the design of **eco-feedback** technology

Jon Froehlich, Leah Findlater, James Landay

dub design: use: build:

UNIVERSITY of WASHINGTON

eco-feedback

sensing behavior paired with feedback to reduce environmental impact

toyota prius


hci


hci
environmental psychology


power-aware cord
cord light pulsates &
varies in intensity
based on power draw
Gustafsson and Gyllenswärd, *CHI2005*

jetsam

visualization allows pedestrians to view amount and type of garbage at-a-glance

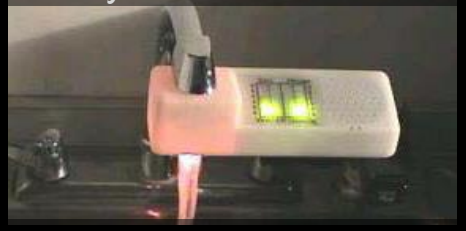
Paulos and Jenkins, *CHI2005*


new sensing
100 %
PHILIPS

smart meters

eco-feedback
a brief history

Arroyo et al., *CHI2005*



Kuznetsov et al., *CHI2010*

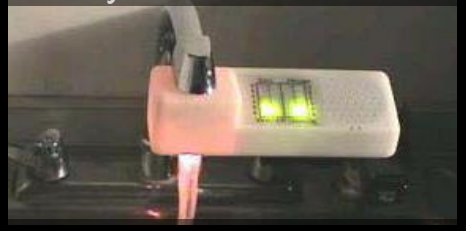
hci/ubicomp

2003 2010

Fogg, B.J., *Persuasive Technology,* 2003

eco-feedback
a brief history

Arroyo et al., *CHI2005*



Kuznetsov et al., *CHI2010*

Kohlenberg et al., *J. Applied Behavior Analysis, 1976*

environmental psychology

hci/ubicomp

1970 1976 2003 2010

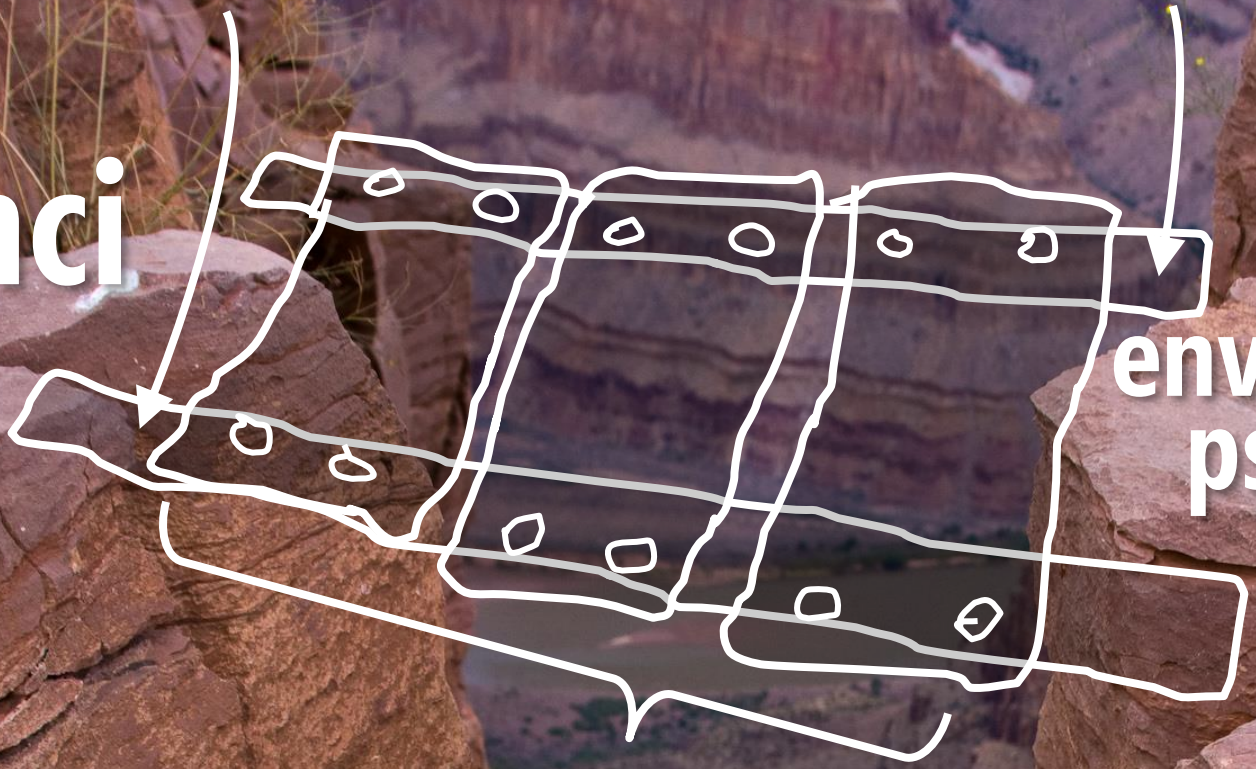
Fogg, B.J., *Persuasive Technology,* 2003

our focus

1. what can we learn from environmental psychology?
2. what should our role be in eco-feedback research?
3. how should we assess our contributions?

1. why do people engage in environmental behavior?

2. what techniques are used to motivate environmental behaviors?



3. what is hci's role?


1. why do people engage in environmental behavior?
hci
environmental psychology

why?

why?

to design eco-feedback technology effectively, these are the very questions that we need to answer in the design process

proenvironmental behaviors

self-interest

e.g., carpooling to make use of HOV lanes

concern for others

e.g., using non-toxic cleaning chemicals out of respect for local watershed

proenvironmental behavior models

rational choice models

self-interest

e.g., carpooling to make use of HOV lanes

norm-activation models

concern for others

e.g., using non-toxic cleaning chemicals out of respect for local watershed

rational choice models

behavior is regulated by systematic process of evaluating expected utility to self

Congressional Budget Office, *Congress Report*, 2008

norm activation models

proenvironmental behavior is altruistic or based on some perceived notion of good

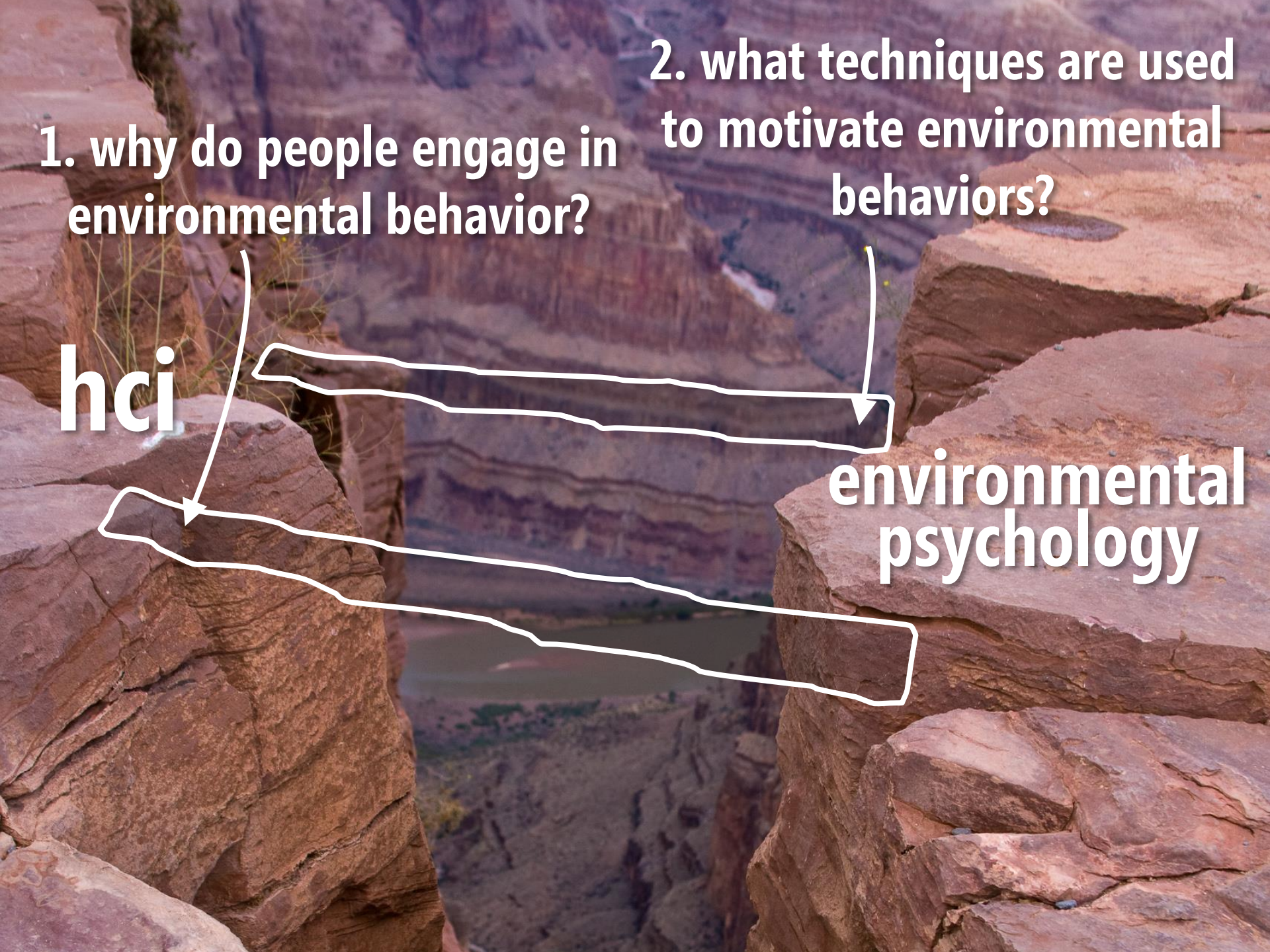
help to **conserve natural resources**
a sense of **responsibility** and
participation

DeYoung, *Environment and Behavior*, 1986

models impact eco-feedback designs

designers build based on models, these fundamentally change their designs

we need to be more about explicit about questioning/exposing the theories used in our designs


1. why do people engage in environmental behavior?
2. what techniques are used to motivate environmental behaviors?
hci
environmental psychology

behavior change
techniques we can use

- information
- prompts
- goal-setting
- comparison
- commitment
- incentives
- feedback

Geller et al., 1990
Health Education Research

behavior change

techniques

- information
- prompts
- goal-setting
- comparison
- commitment
- incentives
- feedback

do you know how much ENERGY is E AY?

LOOK AROUND YOU

prompts

much more effective!

