

Lecture 10

Incentive Design: Badges and Attention

Questions: [#18656](https://sli.do)

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Logistics: Deadlines

- Assignment 2: Due this Friday (Don't wait till the end)
- Assignment 3: Due Oct 27 (Tue)
- Project milestone 1: Due Oct 30 (Fri)
 - Initial literature survey (know what other works are out there)
 - A plan on what you want to do for the remaining of the semester
 - Formalize your research question and approaches, e.g.,
 - Theory/simulation project: formalize your models
 - Data-analysis project: figure out where and how to get data and what you plan to do with it
 - Experiment/application project: have a prototype design and an evaluation plan
 - Include a timeline (weekly or biweekly) on what you plan to do

Logistics: Presentation

- For presenters:
 - Give a **45-50 min** presentation based on the **required reading** and **one optional reading** (2 optional readings for 3-person groups) of a lecture.
 - The papers are the “backbone” of the presentation.
 - Prepare **2 reading questions** for the required reading
 - Prepare **1~2 discussion sessions**
 - Lead the discussion for the discussion sessions
 - Template format (if you are not sure what to do):
 - Explain the required reading (20 min)
 - Discussion session (5~10 min)
 - The option reading (20 min)
 - Feel free to be creative and include materials outside of the papers.

Logistics: Presentation

- For presenters:
 - You do not need to submit the review for the lecture of your presentation
 - Talk to me **one week before your presentation.**
 - Default time: talk to me after class
 - You need to be ready for the following before meeting with me
 - Finish reading the papers
 - A structure of your presentation
 - Two reading questions for the required reading
 - Topics for one or two discussion sessions
- For non-presenters:
 - Read the required reading, submit the review, participate in discussion
 - Complete a peer-review form: try to give constructive feedback

Today's Lecture

- Discussion on the design of non-financial incentives
 - Badges (Steering User Behavior with Badges. Anderson et al. WWW 2013.)
 - Attention (Incentivizing High-Quality User-Generated Content. Ghosh and McAfee. WWW 2011.)
- If time permits, continue on the Oct 8 lecture
 - Scoring rule
 - Brief notes on peer predictions

Badge as Incentives

Steering User Behavior with Badges. Anderson et al. WWW 2013.

Warm-up Discussion

- Have you ever been incentivized by badges?
Share your experience with other students.
- Discuss on whether those badges can be designed better? Try to more **formally** describe the aspects of **design** and define what you mean by **better**.
 - Think of this as a practice to "model" the world that you care about.

Modeling Badges

- Focus on threshold badges

● Civic Duty

Vote 300 or more times

● Editor

First edit

● Strunk & White

Edit 80 posts

● Copy Editor

Edit 500 posts (excluding own or deleted posts and tag edits)

- Representation of threshold badges:

- Earn a badge for “taking an action K times”

Modeling Badges as Incentives

- Key elements in modeling incentives
 - **Players**, Action space, Payoff
- One naïve model for threshold badges
 - **Players**: Only single user since there is no user interaction in threshold badges
 - **Action space**: # actions the user decides to take
 - **Payoff**: Utility(HasBadge(# actions)) - Cost(# actions)
- Model prediction: Users take actions that maximizes payoff
- This model helps answer some questions but not others
 - What can this model tell us?

*All models are wrong
but some are useful*



George E.P. Box

Modeling Badges (Action)

- Interactions between different types of actions.

Introduce action types $(A_1, \dots, A_n, A_{n+1})$, where A_{n+1} is the “life action”

- Sequential decision making instead of one-shot decision

User history is summarized in a vector $\mathbf{a} = (a^1, \dots, a^{n+1})$

a^i : # times actions of type i has been taken

The user can only take one (mixed) action at a time

User policy $\mathbf{x}_{\mathbf{a}}$: given history \mathbf{a} , the prob. distribution over action types

Modeling Badges (Payoff)

- Cost of actions

User have a preferred (mixed) action \mathbf{p}

Cost for take action x : $g(x, \mathbf{p})$ distance to the preferred action

- Utility for obtaining badges

Value of the badge b : V_b (assume this is given)

