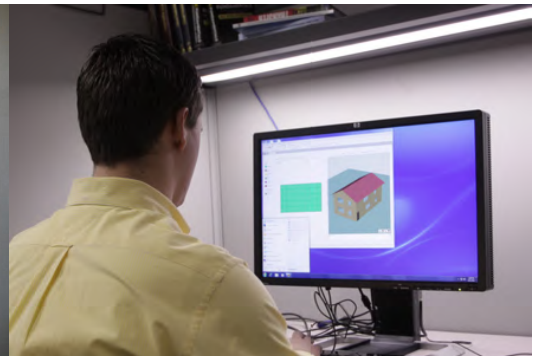
Field evaluation of programmable thermostats: Does usability matter?

Olga Sachs, Ph.D.

Fraunhofer Center for Sustainable Energy Systems, CSE

osachs@fraunhofer.org

Fraunhofer USA

Why thermostats?

- Programmable thermostats have a large energy saving potential
- Thermostat effectiveness depends on home occupant behavior
- Thermostat usability may facilitate energy saving behavior

Source: DOE/EIA.

Thermostat usability

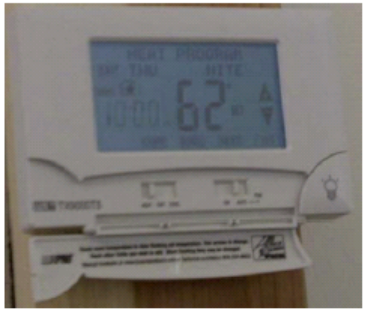
Development of new specifications for EnergyStar:

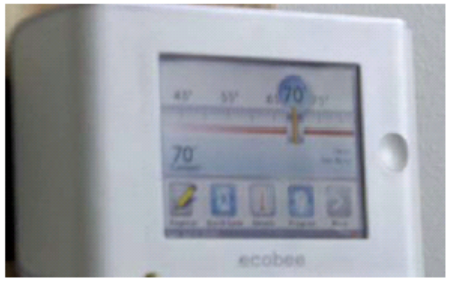
- Main assumption:
  - Improved usability will facilitate energy saving behavior
- Main questions:
  - How to measure usability of programmable thermostats?
  - How usability affects use and adoption of thermostat energy saving features?

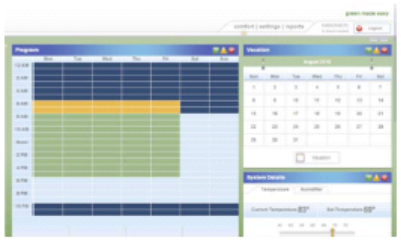
Thermostat usability

Usability tests at LBNL (A.Meier et al.):

- 5 thermostat interfaces
- 31 participants
- 2 intefaces per person
- 6 tasks for each test
- 372 videos