Winett et al., *Journal of Applied Psychology, 1978*

SWITCH OFF

unnecessary bulbs

SAVE THE PLANET.
ONE SWITCH AT A TIME.

behavior change
techniques we can use

- information
- prompts
- goal-setting
- comparison
- commitment
- incentives
- feedback

behavior change

techniques

information

prompts

goal-setting

comparison

commitment

incentives

feedback

1. directs attention
2. has energizing function
3. affects persistence

Locke & Latham, *American Psychologist, 2002*

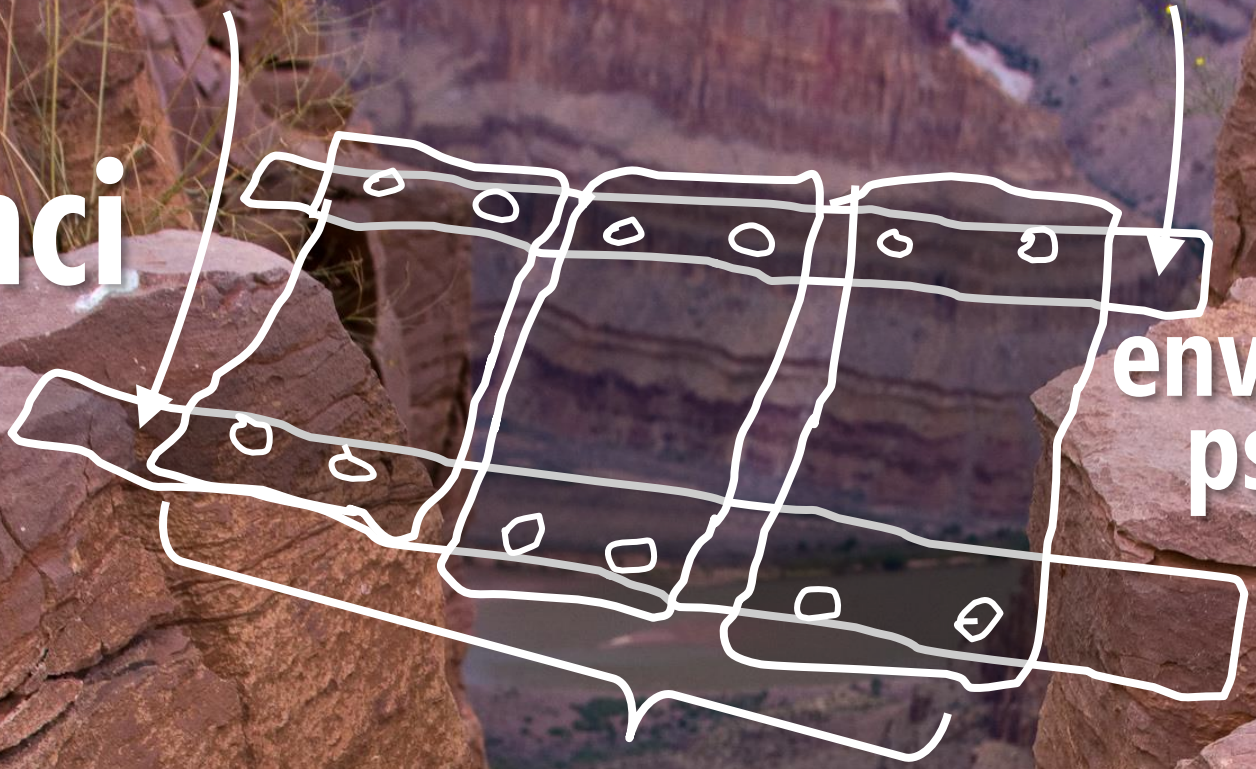
behavior change
techniques we can use

information
prompts
goal-setting
comparison
commitment
incentives
feedback

integrate these techniques into our eco-feedback designs

1. why do people engage in environmental behavior?

2. what techniques are used to motivate environmental behaviors?



3. what is hci's role?

how are the eco-feedback interfaces presented?

what behaviors are targeted?

how are the eco-feedback interfaces evaluated?

hci

environmental psychology

3. what is hci's role?

hci corpus

Sources: CHI, UbiComp, Persuasive

139 papers on "environment" or "sustainability."

56 related to eco-feedback

92% published in last three years

44% in 2009 alone

environmental psychology corpus

Sources: Journals of Environmental Psychology, Consumer Research, Social Issues, Applied Social Psychology, Applied Experimental Psychology, Environment and Behavior

82 papers on effects of eco-feedback

12 on eco-feedback technology


hci
58%
environmental psychology
0%

how are the eco-feedback interfaces presented?

hci

environmental psychology

3. what is hci's role?

presentation of the eco-feedback interface

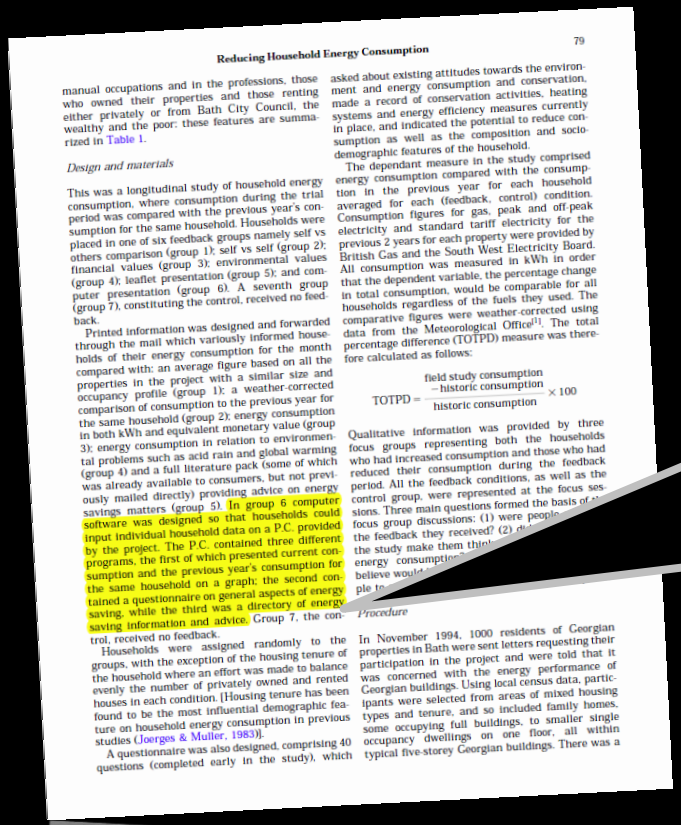
papers that provide a graphic of their eco-feedback interface

50% vs 85%

environmental psychology

hci

environmental psychology
used short written descriptions



Reducing Household Energy Consumption 79

manual occupations and in the professions, those who owned their properties and those renting either privately or from Bath City Council, the wealthy and the poor: these features are summarized in Table 1.

Design and materials

This was a longitudinal study of household energy consumption, where consumption during the trial period was compared with the previous year's consumption for the same household. Households were placed in one of six feedback groups namely self vs others comparison (group 1); self vs self (group 2); financial values (group 3); environmental values (group 4); leaflet presentation (group 5); and computer presentation (group 6). A seventh group (group 7), constituting the control, received no feedback.

Printed information was designed and forwarded through the mail which variously informed households of their energy consumption for the month compared with: an average figure based on all the properties in the project with a similar size and occupancy profile (group 1); a weather-corrected comparison of consumption to the previous year for the same household (group 2); energy consumption in both kWh and equivalent monetary value (group 3); energy consumption in relation to environmental problems such as acid rain and global warming (group 4) and a full literature pack (some of which was already available to consumers, but not previously mailed directly) providing advice on energy savings matters (group 5). In group 6 computer software was designed so that households could input individual household data on a P.C. provided by the project. The P.C. contained three different programs, the first of which presented current consumption and the previous year's consumption for the same household on a graph; the second contained a questionnaire on general aspects of energy saving, while the third was a directory of energy saving information and advice. Group 7, the control, received no feedback.

Households were assigned randomly to the groups, with the exception of the housing tenure of the household where an effort was made to balance evenly the number of privately owned and rented houses in each condition. [Housing tenure has been found to be the most influential demographic feature on household energy consumption in previous studies (Joerges & Muller, 1983)].

A questionnaire was also designed, comprising 40 questions (completed early in the study), which asked about existing attitudes towards the environment and energy consumption and conservation, made a record of conservation activities, heating systems and energy efficiency measures currently in place, and indicated the potential to reduce consumption as well as the composition and socio-demographic features of the household.

The dependant measure in the study comprised energy consumption compared with the consumption in the previous year for each household averaged for each (feedback, control) condition. Consumption figures for gas, peak and off-peak electricity and standard tariff electricity for the previous 2 years for each property were provided by British Gas and the South West Electricity Board. All consumption was measured in kWh in order that the dependent variable, the percentage change in total consumption, would be comparable for all households regardless of the fuels they used. The comparative figures were weather-corrected using data from the Meteorological Office[1]. The total percentage difference (TOTPD) measure was therefore calculated as follows:

$$\text{TOTPD} = \frac{\text{field study consumption} - \text{historic consumption}}{\text{historic consumption}} \times 100$$

Qualitative information was provided by three focus groups representing both the households who had increased consumption and those who had reduced their consumption during the feedback period. All the feedback conditions, as well as the control group, were represented at the focus sessions. Three main questions formed the basis of [illegible] focus group discussions: (1) were people [illegible] the feedback they received? (2) [illegible] the study make them think [illegible] energy consumption [illegible] believe would [illegible] ple [illegible]

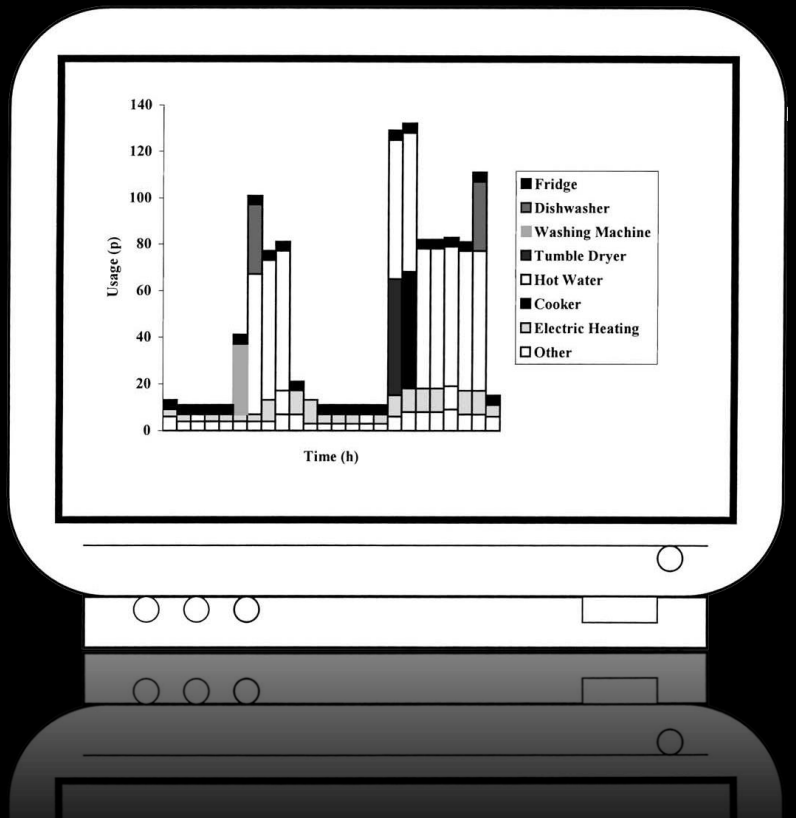
Procedure

In November 1994, 1000 residents of Georgian properties in Bath were sent letters requesting their participation in the project and were told that it was concerned with the energy performance of Georgian buildings. Using local census data, participants were selected from areas of mixed housing types and tenure, and so included family homes, some occupying full buildings, to smaller single occupancy dwellings on one floor, all within typical five-storey Georgian buildings. There was a

½ paragraph
eco-feedback interface
description in an
11 page paper

Brandon & Lewis, *Environmental Psychology, 1999*

environmental psychology
common interfaces

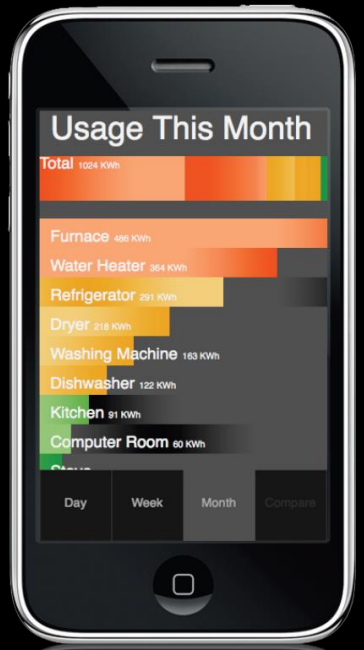


Keirstead, *Energy Policy, 2007*

Dobson & Griffin, *Proc of ACEEE, 1992*

hci/ubicomp
range of interfaces

Shiraishi et al., *Persuasive2009*



Petersen et al., *CHI 2009*

Arroyo et al., *CHI 2005*

simple interfaces were effective

lack of design focus
simple interfaces
yet...
significant reductions

simple interfaces were effective

lack of design focus
simple interfaces
yet...
significant reductions

eco-feedback interfaces

what should be the role of hci?

exploring diverse presentation mediums
engaging users for sustained motivation
designing for least motivated users

how are the eco-feedback interfaces presented?