Indicator function of whether the badge is obtained

$$I_b(a) = \begin{cases} 1, & \text{if the history } a \text{ qualify for badge} \\ 0, & \text{otherwise} \end{cases}$$

Modeling Badges (Payoff)

- Discounted future payoff

The payoff in the next round is discounted by $\theta = 1 - \delta < 1$

Users aim to take action x_a that maximizes $U(x_a)$

$$U(\mathbf{x}_a) = \sum_{b \in B} I_b(\mathbf{a}) V_b + \theta \sum_{i=1}^{n+1} \mathbf{x}_a^i \cdot U(\mathbf{x}_{\mathbf{a}+\mathbf{e}_i}) - g(\mathbf{x}_a, \mathbf{p})$$

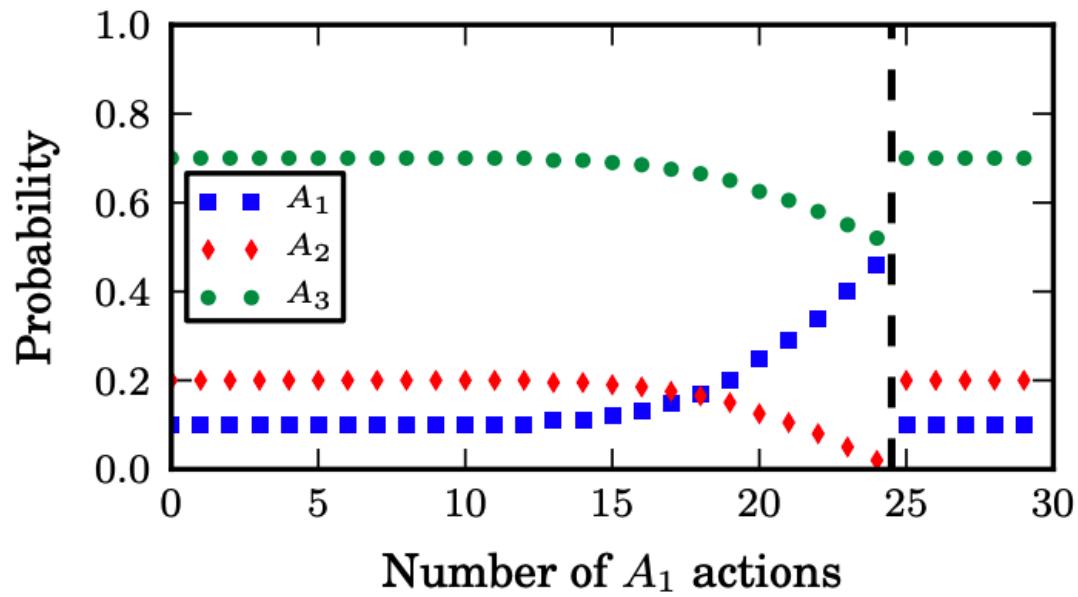
Payoff from current badges

Cost of action

Payoff from “future” badges from actions

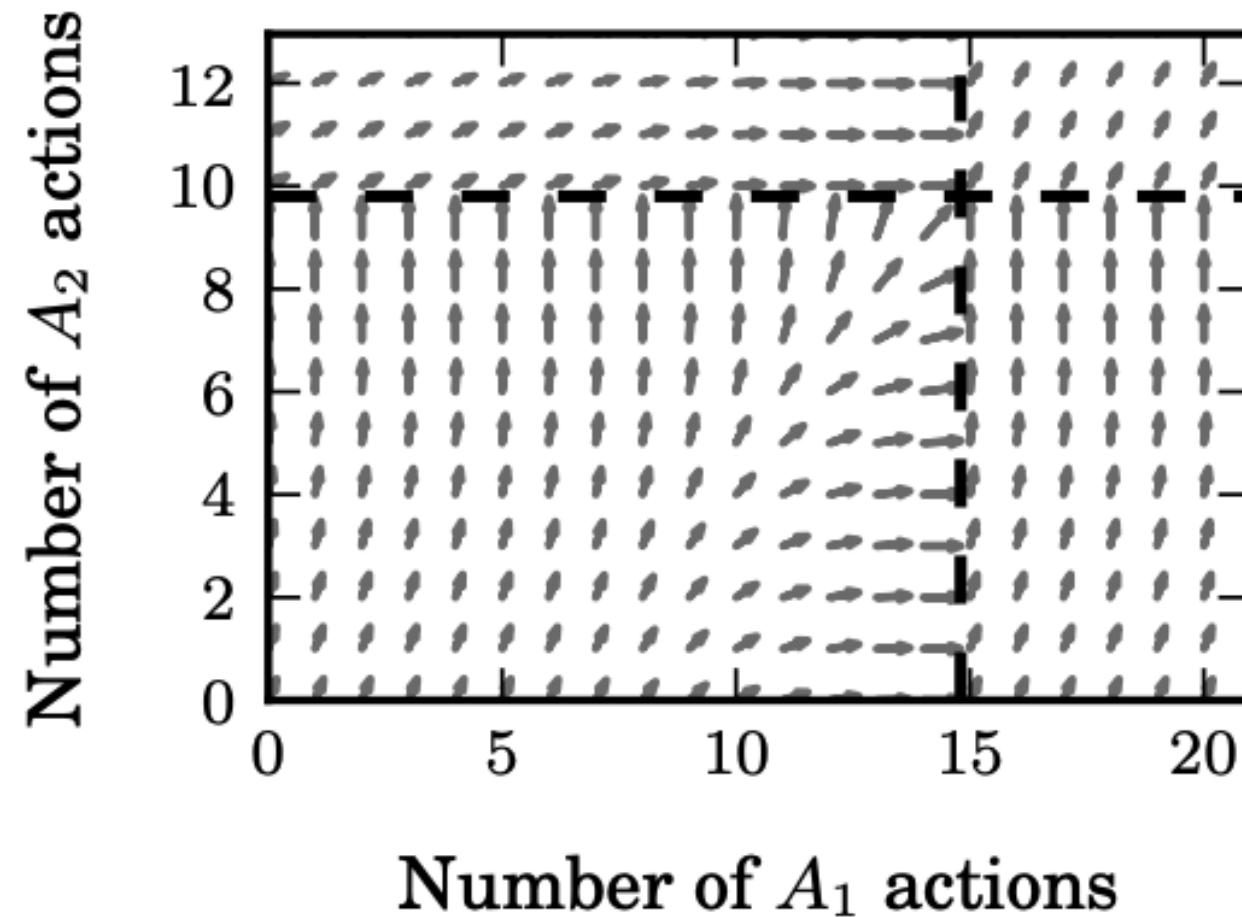
Think about what actions users will take if we believe this model is correct?

Model Predictions



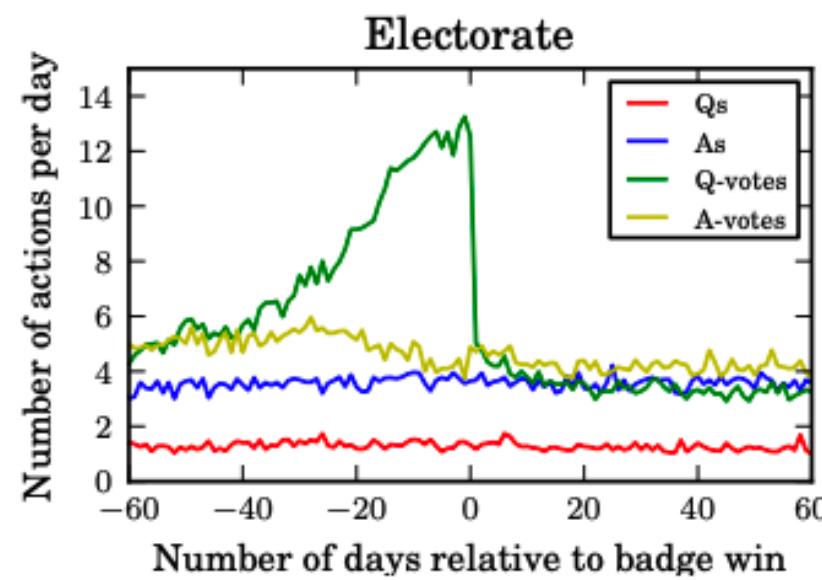
- More sensitive to badges when closer to obtaining it.
- Increase the action of one type decrease the others.
- The incentive of a badge disappears after obtaining it.