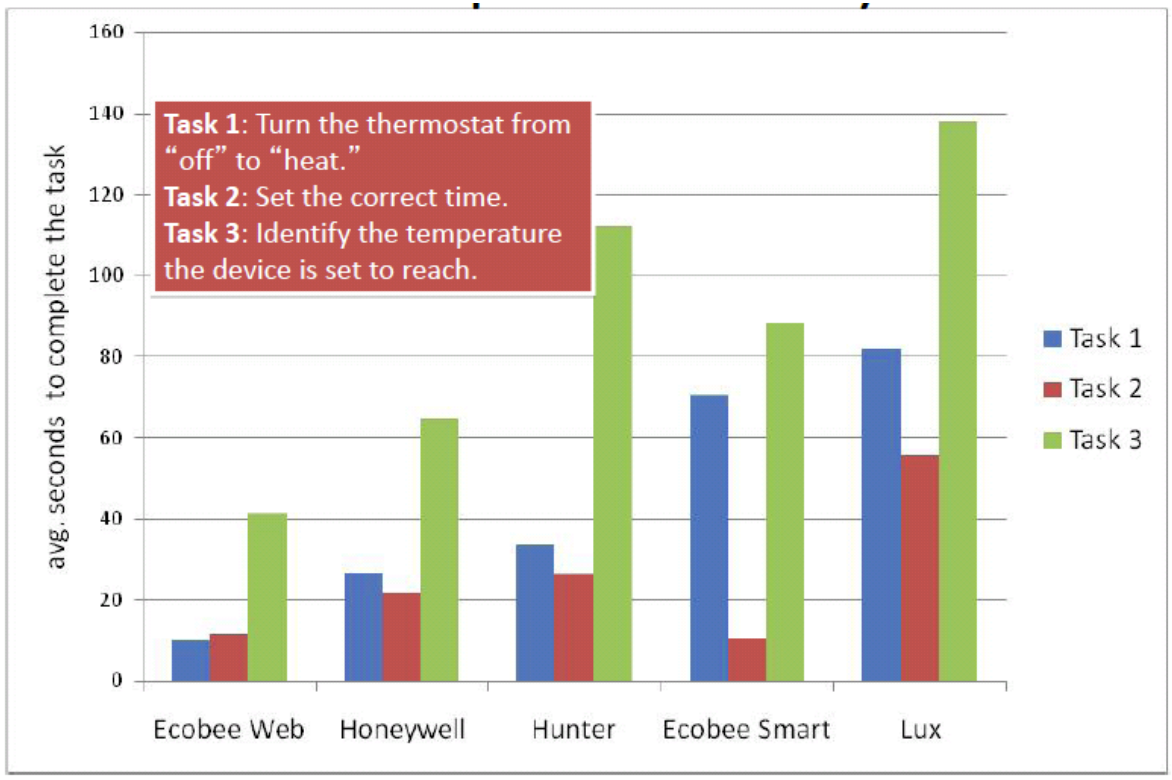



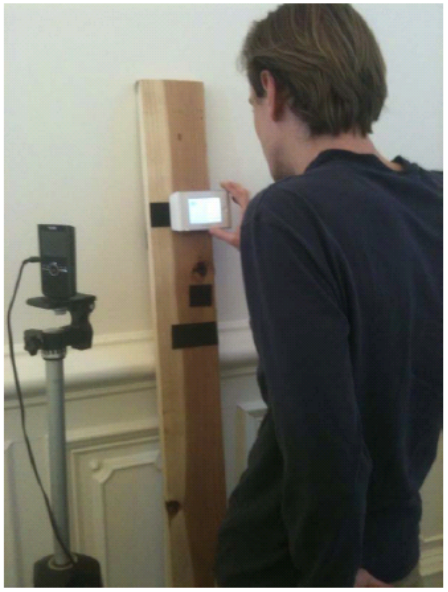


Fraunhofer USA

Thermostat usability

Usability tests at LBNL (A.Meier et al.):





Fraunhofer USA

Thermostat usability

Findings from usability tests at LBNL (A.Meier et al.):

- Touchscreen interface performed better than button interface
- Best-performing thermostat requires internet (WiFi) and computer
- Second best is Honeywell VisionPro

Does usability facilitate energy saving behavior?

U.S. Department of Energy (DOE), Building America project

- Field Evaluation Study
- Research question:

Are people with a high-usability thermostat more likely to use energy-saving settings?

Fraunhofer Project

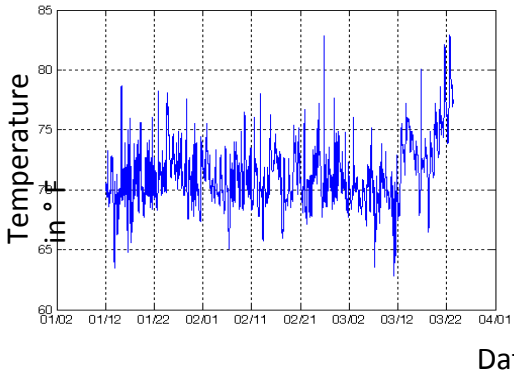
- Multifamily affordable housing building in Revere, MA
- Weatherization in entire building
  - Furnace/AC replacement, insulation and air-sealing of the back wall in the utility closet
- Opt-out recruitment
- 83 out of 92 households participated in the study
- 63 valid datasets

Fraunhofer USA

Fraunhofer Project

Winn Residential

- Touch screen (high-usability) thermostats
- Button interface (low-usability thermostats)
- Non-intrusive sensors to measure
  - Temperature
  - Humidity
  - Furnace on/off state
- Questionnaire data
- Gas meter readings
- Weather data (Boston)