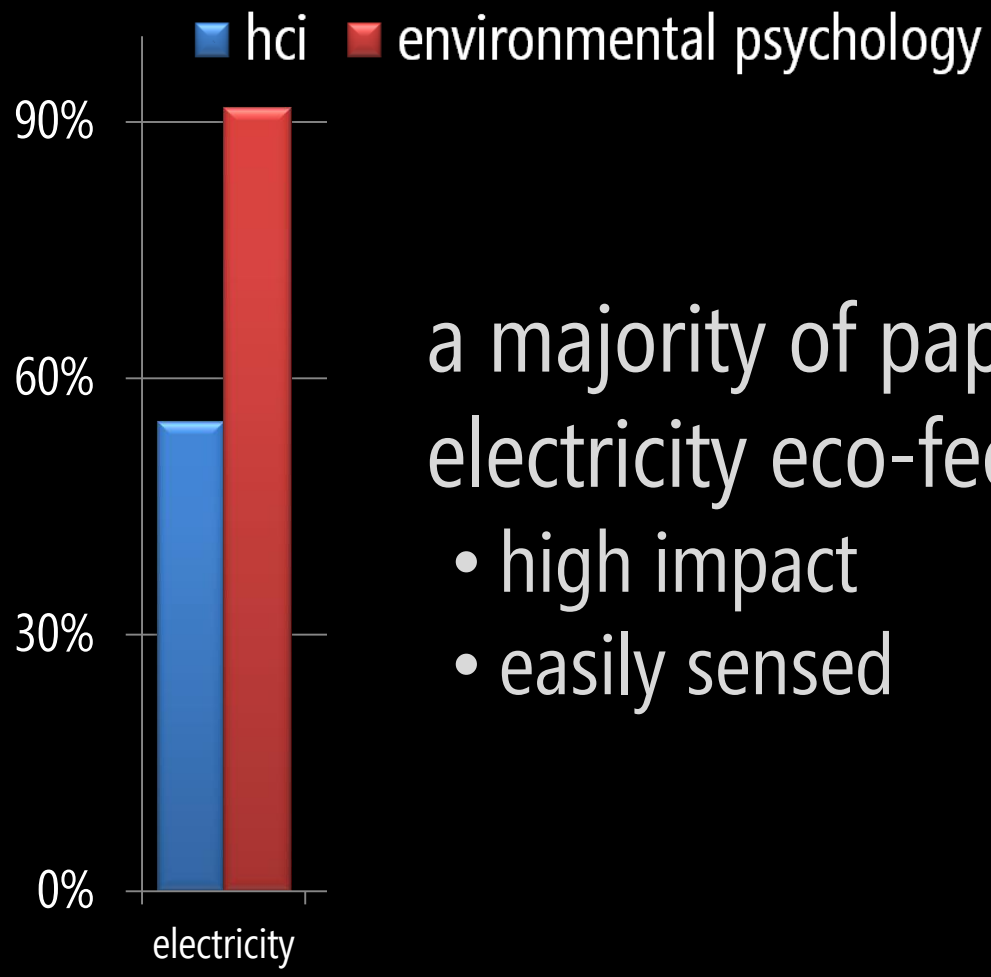
what behaviors are targeted?

hci

environmental psychology

3. what is hci's role?

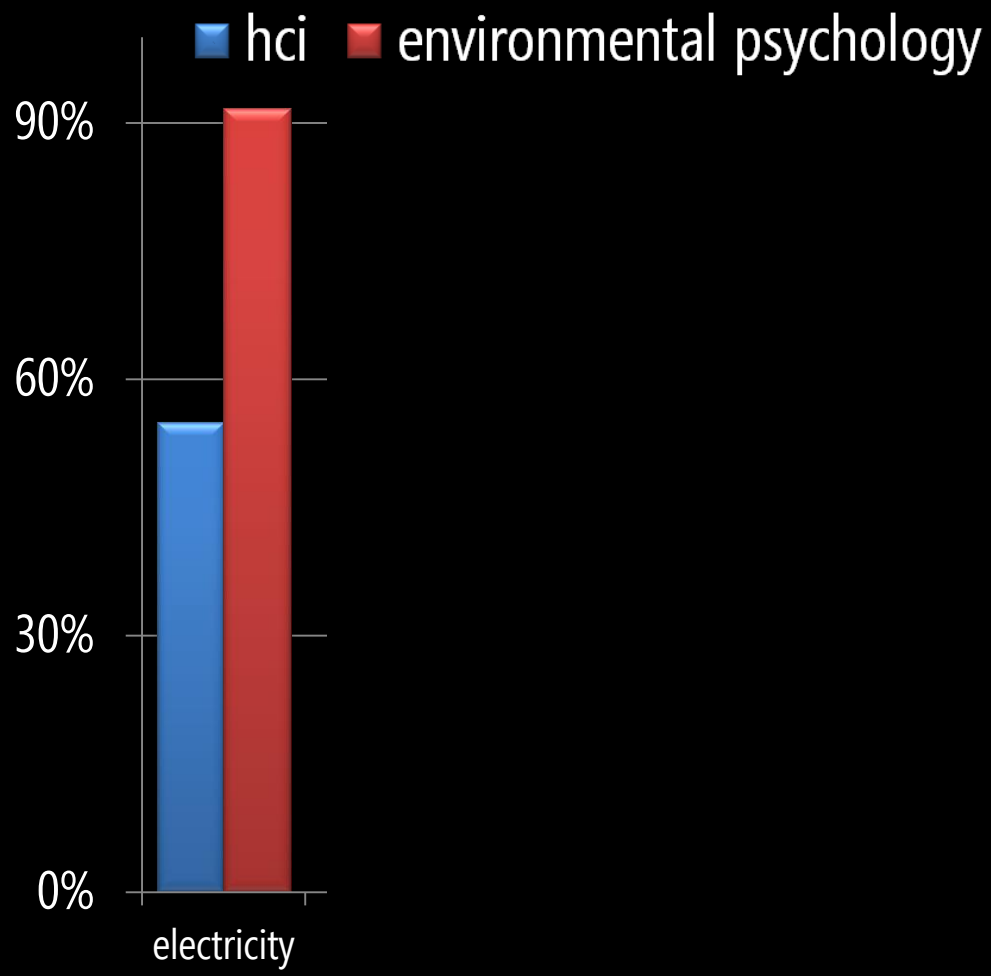
targeted behaviors



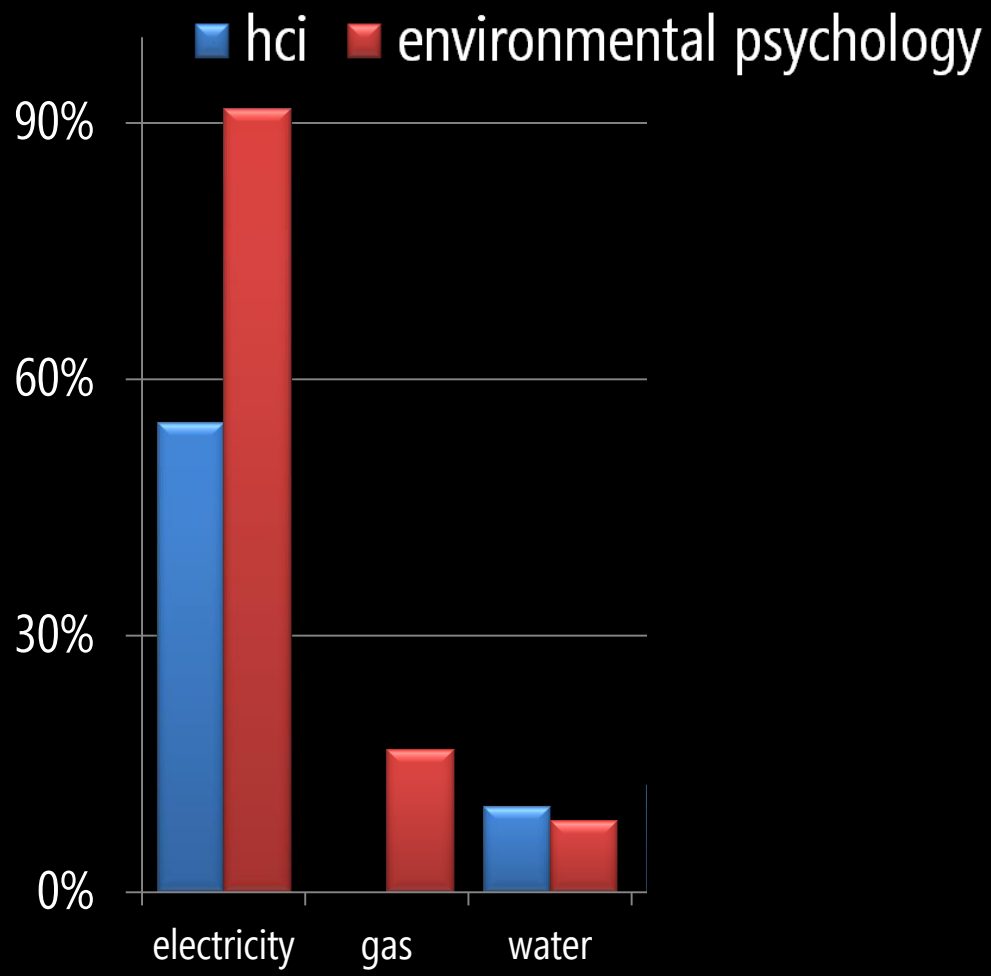
a majority of papers focus on electricity eco-feedback

- high impact
- easily sensed

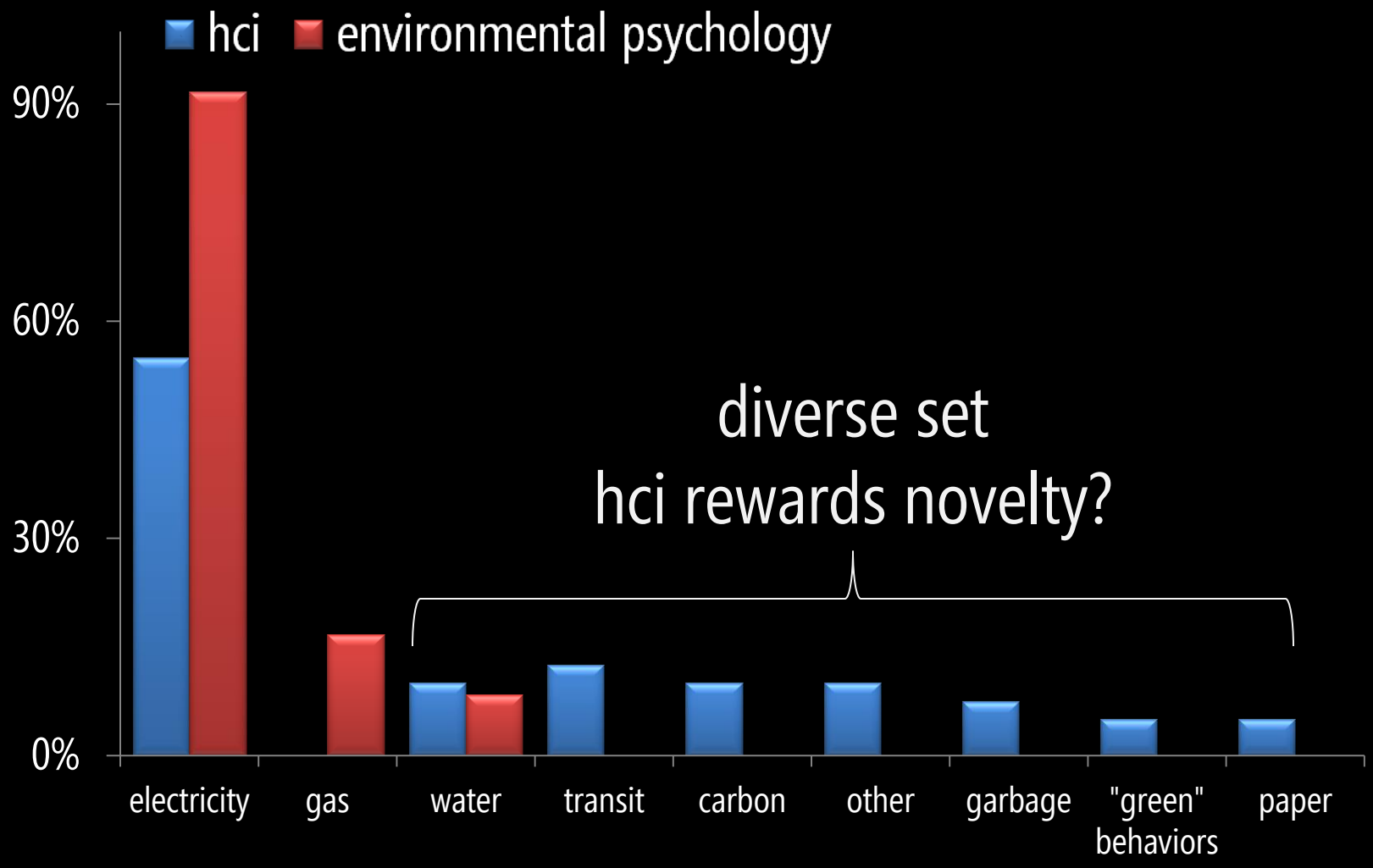
targeted behaviors



targeted behaviors



targeted behaviors



targeted behaviors

what should be the role of hci?

