Cognitive Bias and Demand Response

Overview and Problem Statement

To improve reliability and efficiency in the "smarter" grid, utilities are looking at *demand-response (D-R)* programs, in which the utilities use higher prices to motivate users to reduce their electric loads during periods of high grid stress. As we move towards smart homes connected by the *Internet of Things (IoT),* it's becoming easier to do that automatically. For example, a user might give his smart thermostat both a desired temperature and a "comfort vs. savings" preference. If the grid is experiencing stress, the utility communicates a higher price to the smart thermostat, which (for the users who chose some amount of "savings") will reduce the local load, and also save the user money—at the expense of a less comfortable temperature.

However, to be effective, that model makes some assumptions:

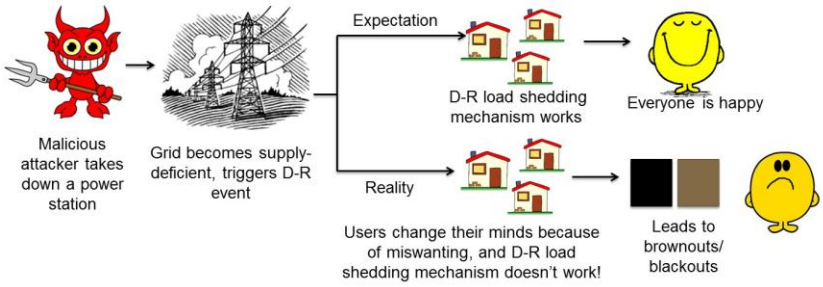
1) Users will construct accurate mental models from what their smart devices tell them.
2) Users will make *rational, logical* decisions based on that information—in this case, an educated decision to minimize their energy costs by enduring some reasonable amount of inconvenience.
3) Users will be able to use the infrastructure provided by the technology to implement their decisions correctly.

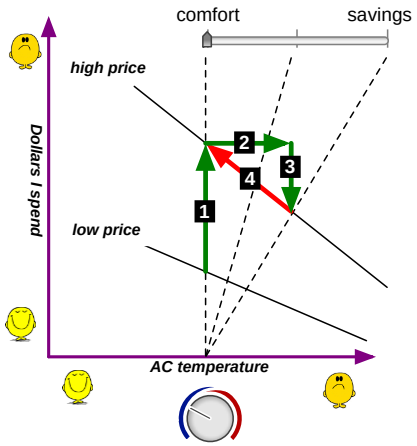
However, a large body of psychology work contradicts these assumptions and provides a catalog of cognitive biases and misperceptions that affect the decision process of the human mind. Those cognitive biases may skew users' perceptions of a scenario, leading them to make decisions that might not be optimal for that scenario, or they may mislead users into selecting choices that do not actually represent their intended decisions.

One of the most common of those biases is the *impact bias*, which is the disparity between what we predict, and what we ultimately experience. Those errors in estimating what would be desirable to us in the future lead to *miswanting*.

In this project, we analyze how the impact bias affects user decisions in a D-R scenario similar to the one employed in the power grid.

Why Impact Bias is Important:



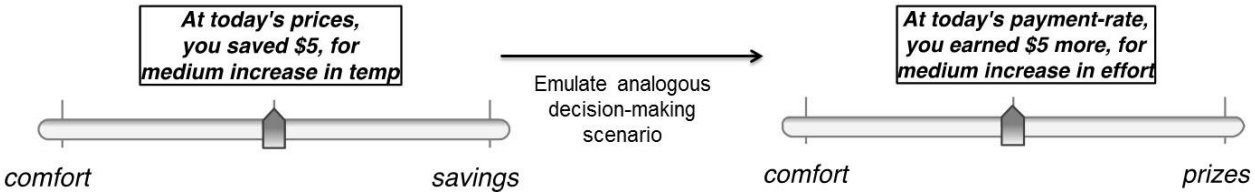


A smart thermostat may let the user specify a comfort/ savings preference in addition to desired temperature, enabling automatic DR: (1) The utility raises the price; (2) the thermostat automatically reduces the AC load; (3) the user saves money. If the impact/miswanting bias occurs, the user, in that moment, will decide he's too uncomfortable, and (4) change the setting back.

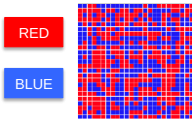
Research Objectives

- To understand how the cognitive biases of users, and, in turn, user decisions, affect the security and reliability of the power grid.
- To understand, in particular, how impact bias and miswanting affect the security and integrity of the demand-response systems in the grid.
- **Smart Grid Application Area:** Demand-response systems.

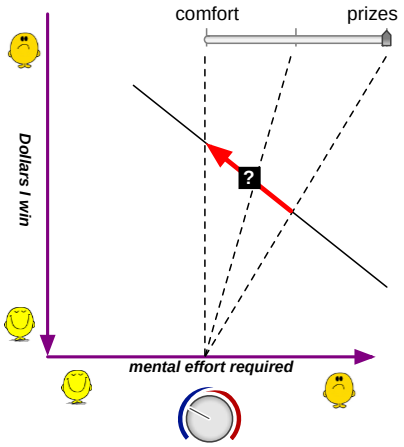
Solution Approach



- The goal is to test for impact bias and miswanting in a decision-making scenario similar to that of the D-R system in the power grid.
- Test subjects will be given a perception-based test in which they need to estimate whether a figure is more red or more blue. We control how difficult the task is.



- The more difficult the instance, the less comfortable the test subject will be, analogous to the discomfort experienced with a too-warm AC setting.
- A higher difficulty means higher monetary compensation, but test subjects won't be compensated for giving the wrong answer. Hence, they'll face a comfort/savings trade-off analogous to that of AC settings.
- Each test subject will choose a comfort/savings slider setting. We will calculate the corresponding level of discomfort for a variety of price levels.
- Test subjects will then play the game for a sequence of the discomfort levels, analogous to experiencing what their smart thermostat chooses for them, based on their slider preference, in response to the current price.
- Throughout, we will ask them if they wish to change their slider preference, once they've experienced what it actually means in practice.
- That will give us an idea of how the test subjects would behave in a real-time D-R scenario, showing the impact of cognitive bias, if any.
- (We will use a calibration run to calculate each test subject's psychometric function, so we can normalize perceived difficulty across the subjects.)



In our experiment, we will replace room temperature with difficulty of perception-based tasks, and replace "savings" with prize money for giving the right answers. If we observe miswanting (such that some users overestimate how much "discomfort" they can tolerate and hence want to revert to an easier level), it will prove that impact bias can affect users' predictions of their preferences and, in turn, the effectiveness of security measures that depend on such preferences

Researchers

- Vineetha Paruchuri, Vineetha.Paruchuri.GR@dartmouth.edu (Computer Science)
- Jason Reeves , Jason.O.Reeves.GR@dartmouth.edu (Computer Science)
- Sean W. Smith, sws@cs.dartmouth.edu (Computer Science)
- Alireza Soltani, Alireza.Soltani@dartmouth.edu (Psychology and Brain Science)

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funded by the U.S. Department of Energy and the U.S. Department of Homeland Security