Fraunhofer USA

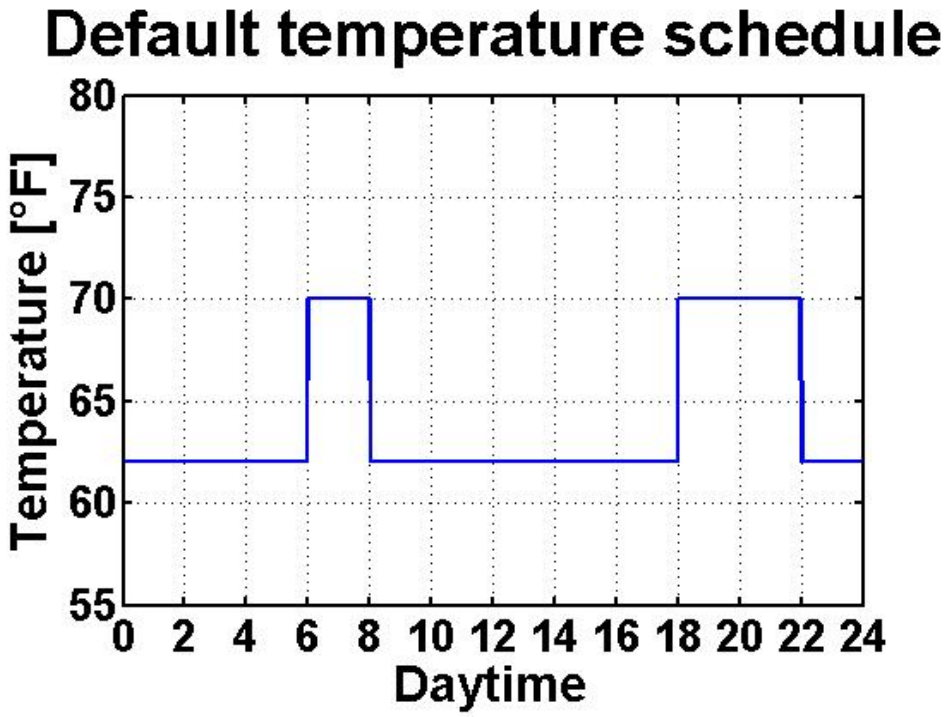
Two thermostat groups, same default settings

- “high usability” touch screen

  VisionPro 8000 (VP)

- “low usability” button interface

  Basic Programmable (BA)