- building sensing techniques for new behaviors
- quickly testing/iterating new design ideas
- rewarding follow-up research

how are the eco-feedback interfaces presented?

what behaviors are targeted?

how are the eco-feedback interfaces evaluated?

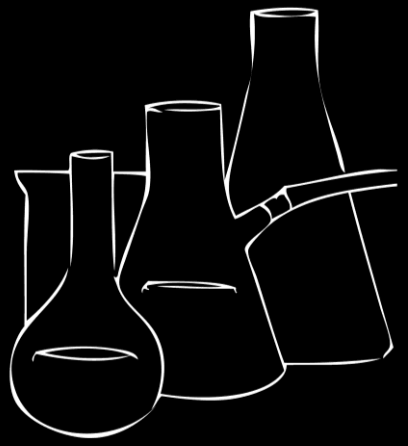
hci

environmental psychology

3. what is hci's role?

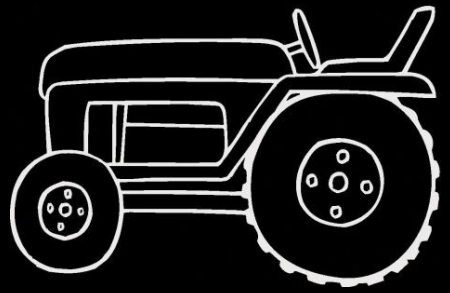
study methodology

laboratory study



qualitative study

field study



hci

environmental psychology

lab study
hci example

power-aware cord

investigate reactions to ambient display

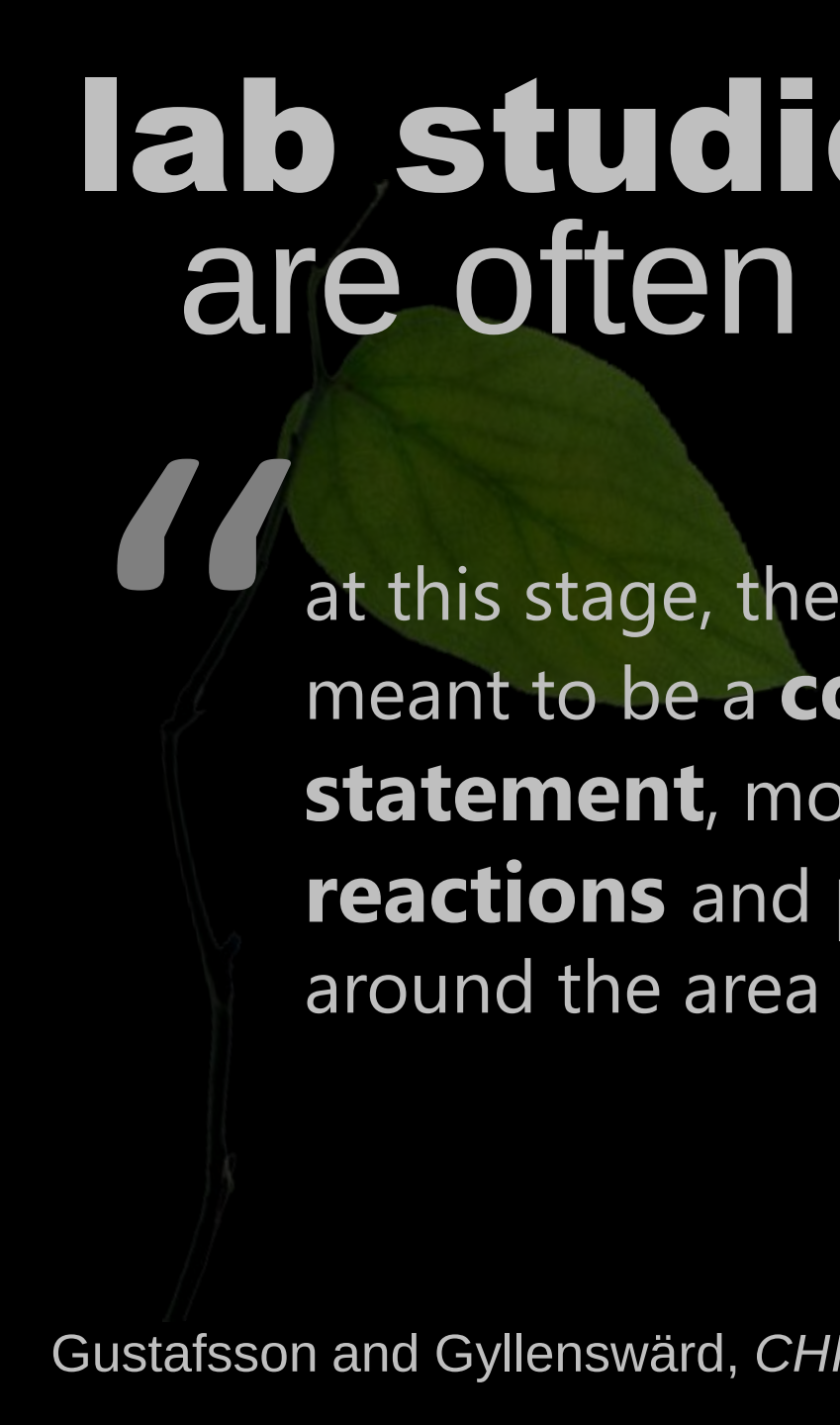
wizard-of-oz study

15 participants

13 participants understood feedback without explanation

Gustafsson and Gyllenswärd, *CHI EA, 2005*

lab studies in hci are often qualitative



> “at this stage, the Power-Aware cord is meant to be a **conceptual design statement**, mostly used to test people’s **reactions** and **provoke thoughts** around the area of energy consumption.”

Gustafsson and Gyllenswärd, *CHI EA, 2005*

lab study

environmental psychology example

product-integrated feedback

100 participants

participants were told studying:

"improvements to the control panel"

4 experimental groups:

1. feedback w/no goal
2. feedback w/self-set goal
3. feedback w/assigned goal
4. baseline (no feedback/no goal)

McCalley & Midden, *Journal of Economic Psychology, 2002*

field study
hci example

"show-me" water display

4 households

3-week study

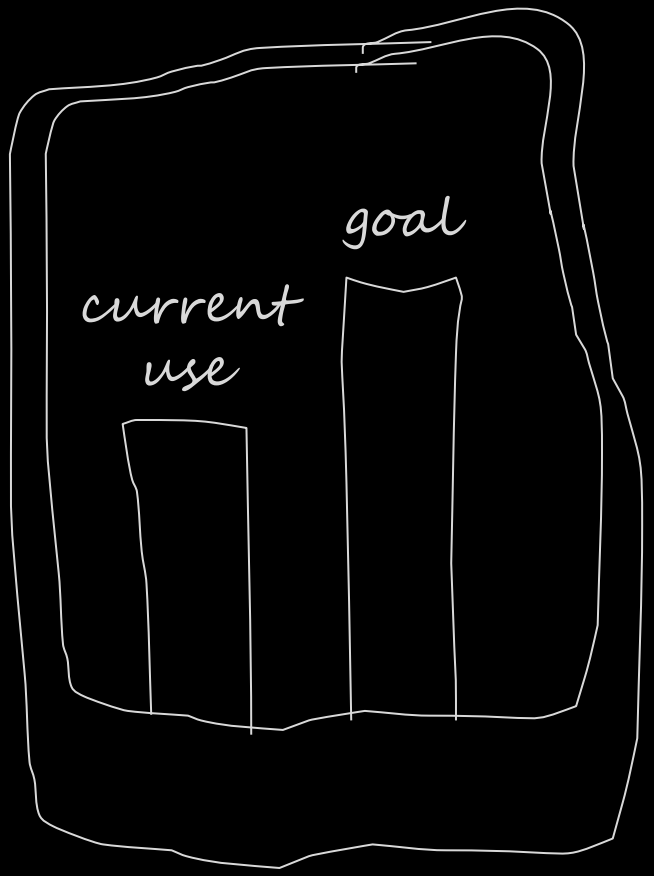
no control or baseline data

average reported water savings was 10 liters; no statistical analysis provided

Kappel and Grechenig, *Persuasive, 2009*

field study

environmental psychology example



gas usage eco-feedback study

325 households

three year study (1 year baseline)

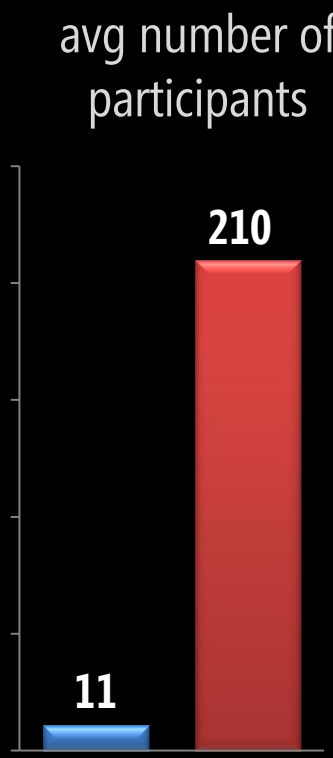
6 experimental groups

12.5% usage reduction with electronic eco-feedback condition

Van Houwelingen, & Van Raaij, *Journal of Consumer Research, 1989*

field studies

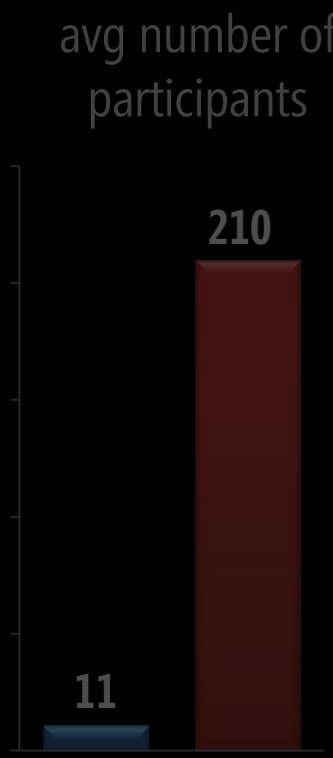
hci (n=8 of 27) **environmental psychology** (n=10 of 12)

