Cognitive Bias and Demand Response

Impact of Cognitive Biases in System Security

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GOALS

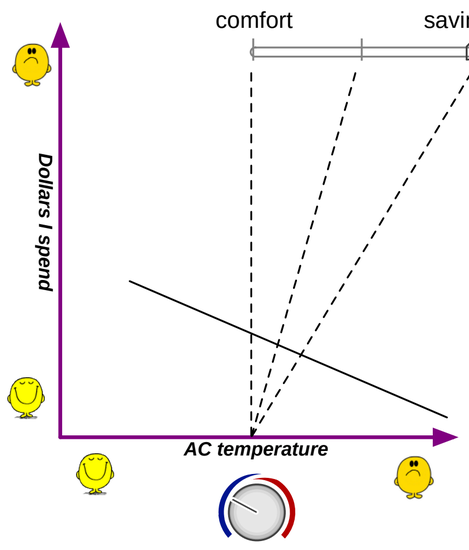
- To understand how the cognitive biases of users, and, in turn, user decisions, affect the security and reliability of the power grid.
- To understand, in particular, how ***impact bias*** and ***miswanting*** affect the effectiveness of ***consumer-side demand-response*** as a mechanism for security and reliability.

DEMAND-RESPONSE SYSTEMS

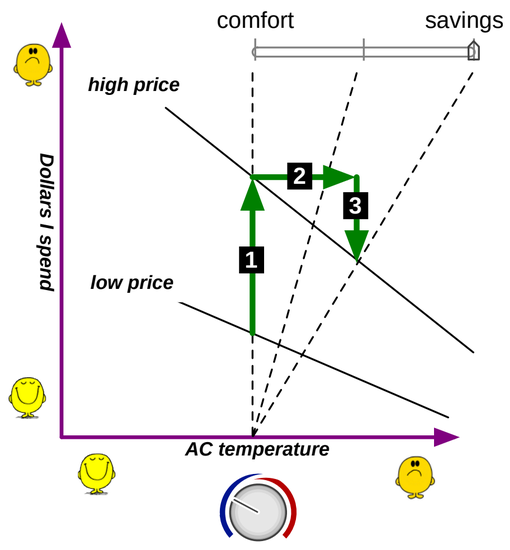
- Demand-response is "the ability of customers to respond to either a reliability trigger or a price trigger by lowering their power consumption." [1]

WHY DEMAND-RESPONSE SYSTEMS?

- The power distribution and consumption scenario is changing: new loads to support, such as electric vehicles; smart homes connected via the Internet of Things (IoT); renewable energy, etc.
- To make the grid reliable in the face of those changes, and to leverage the technological advancements towards achieving a smarter grid, one of the things we can do is use consumer-side demand-response.
  - Customers can save money by shifting loads to time periods when rates are low [2].
  - Utilities can reduce stress on the grid by encouraging and/or coercing customers to shift loads [3].
  - EVERYBODY WINS!



A smart thermostat may let the user specify a comfort/savings preference in addition to desired temperature.



Automatic DR is enabled according to user specifications. (1) The utility raises the price; (2) the thermostat automatically reduces the AC load; (3) the user saves money.

THE PROBLEM

- Since the users have a certain level of decision-making control in the demand-response system, understanding how the user behavior affects the system is crucial.
- Most researchers assume that consumers will always make the rational choice to maximize their utility.

> *"We show that… when users selfishly maximize their own surplus under the optimal prices, their consumption decisions… maximize the social welfare." [4]*

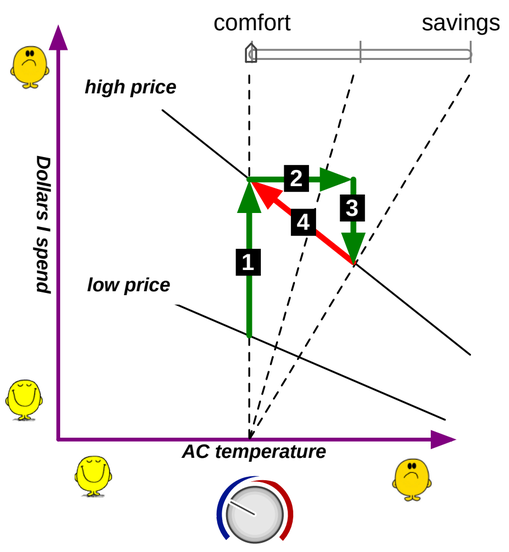
> *"Consumer rationality assumptions indicating real world scenarios have been utilized." [5]*

- The rationale behind a demand-response (D-R) event is that users are allowed to choose in advance how their systems behave during high-price periods (such as when the grid is supply-deficient), and the utilities assume that people will make a rational decision to save money and thus give the utility the ability to shed load just by raising the price of power.

PROBLEM: Humans don't always make rational decisions!

Psychology shows that users are prone to certain ***cognitive biases***, and these biases can potentially affect user decisions.

Understanding how these biases affect the security of the system as a whole is crucial.



