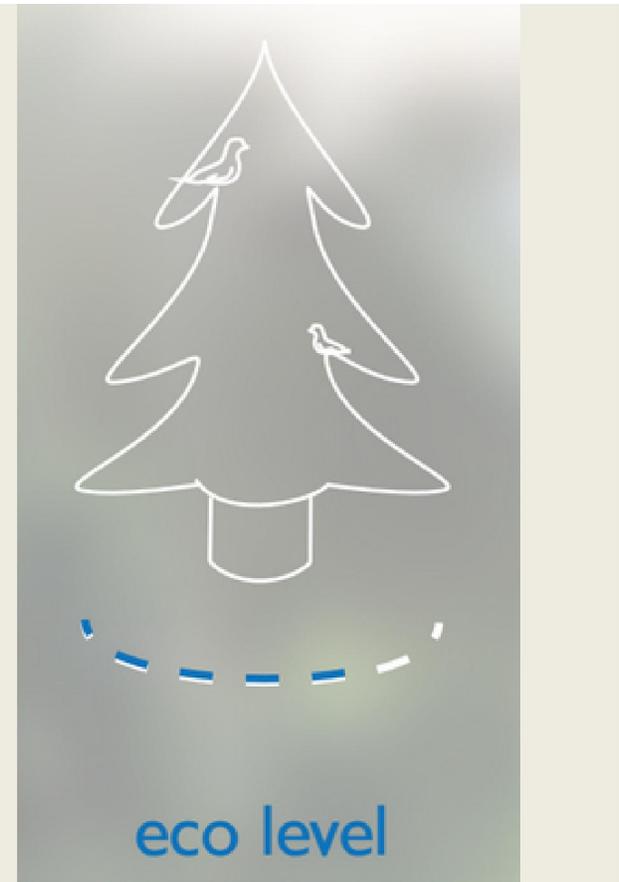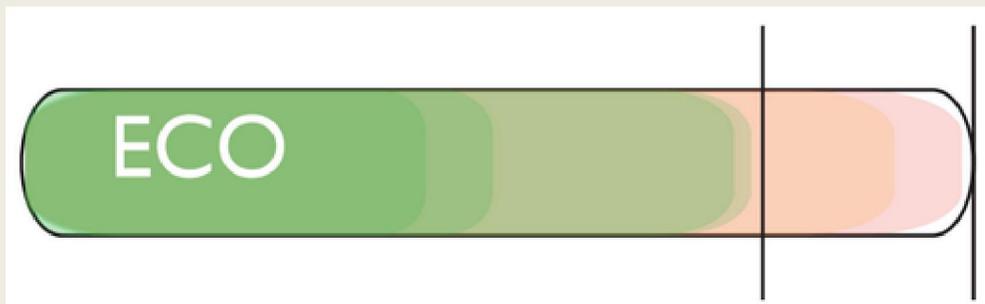
HOW IS ECO-DRIVING PROMOTED?

- Feedback is more effective when it:
  - aligns with driver's goals, e.g., to get around faster, save money, etc.
  - is adaptive, becoming more challenging as the driver progresses
- Other influential features include:
  - specificity of targeted behaviors
  - mode of interface, e.g., haptic or visual
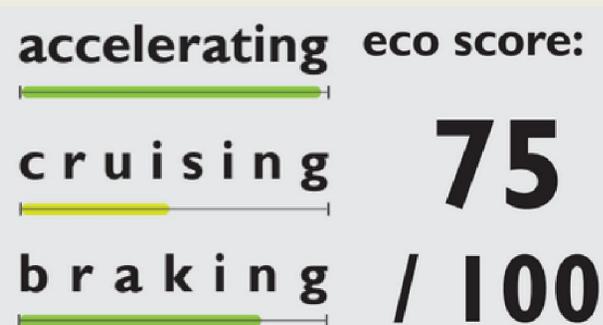
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HOW IS ECO-DRIVING PROMOTED?

The path to more effective eco-driving feedback

- Meta-analysis of literature
- Systematic comparative research
  - Findings from the few comparative studies are singular
  - Map well-defined behaviors onto well-defined feedback types
    - Most studies are devoid of behavioral theory (re: design and measurement)
    - Address for whom and in what contexts feedback works for which behaviors
- Assessment of commercially available in-vehicle feedback

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5. WHAT IS A POLICYMAKER TO DO?

- Standardized test procedures, e.g., CAFE, serve useful purposes
- Be careful of promises of energy and emissions outcomes
  - What behaviors?
    - Is $k > 1$?
  - Enacted by whom, where, and when?
    - Who is the population (n); how many of them will take up the behavior (p)?
    - Not just technical potential
  - What are the distributions of outcomes?
    - Across behaviors (functions, typologies, contexts), promotions, …and individual driver-owner-buyers
  - What are the aggregate impacts over time?
- Do something

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Ken Kurani
knkurani@ucdavis.edu

Angela Sanguinetti
asanguinetti@ucdavis.edu

http://ncst.ucdavis.edu/research/white-papers/