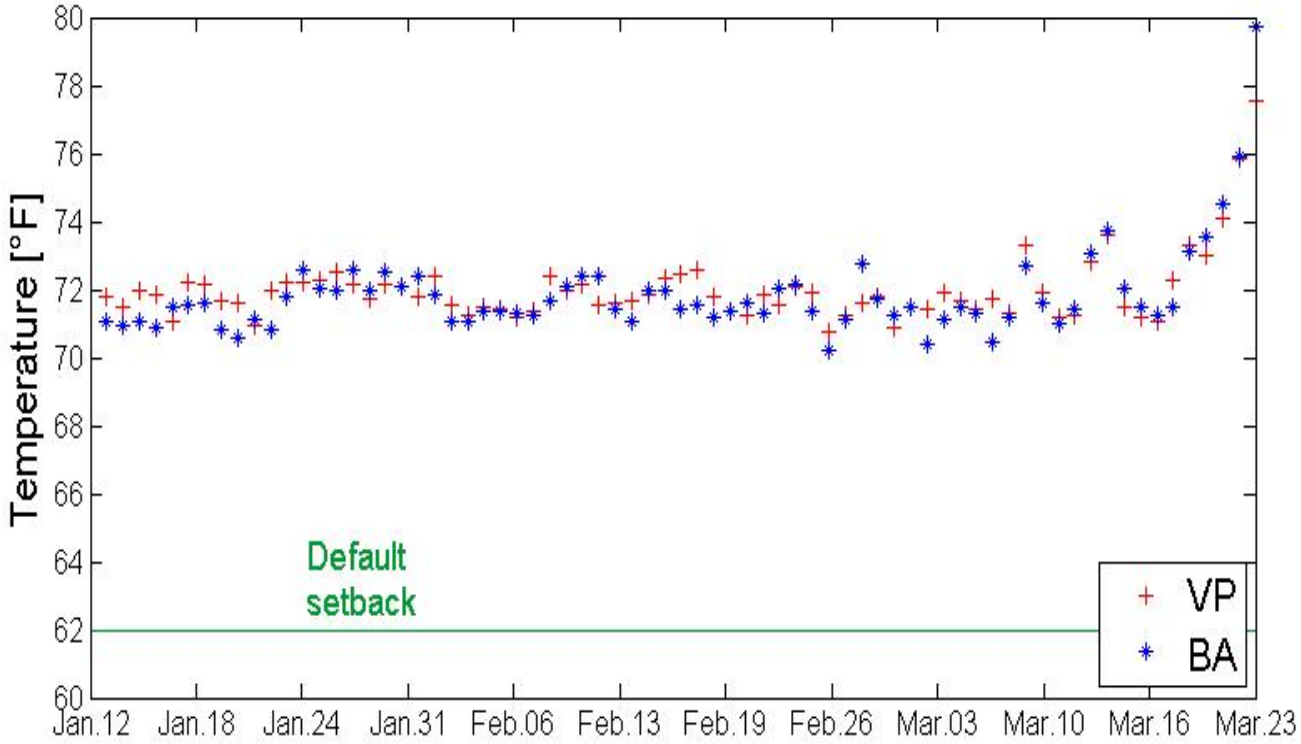


Fraunhofer USA

Behaviors analyzed

- Nighttime setbacks
- Daytime setbacks
- Permanent hold events

Mean Night temp – setback or not?