Model Predictions

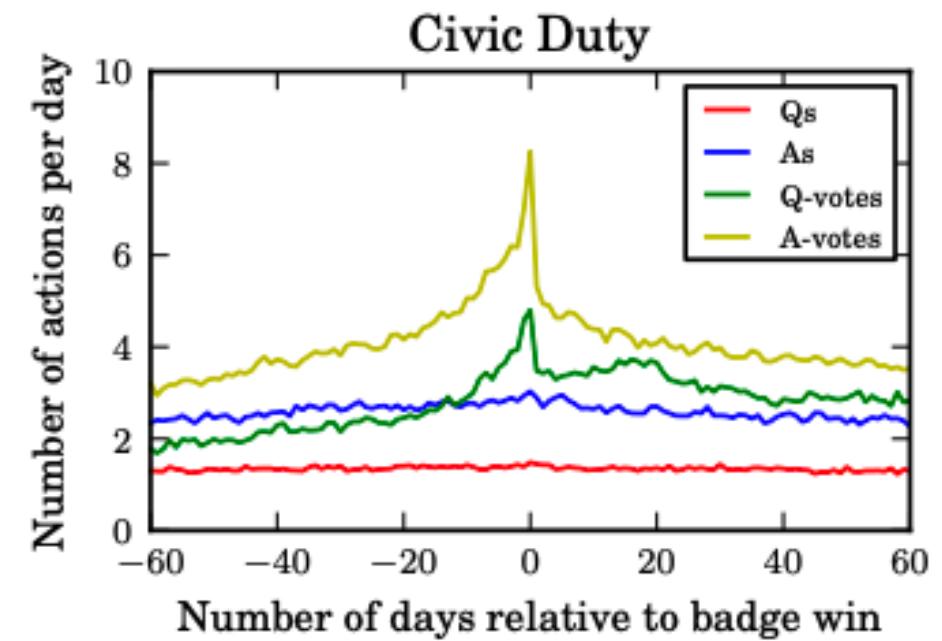


Empirical Evidence from Stack Overflow

• Electorate
Vote on 600 questions and 25% or more of total votes are on questions

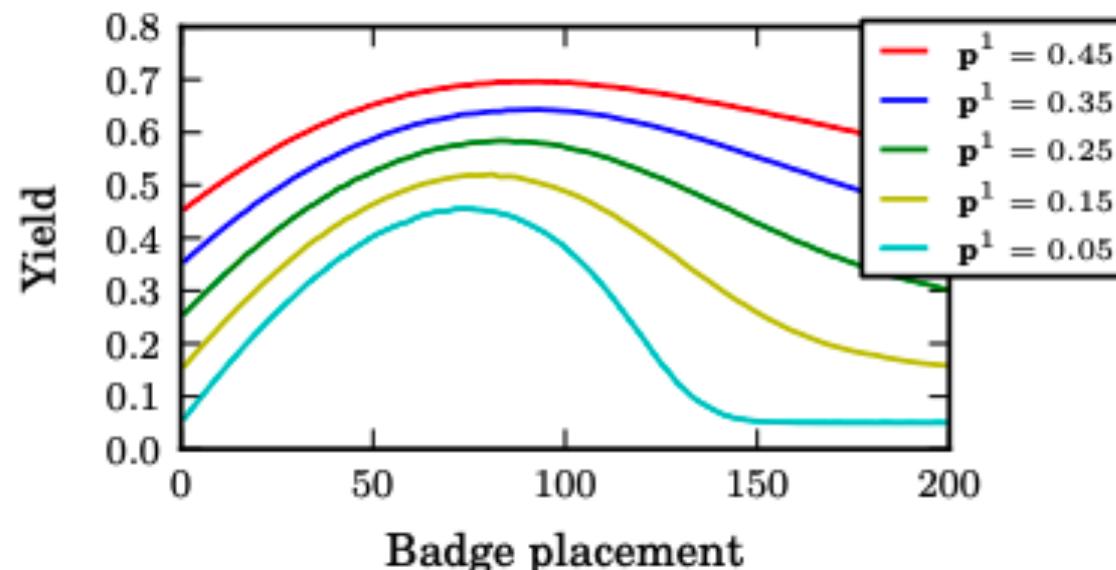


• Civic Duty
Vote 300 or more times



Badge Design

- How to optimally design the badges?
- Single threshold badge: what is the optimal threshold



The paper discusses more design questions, but be careful on what the model/evidence really captures.

