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Understanding and Influencing Sustainable Behaviors:

Promoting energy conservation, recycling, and alternative transportation

Mapping Strategies to Outcomes & The Role of Behavior

Technology

Infrastructure

Incentives

Marketing

Behavior

Environment

Economy

Equity

Quality of Life

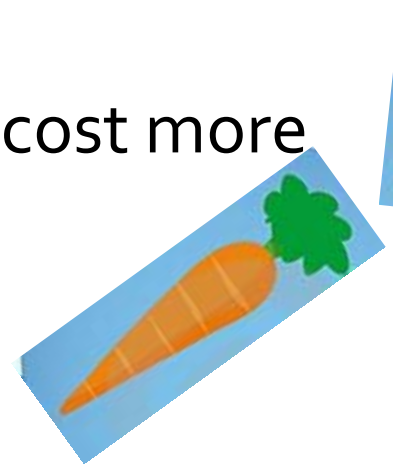
Outline

- Examples of programs to promote sustainable behaviors
- Modeling behavior
- Example of behavioral experiment and model
- Current research
- Conclusion

Examples of programs to promote sustainable behaviors

Waste Reduction

- Berkeley program
  - Larger garbage cans cost more
  - FREE! Recycling
  - FREE! Green Waste



- 57% Diverted

Southern California Edison

- Efforts of Southern California Edison to encourage energy conservation
  - Emails and text messages regarding energy use

    No effect
  - Ambient Orb:
    red during high energy, green during low

    40% reduction during peak periods

Thomson (2007)

Driving green

- Ford efficiency leaves
- Honda Insight Hybrid – leaves + score

Impact?

- Focusing on mpg
  - 7 to 14% less gas consumption
- Honda with scoring
  - Avg 10%, max 20%

Energy Use Study in CA (Schultz et al., 2007)

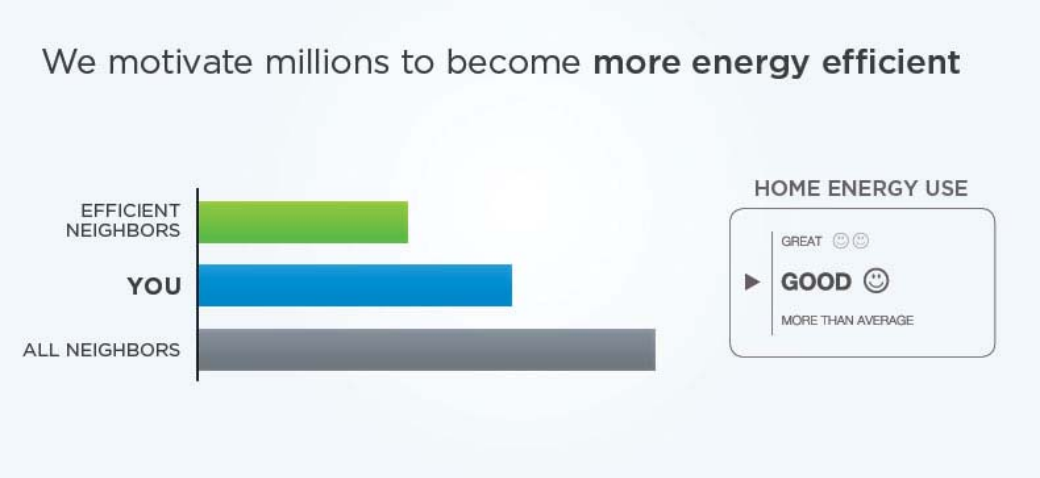
- Feedback approach 1:
  Household energy use
  Avg energy use in neighborhood
- Feedback approach 2:
  Same as above, but with ☺ ☹