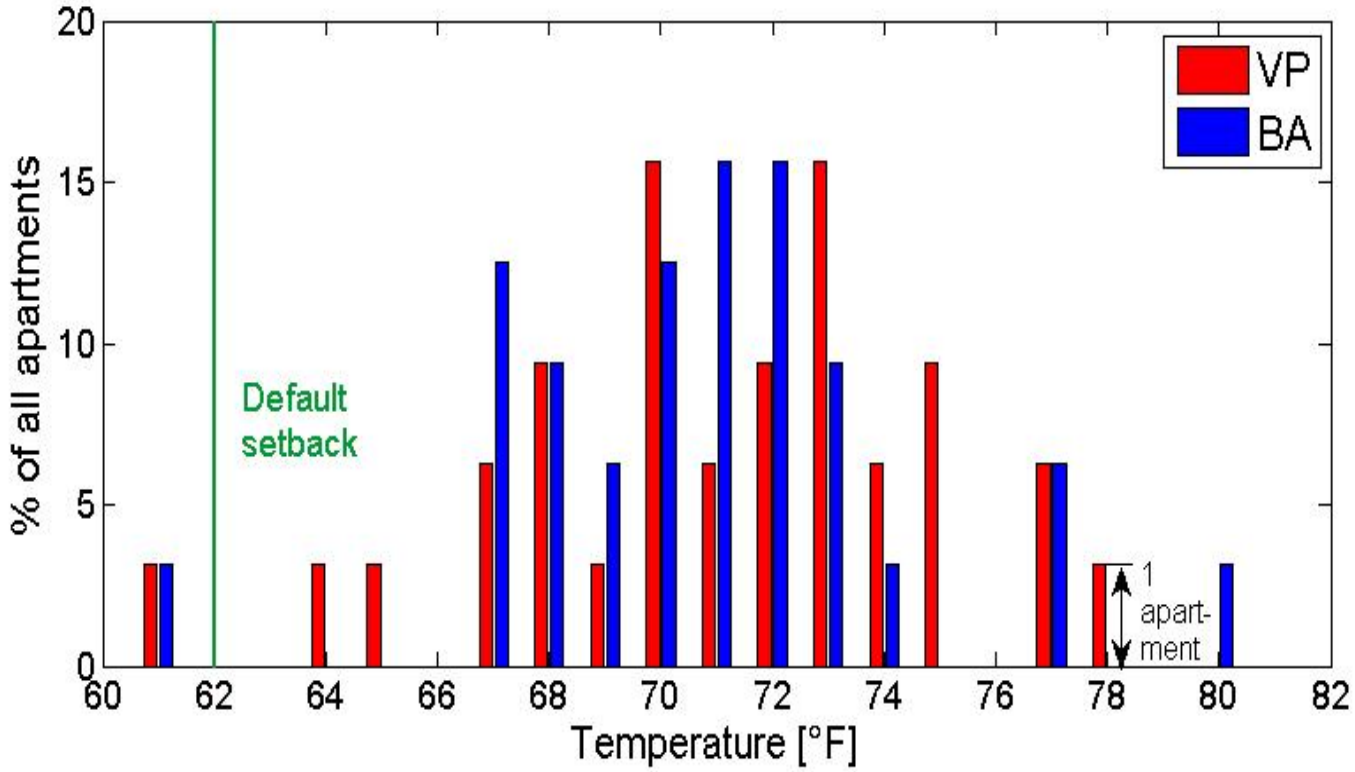


Fraunhofer
USA

Coldest nights

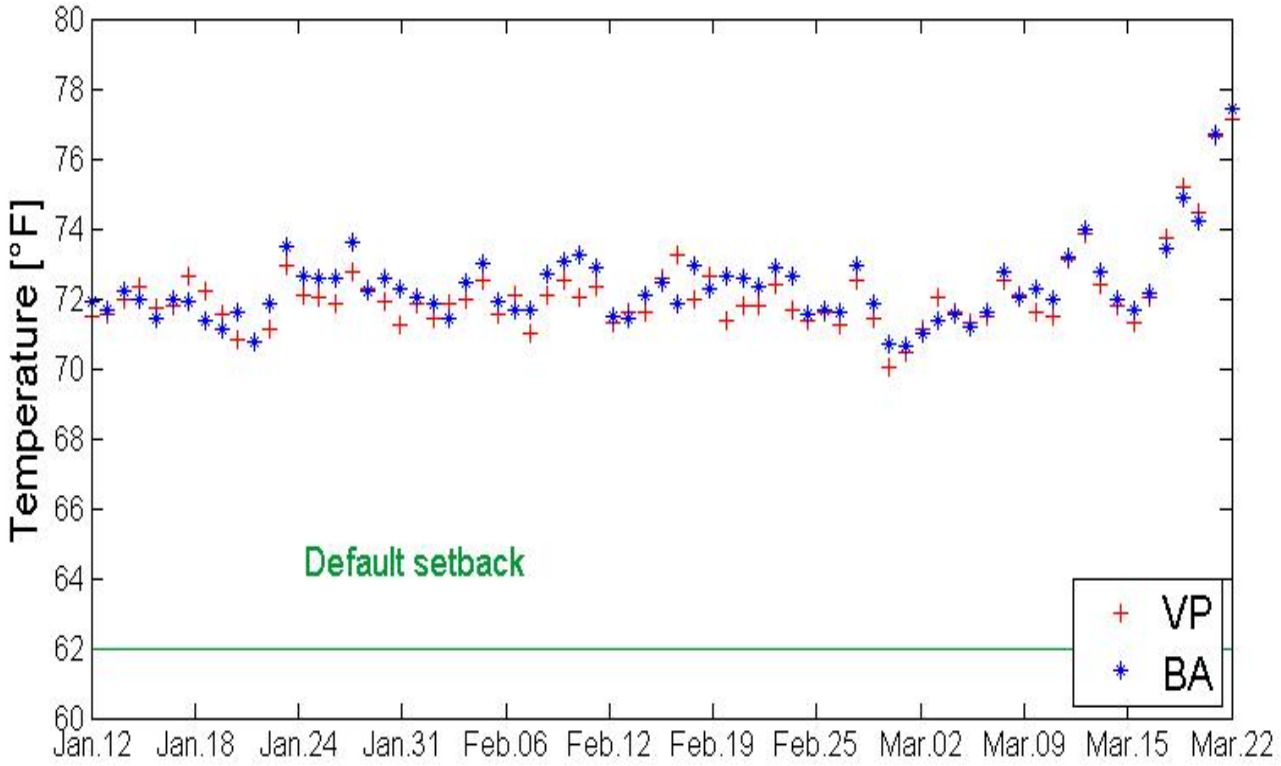
- Only nights when temperature fell below freezing 32°F (22 nights after January 12)
- Calculated average temperature for each apartment between midnight and 4AM
- Averaged for 22 cold nights