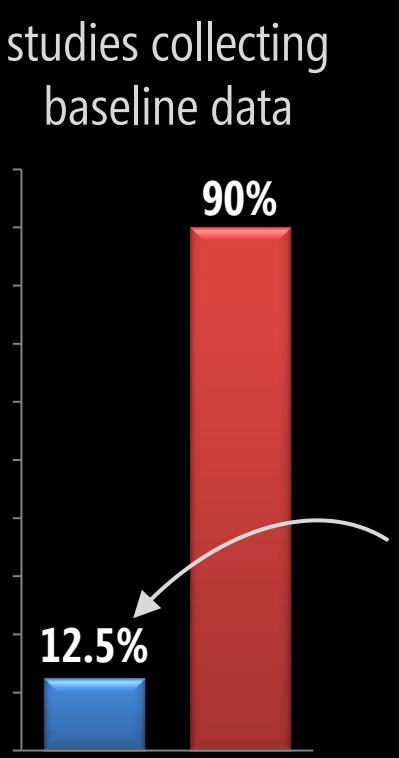


larger environmental psychology studies *(avg=414)* often partner with a utility

field studies

hci (n=8 of 27) **environmental psychology** (n=10 of 12)





baseline data

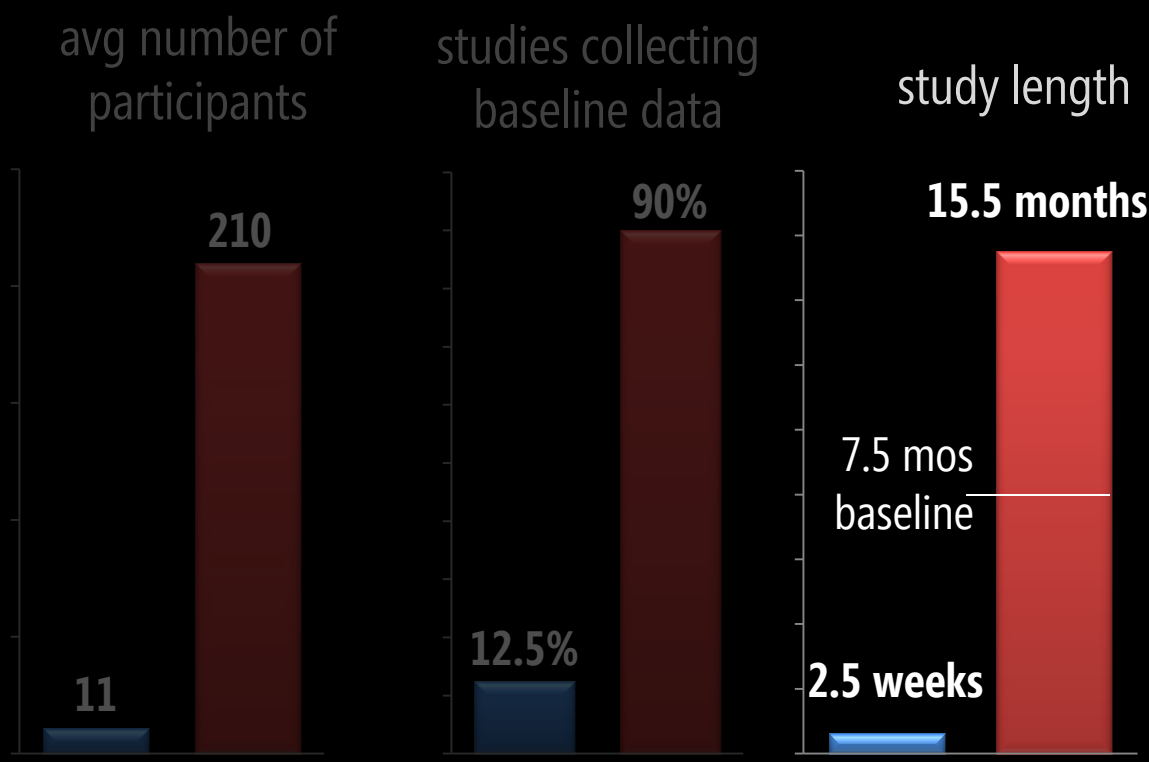
- previous year's consumption
- pre-intervention period

1 study with **1 week** baseline data

Holstius et al., DIS, 2004

field studies

hci (n=8 of 27) **environmental psychology** (n=10 of 12)



field studies

hci (n=8 of 27) **environmental psychology** (n=10 of 12)

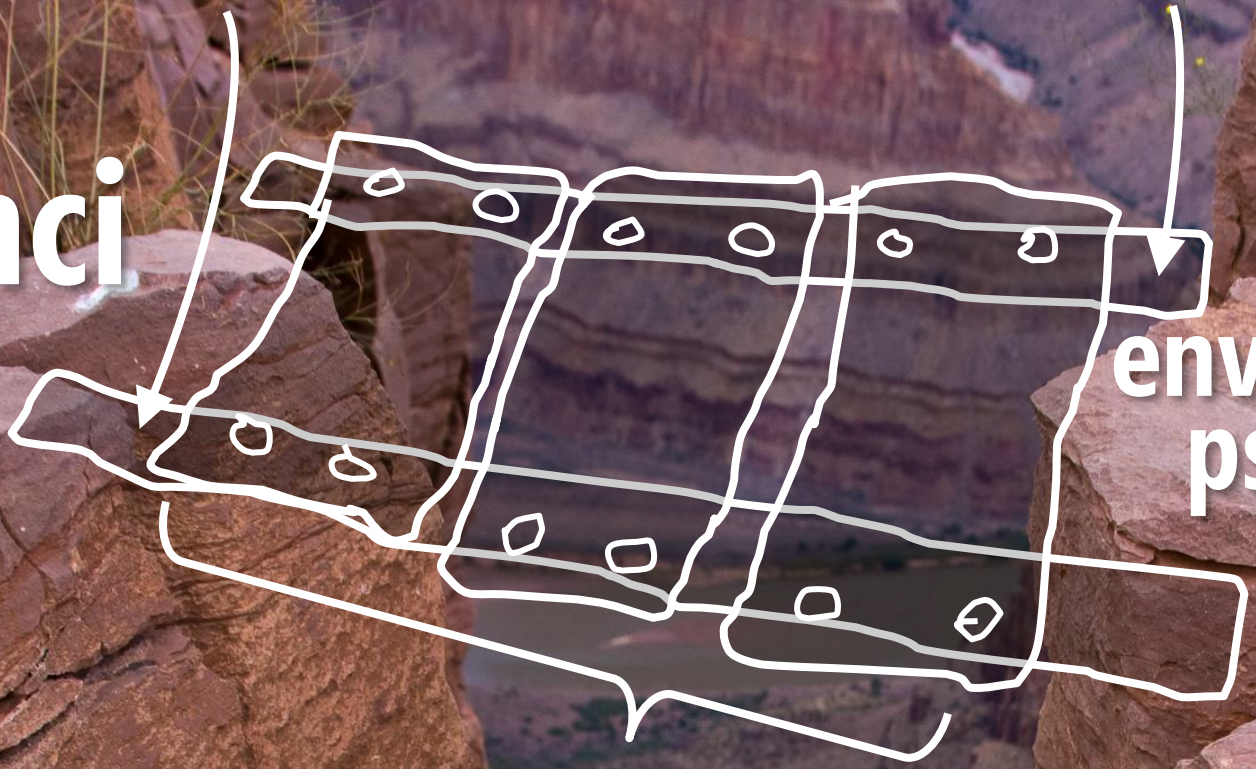
study methodology

what should be the role of hci?

- moving beyond lab studies/short field studies
- being more rigorous in our evaluations
- partnering outside the community

1. why do people engage in environmental behavior?

2. what techniques are used to motivate environmental behaviors?



3. what is hci's role?

our focus

1. what can we learn from environmental psychology?
2. what should our role be in eco-feedback research?
3. how should we assess our contributions?

eco-feedback

where are we going?

?

1970

1976

2003

2005

2010

the future

emergence of environmental psychology

the design of

eco-feedback

technology

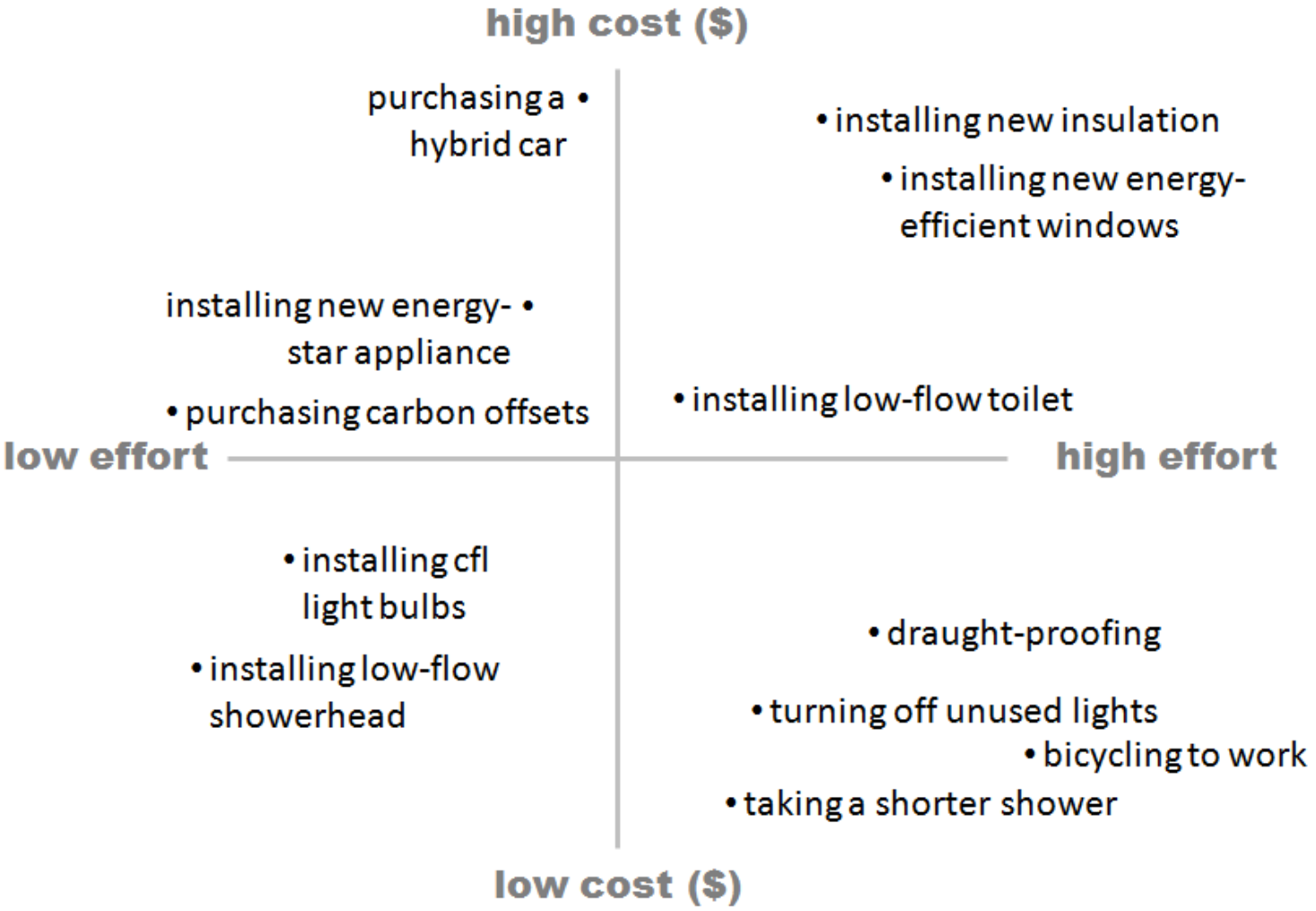
@jonfroehlich

dub design: use: build:

UNIVERSITY of WASHINGTON

other slides

efficiency vs. curtailment

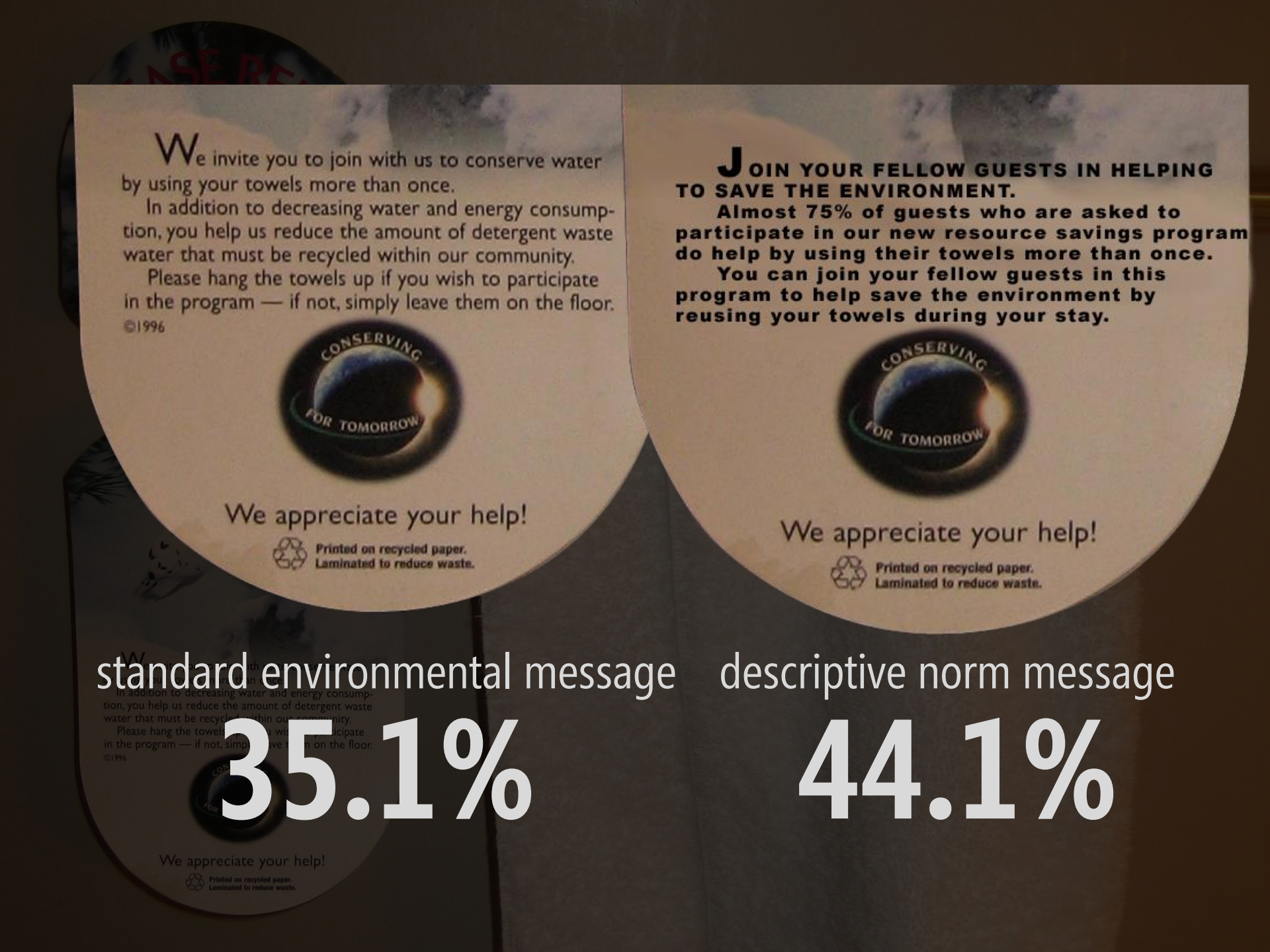



u.s. energy utilities spent
$2 billion
in 2002 alone promoting
energy conservation
Lin, J. *Energy Policy, 2007.*

comparison


JAKE 2/6/10
JAKE 11/9/09
Jake 7/6/09
JAKE 4-12-09
JAKE 2/20/09
JAKE 9/26/08
JAKE 1-27-08
JAKE 4/07/07
self comparison


PLEASE REUSE
THE TOWELS
We invite you to join with us to conserve water by using your towels more than once.
In addition to decreasing water and energy consumption, you help us reduce the amount of detergent waste water that must be recycled within our community.
Please hang the towels up if you wish to participate in the program — if not, simply leave them on the floor.
©1996
CONSERVING FOR TOMORROW
We appreciate your help!
Printed on recycled paper.
Laminated to reduce waste.



standard environmental message

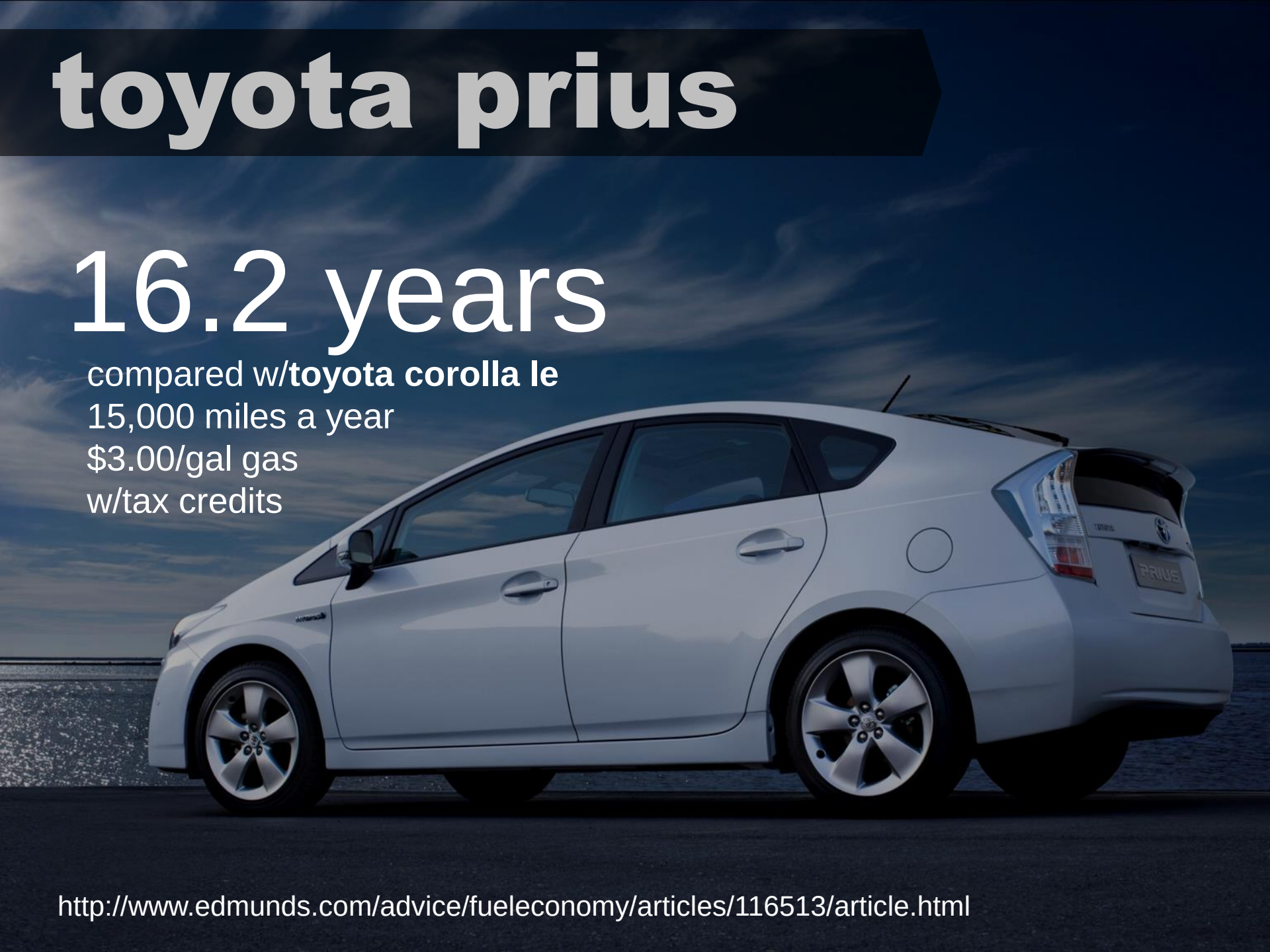
35.1%

descriptive norm message

44.1%

toyota prius

toyota prius



16.2 years

compared w/**toyota corolla le**
15,000 miles a year
$3.00/gal gas
w/tax credits

http://www.edmunds.com/advice/fueleconomy/articles/116513/article.html

pedometer cell phone fitness study

Figure 1. a) The Omron HJ-112 pedometer, b) the pedometer in use, and c) the Nokia 6600 mobile phone running Houston.

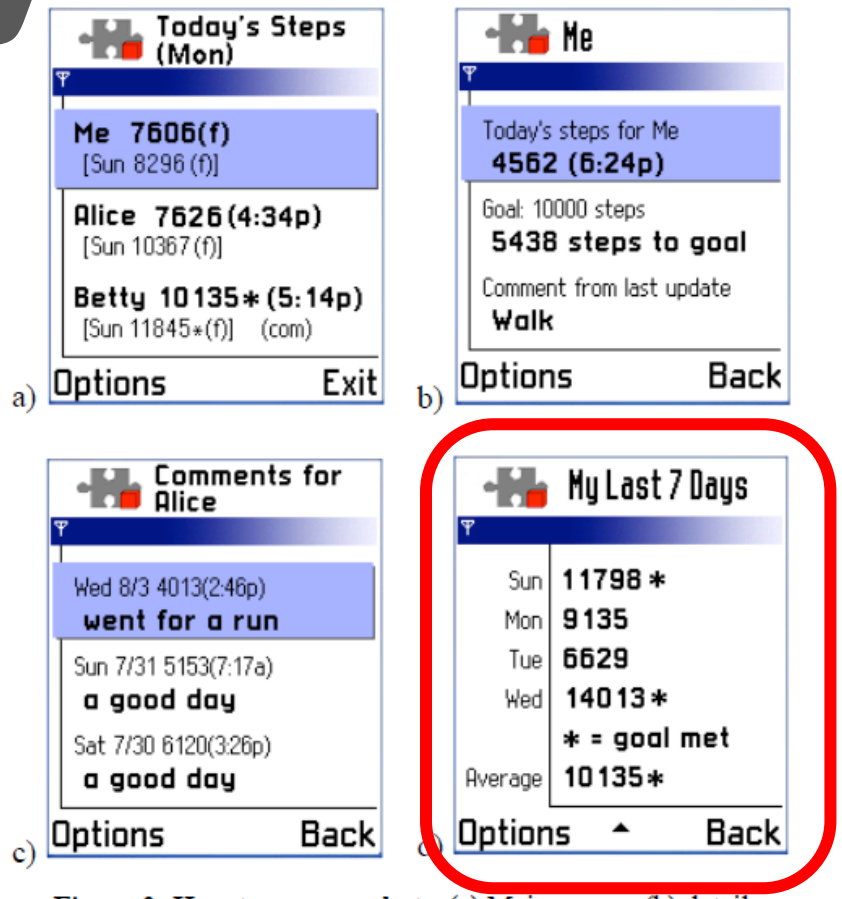
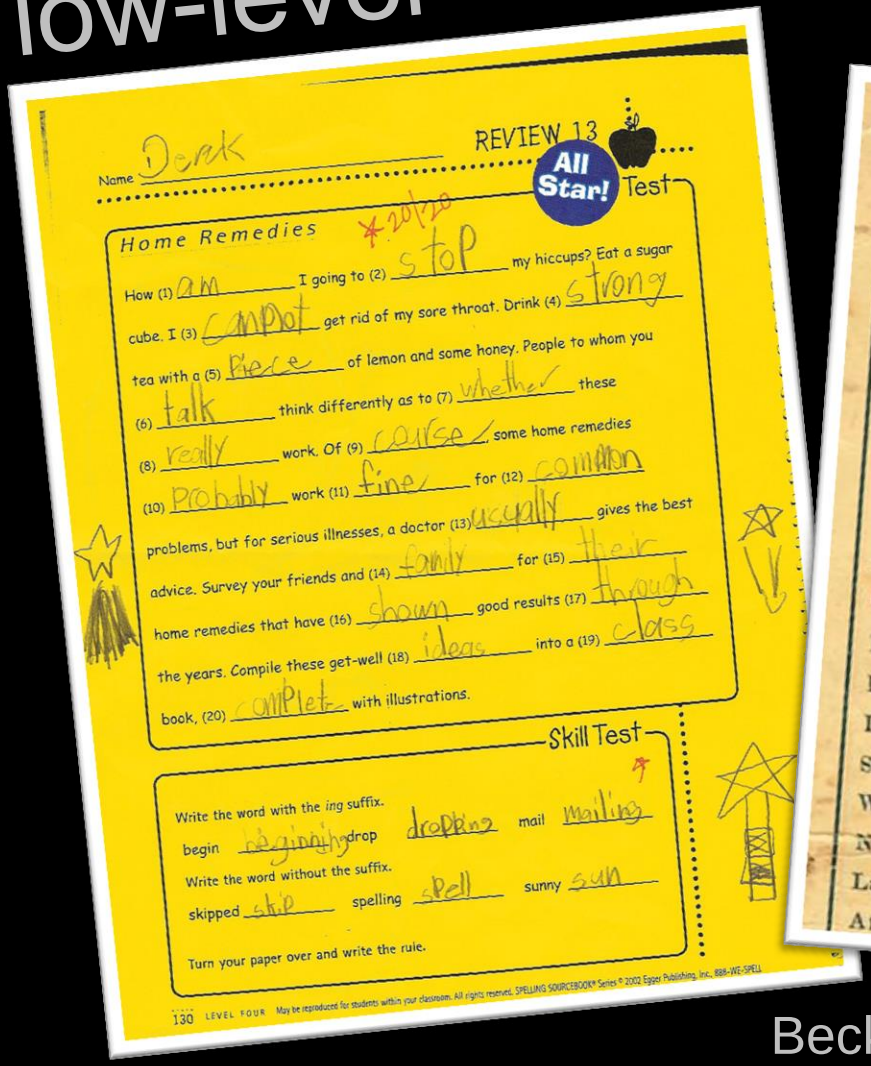