High users reduce,
Low users increase

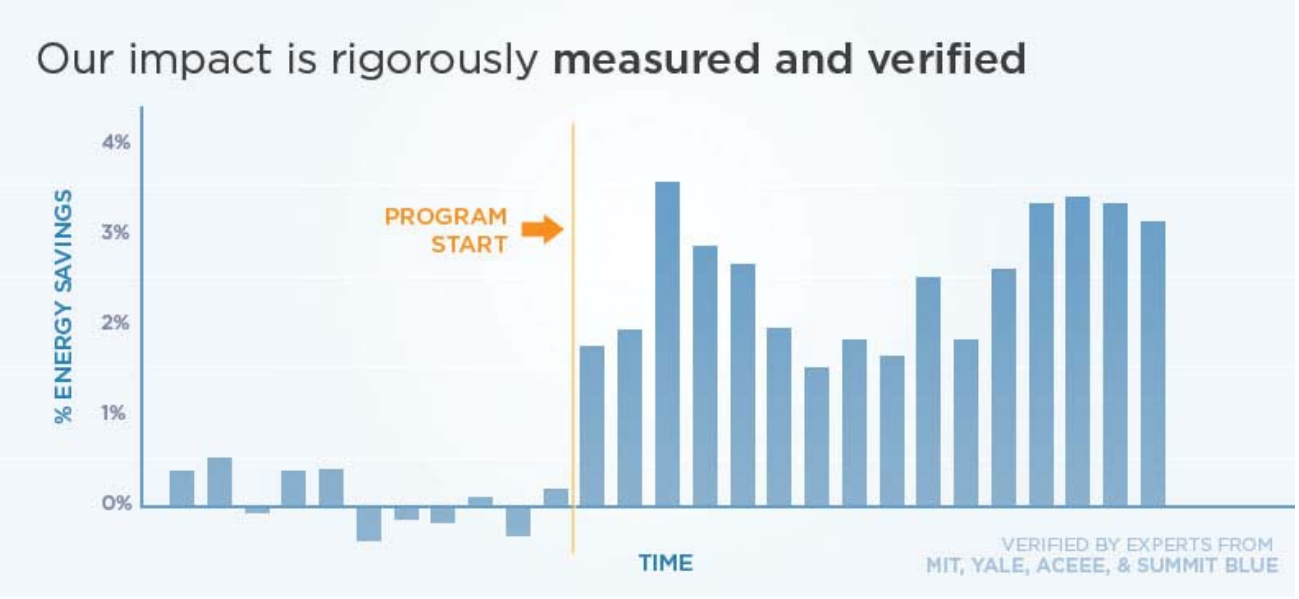
High users reduce more,
Low users don't change