Coldest nights: mean apartment temperature



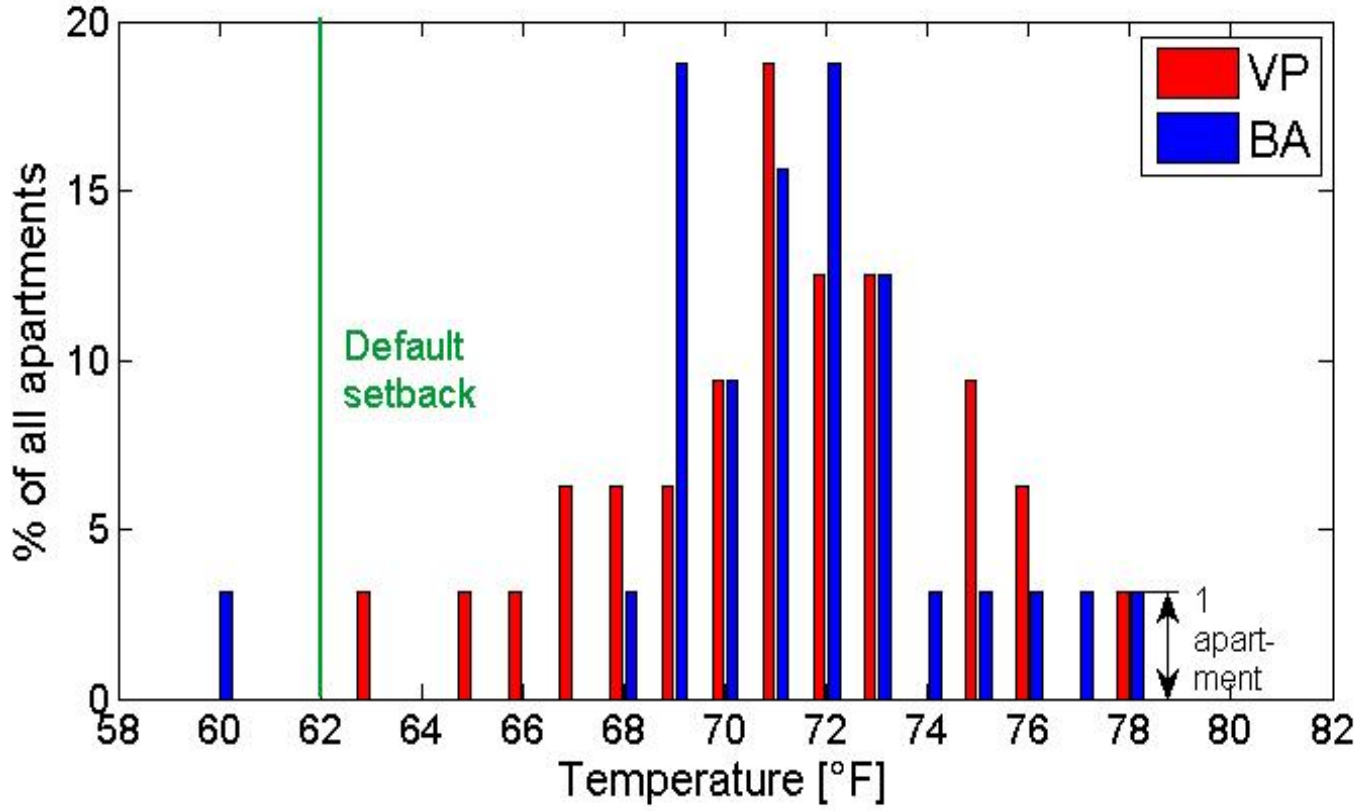
Fraunhofer
USA

Mean daytime (10am-2pm) temp – setback or not?