Figure 2: Houston screen shots. (a) Main screen, (b) detail screen, (c) recent comments, and (d) trending information.

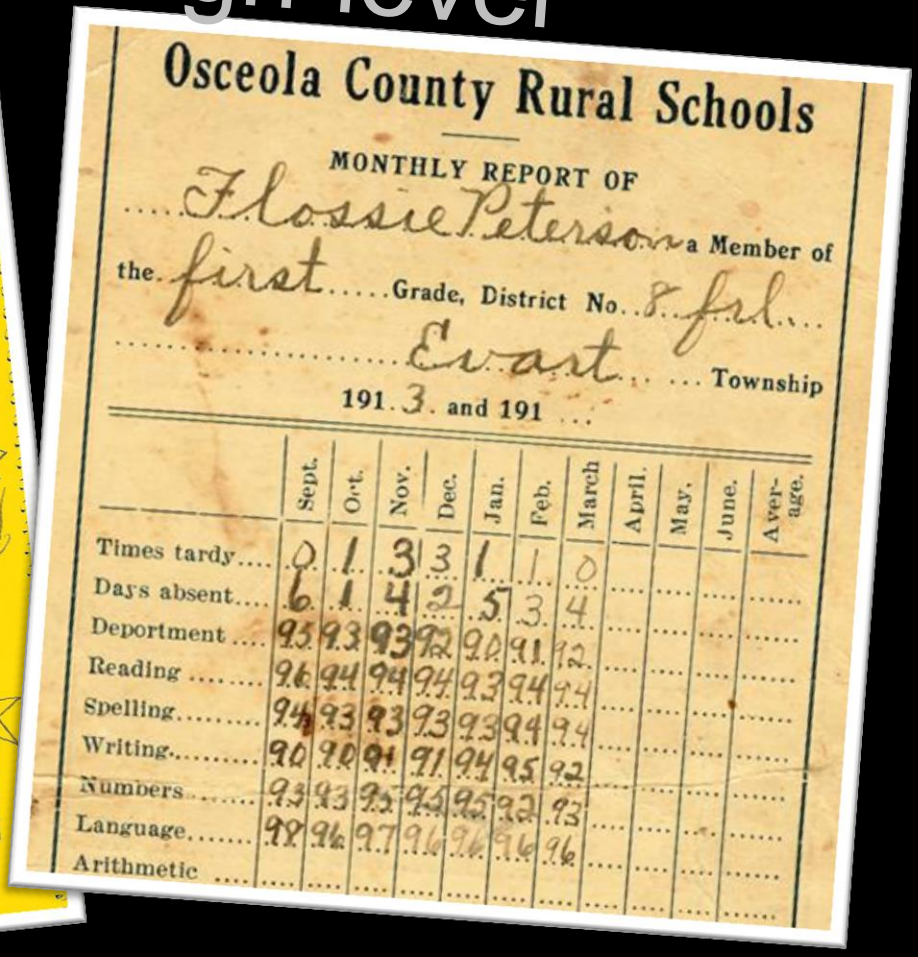
Consolvo, S., et al. Design Requirements for Technologies that Encourage Physical Activity. CHI 2006