OPower

- CO_2 emissions reduced by 100,000 tons



- $18M saved



Energy Smackdown

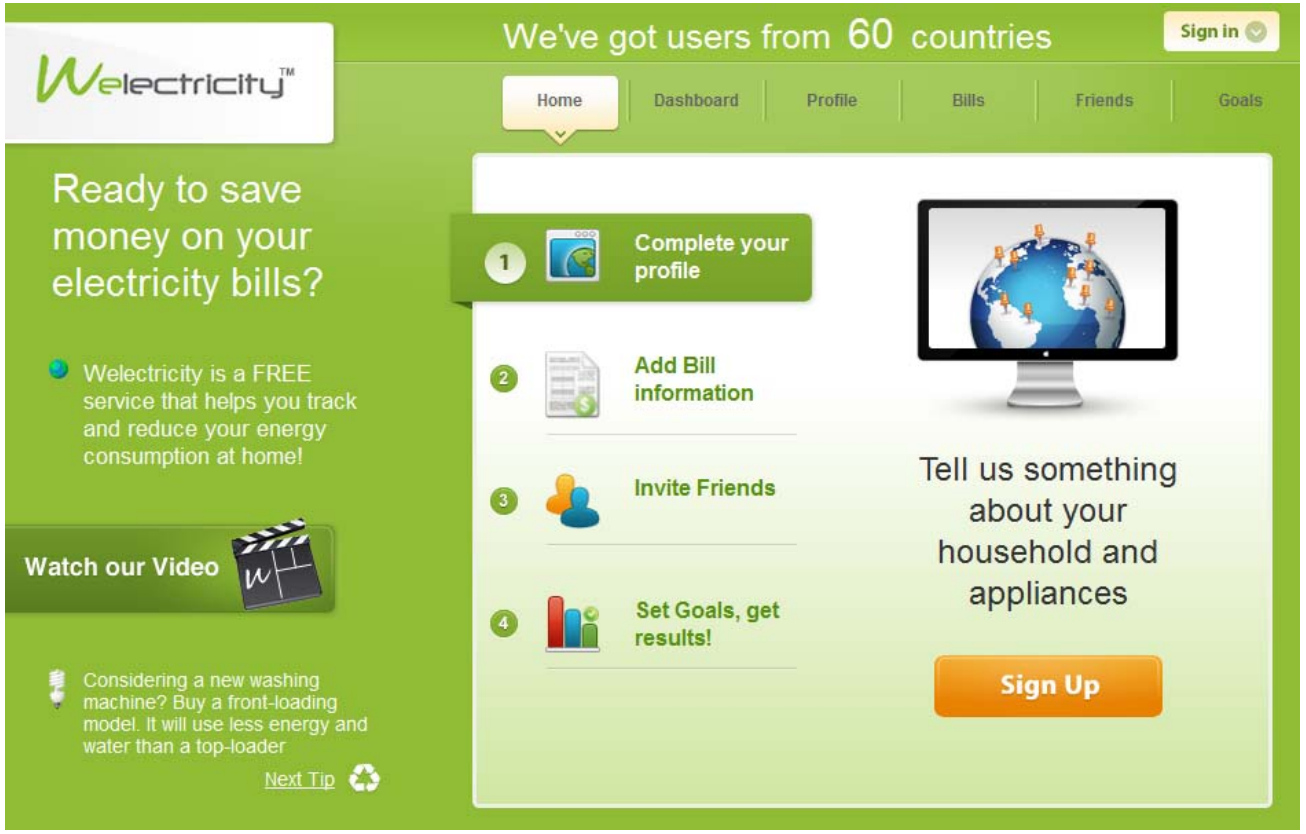
- Boston Area
- Reality TV Competition between 3 towns
- 177 households saved 52 tons of CO_2

Energy Smackdown™

moving from awareness to action

Welectricity

- Energy Efficiency + Social Networking



Themes

- Sticks and carrots
- Power of information and feedback

  … provided in creative ways
  - Visualizing impact
  - Augmented mindfulness
  - Social norms

Modeling Behavior

Economics & Rationality

- People act in their own interest
- They can objectively evaluate all alternatives available to them and
  then choose the one that is best for them.

Vive le Difference

Free Lanes $0.00

Toll Lanes $1.95

Free Lanes $0.00

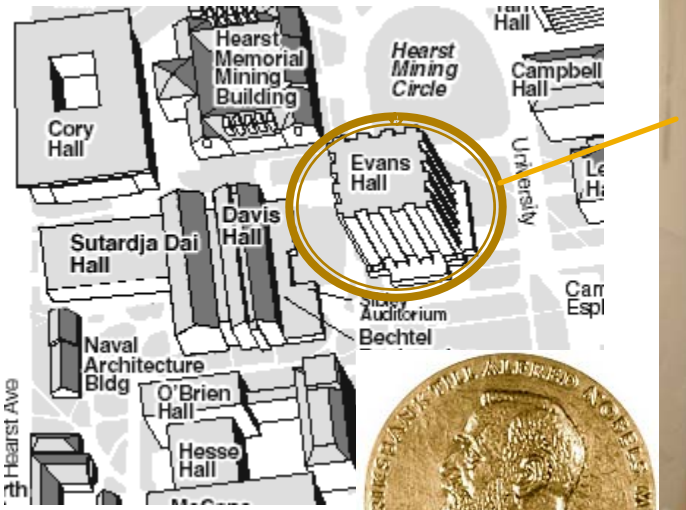
Toll Lanes $9.55

Vive le Difference

- Detailed analysis shows works with some groups, backfires with others
  (Costa and Kahn, 2010)