Fraunhofer USA

Days below freezing point: mean apartment temperature

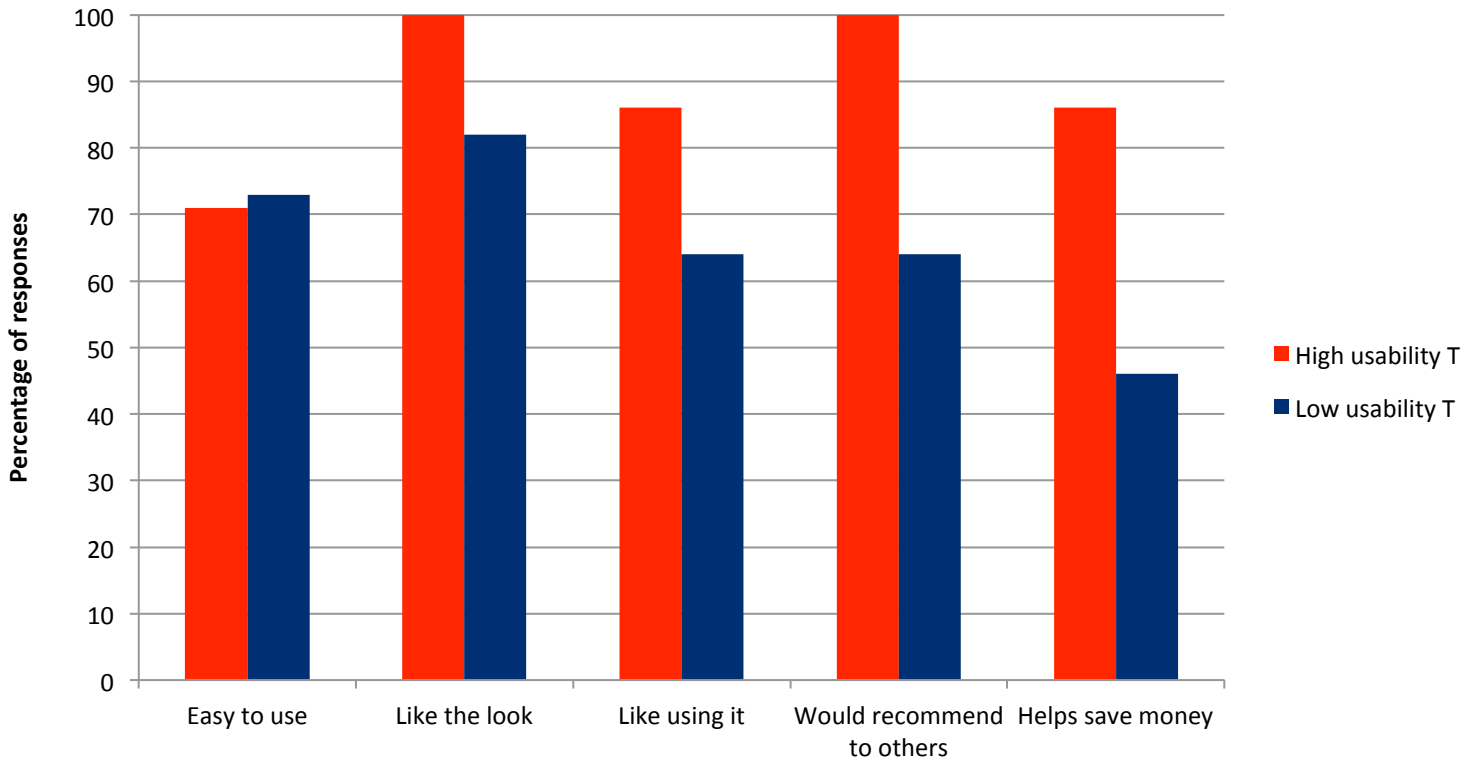


Fraunhofer
USA

Permanent hold events

	Low Usability (BA)	High Usability (VP)
% of apartments using hold feature	49%	25%
Average hold Temperature (°F)	75.3	74.4
Average duration per hold event	1.8 days	1.9 days
Mean of maximum hold event duration*	2.1 days	2.9 days
*Among all apartment who used the hold functionality in each group		