two types of feedback

low-level

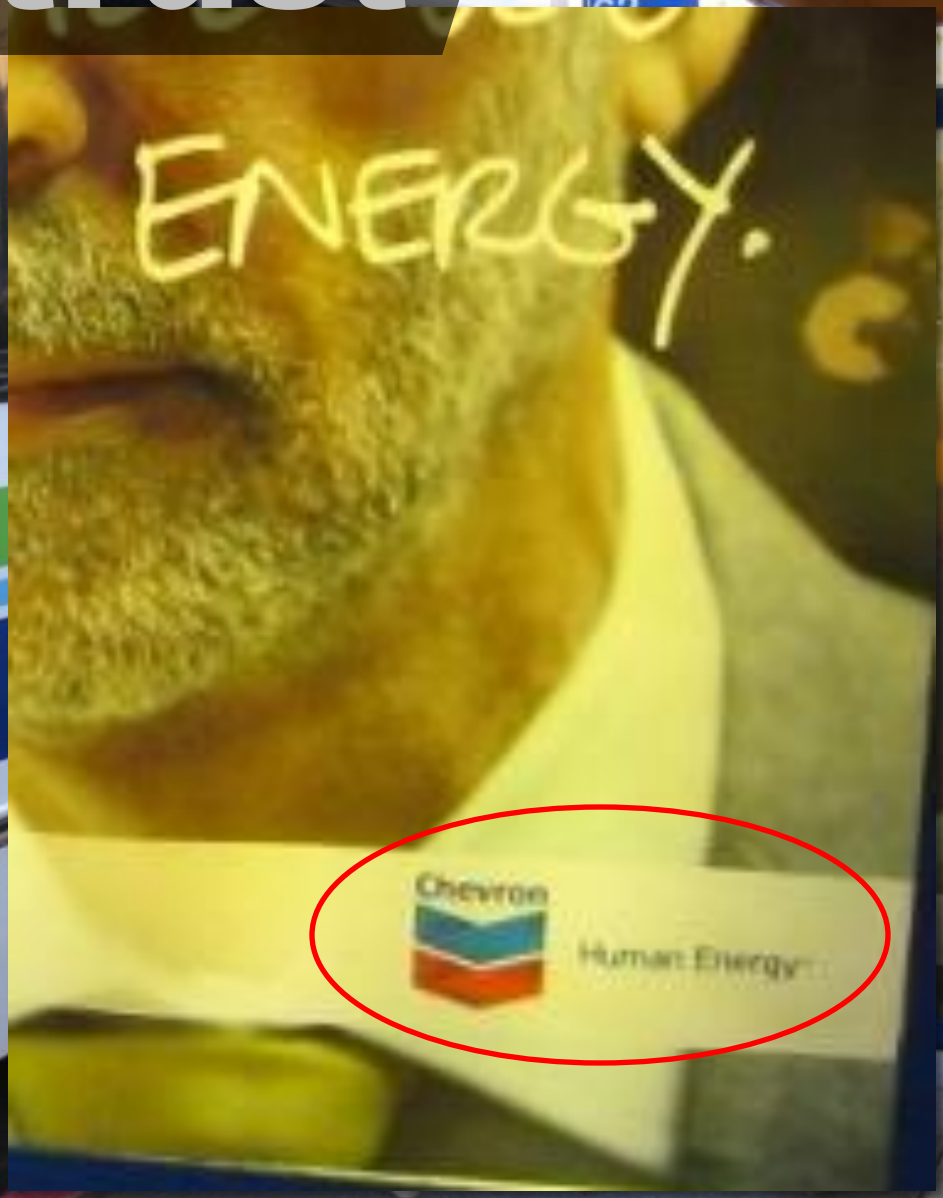


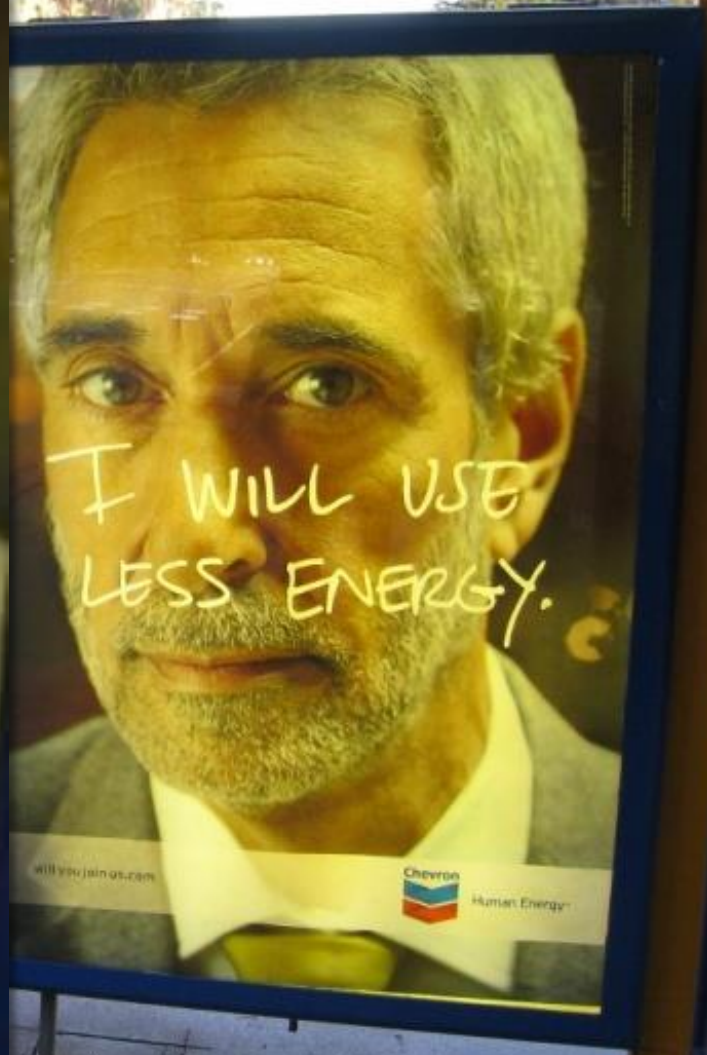
high-level



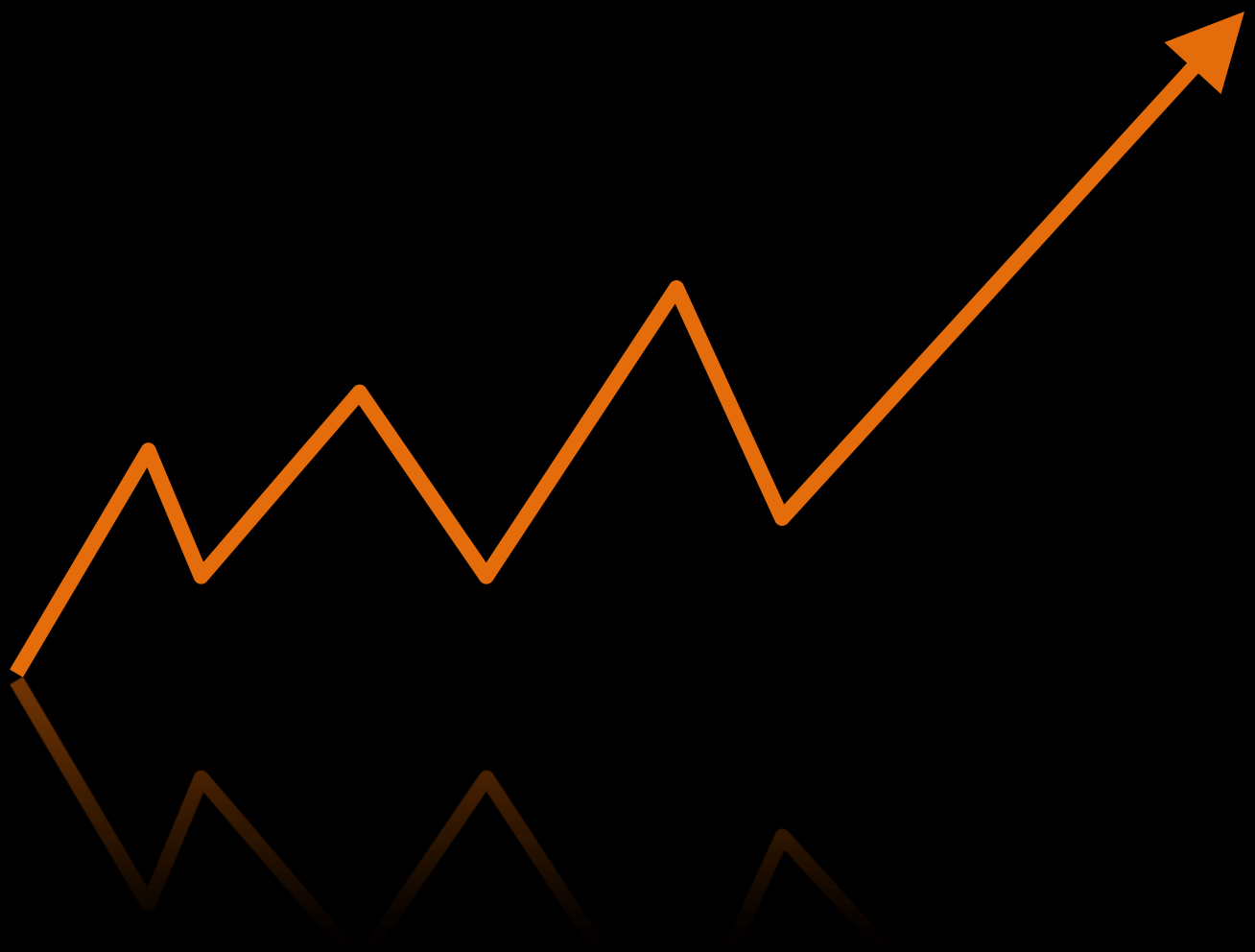
Becker, L.J., *J. of Applied Psychology 1978*

trust


ENERGY.
Chevron
Human Energy


I WILL USE
LESS ENERGY.
Chevron
Human Energy

why not increase costs?

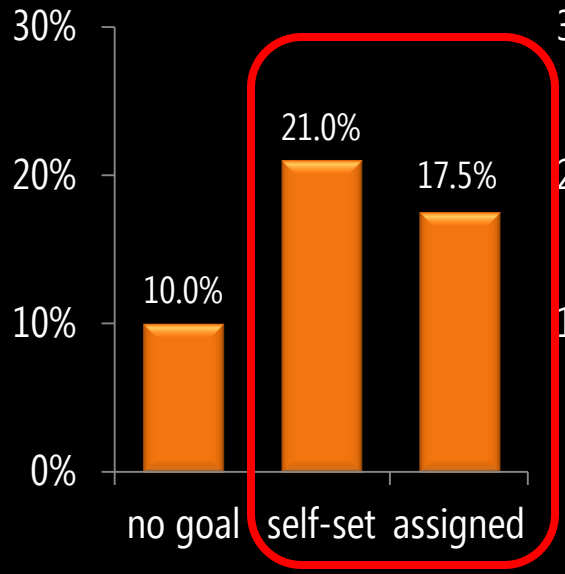


lab study

environmental psychology example

drop in energy usage

overall reductions

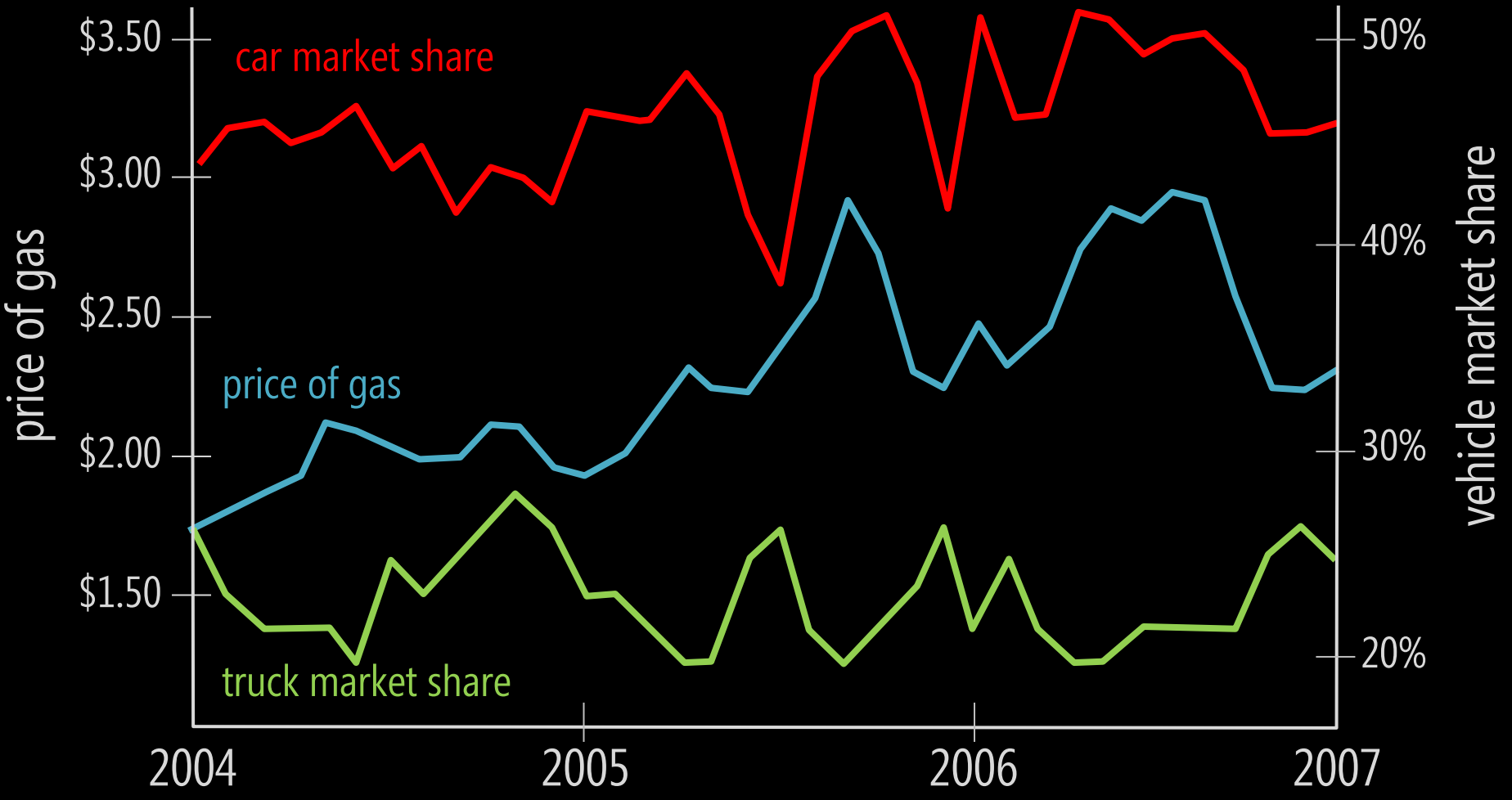


pro-self vs. pro-social

McCalley & Midden, *Journal of Economic Psychology, 2002*

rational choice example

the price of gas affects vehicle purchases



Congressional Budget Office, *Congress Report*, 2008

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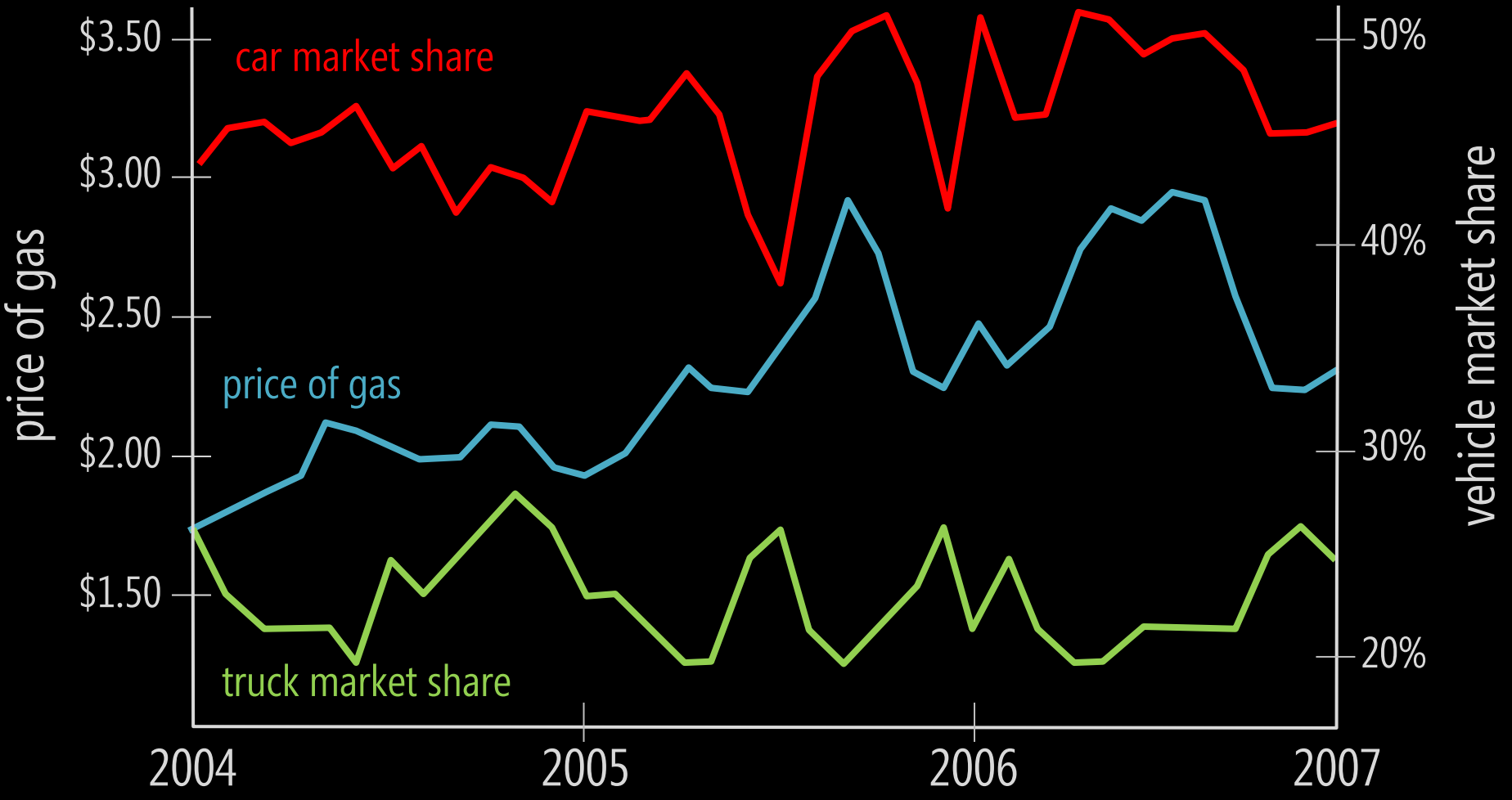

Congressional Budget Office, *Congress Report*, 2008