Economics + Statistics → Model

- Probability(person *n* recycles soda can)
  = f(characteristics of the person
  & attributes of the environment)



Microeconomics review

- Basic concepts
  - Faced with a set of alternatives (consumption bundles)
  - Consumers are able to assign preferences that rank these alternatives in terms of attractiveness
  - Utility function represents mathematically these preferences.
  - Consumers make choices that maximize their utility (subject to a budget constraint)

Utility of a Transportation Mode

- Utility function for bus

$$U_{bus} = \beta_0 + \beta_1 WT_{bus} + \beta_2 TT_{bus} + \beta_3 C_{bus}$$

  - WT_{bus} waiting time (hours)
  - TT_{bus} total travel time (hours)
  - C_{bus} total cost of trip (dollars)

- Parameters β represent tastes, and vary by education, gender, trip purpose, etc.

$$U_{bus} = \beta_0 + \beta_1 WT_{bus} + \beta_2 TT_{bus} + \beta_3 C_{bus} / Income$$

- Cannot be measured exactly

$$U_{bus} = \beta_0 + \beta_1 WT_{bus} + \beta_2 TT_{bus} + \beta_3 C_{bus} / Income + \varepsilon_{bus}$$

Behavioral Model

- Choice from among *auto ,bus, walk*

$$P(auto) = \frac{e^{V_{auto,n}}}{e^{V_{auto,n}} + e^{V_{bus,n}} + e^{V_{walk,n}}}$$

$$\begin{aligned}
U_{auto,n} &= \beta_{auto} &&+\beta_2 TT_{auto,n} &&+\beta_3 C_{auto,n} / Income_n &&+\varepsilon_{auto} \\
U_{bus,n} &= \beta_{bus} &&+\beta_1 WT_{bus,n} &&+\beta_2 TT_{bus,n} &&+\beta_3 C_{bus,n} / Income_n &&+\varepsilon_{bus} \\
U_{walk,n} &= \beta_{walk} &&&&+\beta_2 TT_{walk,n} &&&&+\varepsilon_{walk}
\end{aligned}$$

$$V$$

How do we estimate β s?

- Gather data from a sample of people
  - His/her mode choice to campus
  - His/her sociodemographics
  - His/her home and work location
    (→ travel time and travel cost of auto, bus, walk)
- Estimate the β s that best explain the observed choices.

Example application

- Joe has 3 options to come to campus
  - Auto: 4 min. walk, 8 minutes in car, $4.50
  - Bus: 15 min. walk, 5 min. wait, 10 min in bus, $4.00
  - Walk: 40 min. walk

  His income is $80,000
- What is Joe's probability of driving?
  - Plug into $P(auto) = \frac{e^{V_{auto,n}}}{e^{V_{auto,n}} + e^{V_{bus,n}} + e^{V_{walk,n}}}$ → $P(auto) = 0.9$
- What if campus doubles parking fees?
  - Update parking cost → $P(auto) = 0.7$

Notion of tradeoffs

$$U_{bus} = \ldots + \beta_{time} Time_{bus} + \beta_{cost} Cost_{bus} + \ldots$$

- Marginal rate of substitution between time and cost

$$MRS = \frac{MU_{time}}{MU_{cost}} = \frac{\partial U_{bus} / \partial \text{ Time}}{\partial U_{bus} / \partial \text{ Cost}} = \frac{\beta_{time}}{\beta_{cost}} \quad \frac{\$}{hour}$$

Value of Time

- Not all time is equal

$$U_{bus} = \ldots + \beta_{time\_wait} TimeWait_{bus} + \beta_{time\_inveh} TimeInVeh_{bus} + \beta_{cost} Cost_{bus} + \ldots$$

→ Value of wait time : $\beta_{time\_wait} / \beta_{cost}$

→ Value of in vehicle time : $\beta_{time\_inveh} / \beta_{cost}$

Behavioral Economics

- Cross between psychology and economics
- Focus on what *really* influences decisions as opposed to what we *think* influences them
  - Emphasis on refuting rationality
- Clever experiments
- Hot area
  - Dan Arieli's *Predictably Irrational*
  - Richard Thaler and Cass Sunstein's *Nudge*