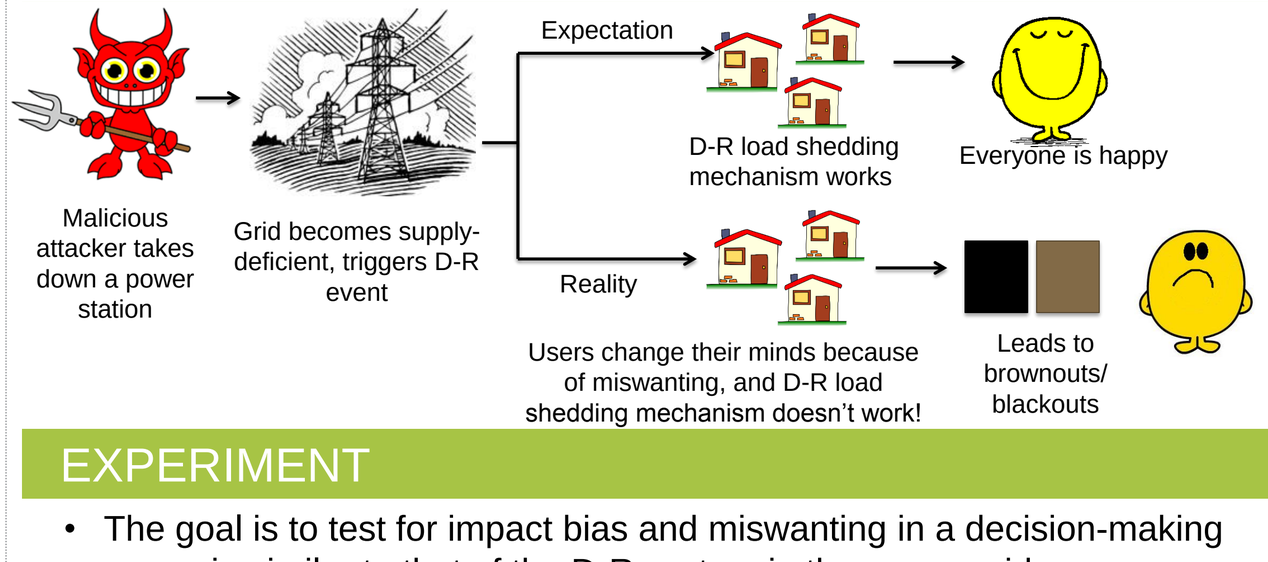
If the impact/miswanting bias occurs, the user, in that moment, will decide he or she is too uncomfortable, and (4) change the setting back. In the aggregate, that may nullify the DR and compromise the integrity of the grid, causing brownouts and/or blackouts.

IMPACT BIAS AND MISWANTING

"You are even wrong to reckon that a cheeseburger you order in a restaurant—this week, next week, a year from now, it doesn't really matter when—will definitely hit the spot. That's because when it comes to predicting exactly how you will feel in the future, you are most likely wrong" [6].

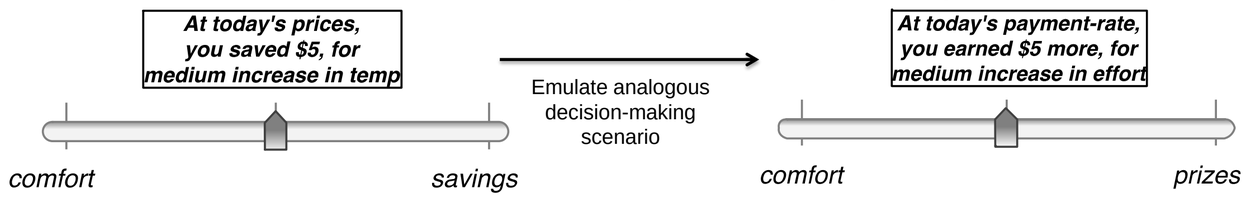
The disparity between what we predict, and what we ultimately experience, is called the *impact bias*. Those errors in estimating what would be desirable to us in the future lead to *miswanting* [7].

WHY IMPACT BIAS IS IMPORTANT

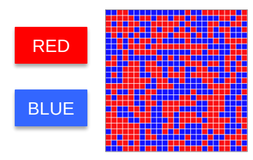


EXPERIMENT

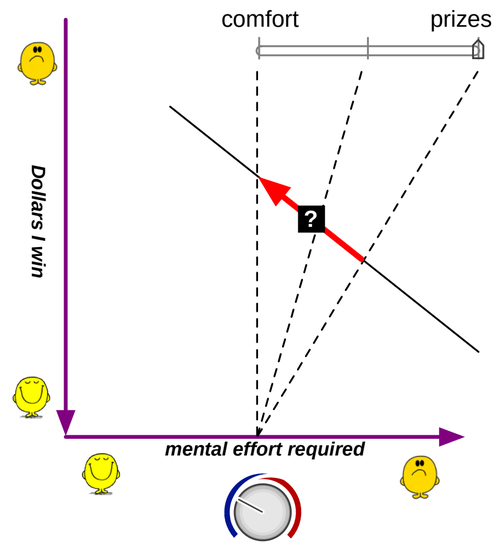
- The goal is to test for impact bias and miswanting in a decision-making scenario similar to that of the D-R system in the power grid.



- 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.

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FUNDING SUPPORT PROVIDED BY DOE-OE AND DHS S&T