Satisfaction with thermostats



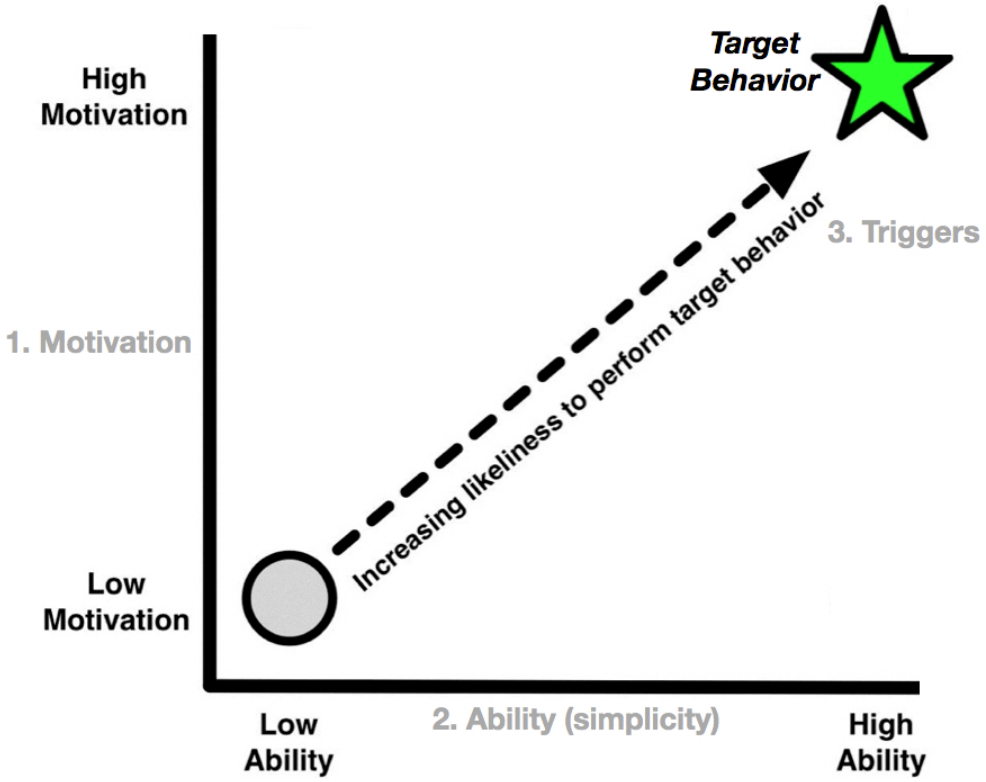
Fraunhofer USA

Summary

- Are people with a high-usability thermostat more likely to use energy-saving settings?
  - Not for nighttime setbacks
  - Not for daytime setbacks
  - Not for low-temperature vacation holds
- Why?

Behavior change requires more than USE-ability

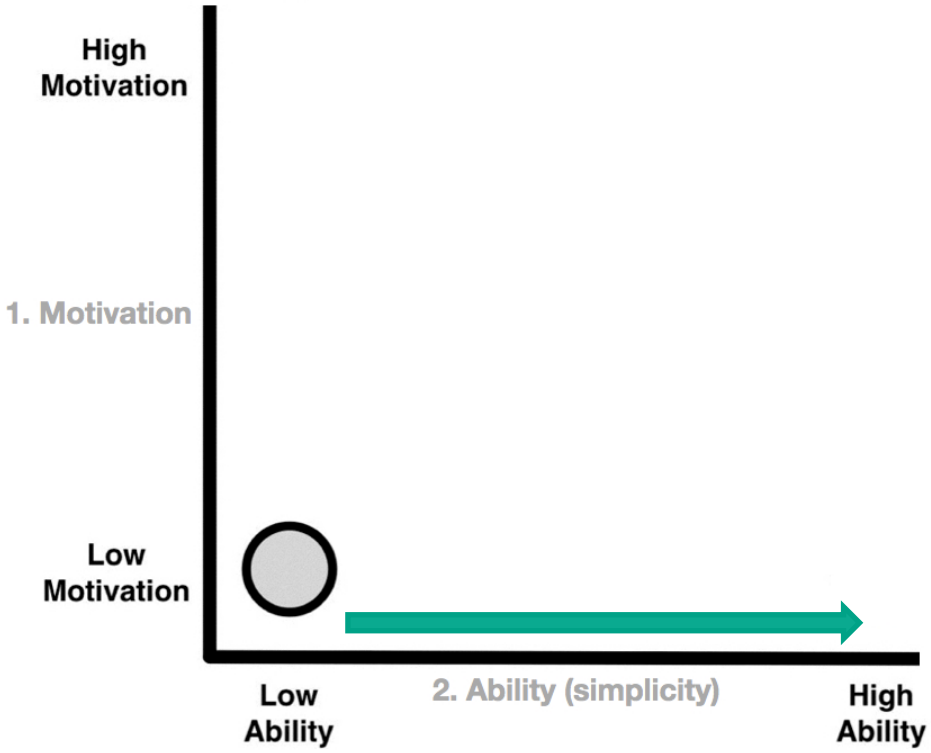
- Factors underlying Behavior Change:
  - Ability
  - Trigger
  - Motivation



Persuasive'09, April 26-29, Claremont, California, USA.

Thermostat behavior change: ability is not enough…

- Three main factors:
  - Ability
  - ~~Trigger~~
  - ~~Motivation~~



Fraunhofer USA

Limitations

- Population sample: affordable housing residents
- Thermostat models used
- Data collection and analysis methodology

Follow-up research

- Summer cooling data collection and analysis
- More realistic setback temp
- Integration of behavioral data into building performance models