Overconfidence and Optimism

- What percent of drivers thing they are above average?
  - 90%
- What percentage of Professors think they are better than the average professor?
  - 94%

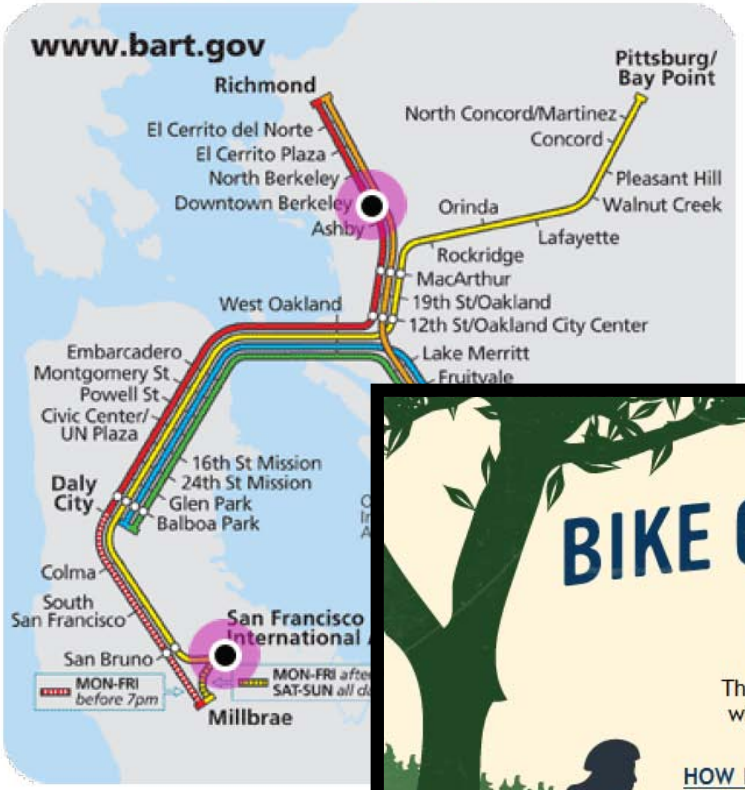
Example of Behavioral Experiment & Model

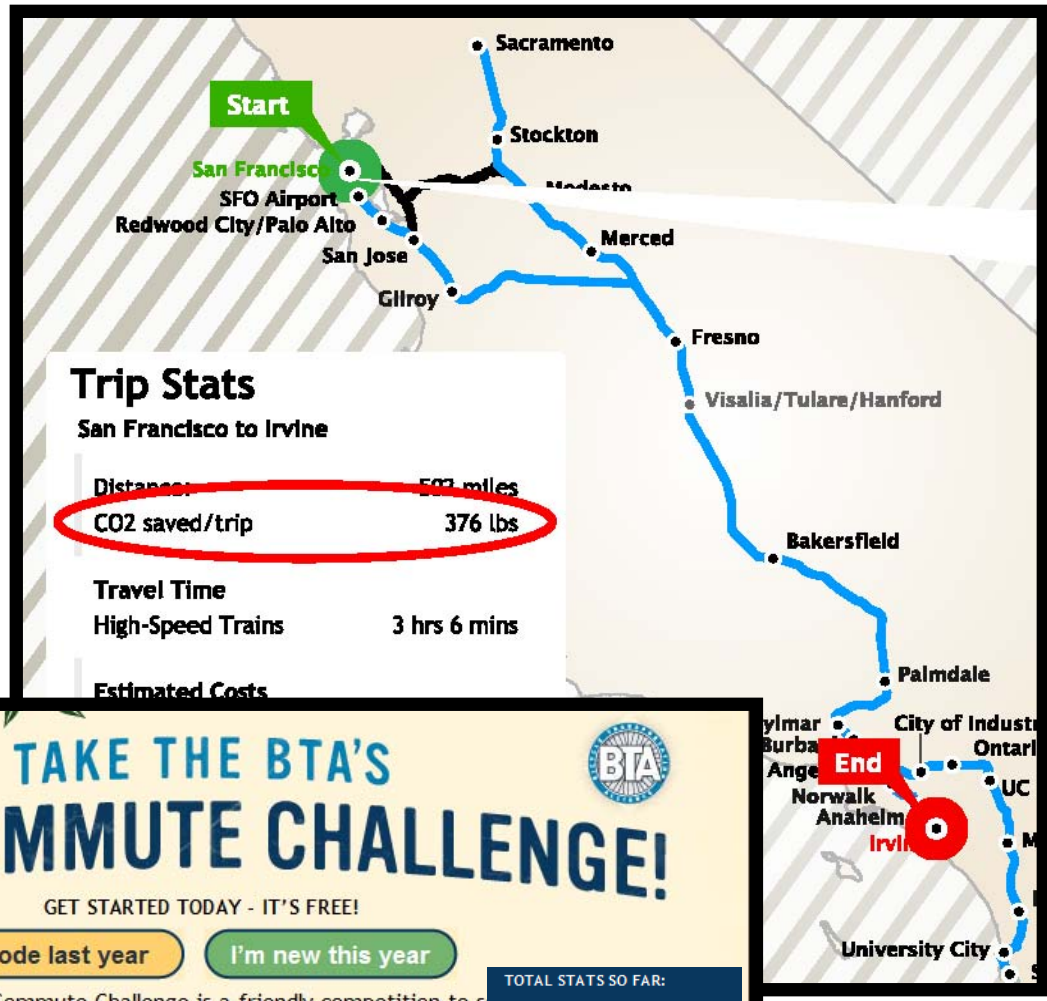
The Power and Value of **Green** in Promoting Sustainable Behaviors

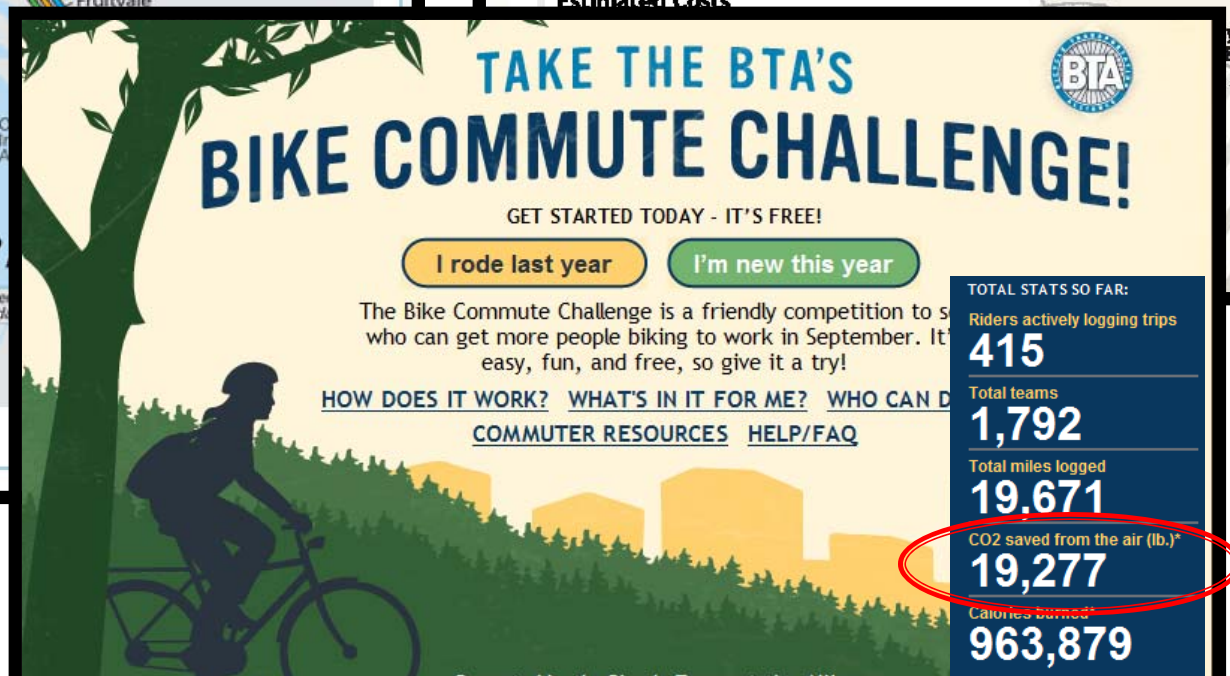
Downtown Berkeley Station
2160 Shattuck Avenue , Berkeley , CA 94704
Connecting Transit, Neighborhood Map and more...

San Francisco Int'l Airport Station
International Terminal, Level 3 , San Francisco Int'l Airport , CA 94128
Connecting Transit, Neighborhood Map and more...

CO2 emissions saved by this BART trip: **23.3 pounds.** Read more







XLAB Experiments

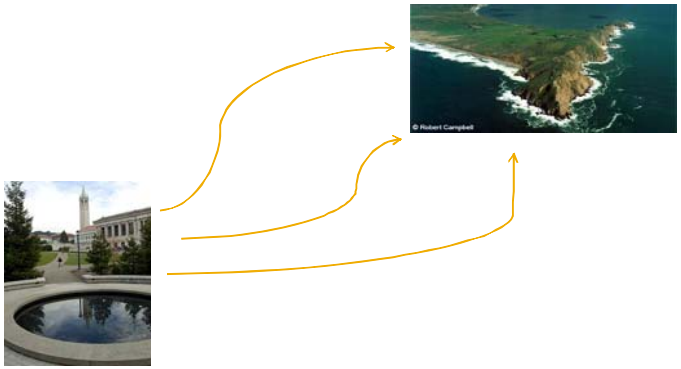
- "Experimental Social Science Laboratory"
  - Subjects paid $15/hour
- Our experiment
  - 312 respondents

Three experiments

- Auto ownership

- Mode choice

- Route choice



Which car option would you choose?

- Scenario
  - Suburban house
  - Trip to work: 30 minutes by car, 60 minutes by transit

Attributes	Conventional Vehicle	Hybrid Vehicle
Purchase Price ($)	16000	22000
Annual Cost ($/year)	5000	4300
Greenhouse Gas Emissions (tons/year)	3.2	3.0

You may be interested in the choices made by some of your peers in the lab right now, which are displayed below:

4 of you peers chose conventional.

6 of you peers chose hybrid.

2 of you peers chose not to buy a car.

Conventional?
Hybrid?
No Car?

Which route would you choose?

Attributes	Route 1	Route 2	Route 3
Time (minutes)	70	90	90
Variation of Time (minutes)	12	18	5
Toll (dollars)	0.75	2.00	0.25
Greenhouse Gas Emission (pounds)	5	3	2
Safety	2	3	1

Experiment 3:
Which mode would you choose?

Estimation Results from Route Choice Experiment

$$U_r = \beta_1 TravelTime_r + \beta_2 TravelTimeVar_r + \beta_3 Cost_r + \ldots + \beta_6 GHG_r + \varepsilon_r$$

	Estimate	t-test	p-value
Travel time (hours)	-4.317	-21.3	0.00
Travel time variance (hours)	-2.400	-3.6	0.00
Cost ($)	-0.490	-10.5	0.00
Safety dummy	0.620	12.8	0.00
FREE! route dummy	0.640	4.8	0.00
GHG emissions (pounds/trip)	-0.069	8.0	0.00
Number of observations	334 subjects * 5 responses each		
Adjusted rho-square	0.412		

Calculating the VALUE OF GREEN

Marginal rate of substitution (MRS) between emissions and cost

$$= \frac{MU_{\text{emissions}}}{MU_{\text{cost}}} = \frac{\partial U / \partial \text{ emissions}}{\partial U / \partial \text{ cost}} = \frac{\beta_{\text{emissions}}}{\beta_{\text{cost}}}$$ in units of cost/units of emissions

$U = \ldots - 0.490(\text{toll cost in \$})$

$-0.069(\text{greenhouse gas emissions in pounds/trip})$

$-4.317(\text{travel time in hours}) \ldots$

→VALUE OF GREEN = $0.14/POUND

→VALUE OF TIME = $8.81/HOUR

Findings

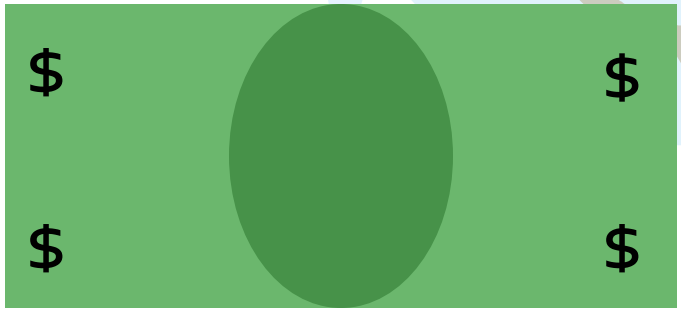
- Students value their time (on average) between $6.50-$9.00/hour
- Student value green (on average) between $0.10-$0.40/pound of CO_2
  - Fairly consistent across **many** variations
- Females more green than males
- Social influences positively impact being green

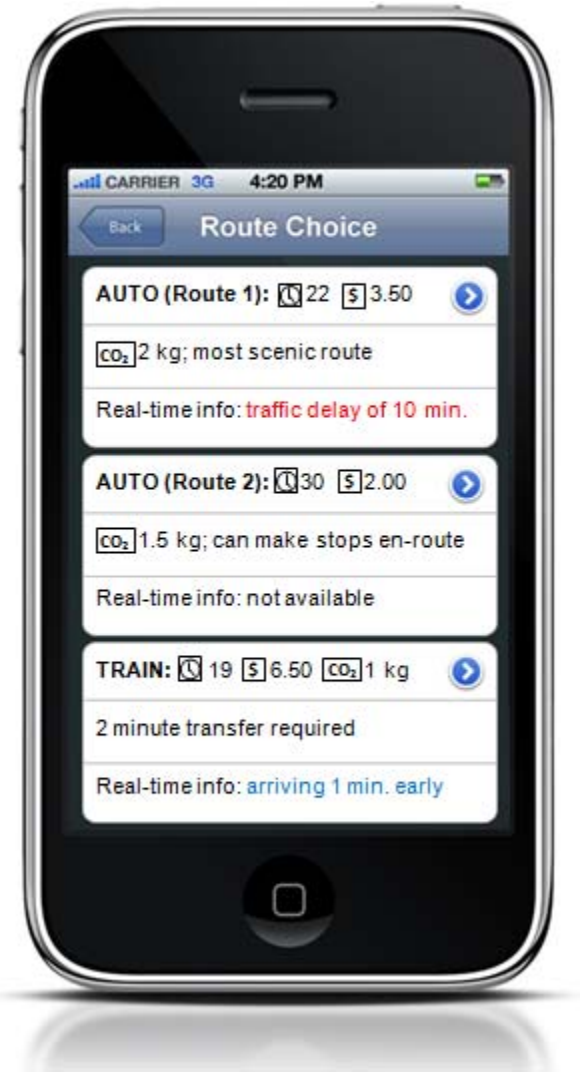
Research Direction

Real people. Real money.

BayTripper

Real-Time Transit Information for Mobile Phones





Conclusions

- Why concern regarding sustainability?
  - People!
- Why behavioral science?
  - Human response often dictates success or failure of policy
  - Cannot force actions
  - Anticipate actions of people, firms, developers, government
- Challenging
  - Dealing with humans… heterogeneous, irrational
  - Ignoring it is not an answer… must develop useful tools
  - Requires multidisciplinary effort