Other Badges

- Requires a “sustained” performance

● Curious

Ask a well-received question on 5 separate days, and maintain a positive question record

● Inquisitive

Ask a well-received question on 30 separate days, and maintain a positive question record

● Socratic

Ask a well-received question on 100 separate days, and maintain a positive question record

- Associates with quality

● Favorite Question

Question favorited by 25 users

● Stellar Question

Question favorited by 100 users

- And more ... (e.g., requires competition)

Final Notes

- Connections to gamification, social status, and reputation systems.
- For all these modeling work, try to always remind yourself what the settings/assumptions are, and consider when/whether they might be useful.
- Discussion:
 - Your general thoughts about the paper.
 - What additional features / perspectives do you think are the most interesting/important next questions to ask for badge design?

Attention as Incentives

Incentivizing High-Quality User-Generated Content. Ghosh and McAfee. WWW 2011.

User-Generated Content Platforms

- Why do people post content on YouTube, Instagram, Quora?

Attention is One of the Major Incentives

- Psychological motivation



-1000 - How not to deal with trolls
+1000 - How not to deal with trolls
0 - How to deal with trolls

- Probably more importantly,
Attention => Money (e.g., through advertisements)
- Platforms have huge power on influencing which content will receive more attention.



Assuming attention is the main motivation for contributors, how should the platform design their content displaying algorithm?

Modeling Attention as Incentive

- **Players:** Platform, Users
- **Actions:**
 - Sequential game: the platform takes action first, then users take actions
 - Platform: Content displaying mechanism
 - Users: quality of the contributed content
 - Simplification: Quality $q \in [0,1]$: a ratio of q viewers will like the content
- **Payoff:**
 - Platform: depending on the qualities of all content on the platform
 - Users: Utility(# views(quality)) – Cost(quality)
- Solving the equilibrium (everyone is taking best-response actions)

More Settings/Assumptions

- The platform aims to allocate M views to K contributors (assuming viewers just read whatever the platform recommends)
- Extensive-form game
 1. The platform announces her allocation mechanism
 2. K contributors **simultaneously** decide on the **quality** of their contributions

Each contributor aims at maximizing Utility(# views(**quality**)) – Cost(**quality**)

Three Mechanisms

Q: What are the implications/results of the mechanisms?

- Random: randomly allocating M views to K content
- Proportional mechanism:
 - Let q_1, \dots, q_K be the quality of the K content
 - (assume q means the ratio of viewers who like the content)
 - Content i receives $M \frac{q_i}{\sum_{j=1 \text{ to } k} q_j}$ views
- Elimination mechanism:
 - Each content is evaluated by a random select of A viewers
 - Only when all A viewers like the content, it goes to the 2nd stage
 - All content in 2nd stage equally shares the remaining views

Three Mechanisms

Flood of bad content

- Random: randomly allocating M views to K content

Requires good estimate of q
Quality converge to a suboptimal value

- Proportional mechanism:

- Let q_1, \dots, q_K be the quality of the K content
 - (assume q means the ratio of viewers who like the content)
 - Content i receives $M \frac{q_i}{\sum_{j=1 \text{ to } k} q_j}$ views

By tuning A , quality might achieve optimal if $M \rightarrow \infty$

- Elimination mechanism:

- Each content is evaluated by a random select of A viewers
 - Only when all A viewers like the content, it goes to the 2nd stage
 - All content in 2nd stage equally shares the remaining views

Additional follow-up work

- Mixture of learning and incentives: [Ghosh and Hummel. ITCS 2013]
 - Showing a content to viewers:
 - Create incentives for contributors
 - Platform can learn content quality from viewer feedback
 - How to simultaneously address joint issues of learning and incentives
- Incorporating human biases in learning [Tang and Ho. AAMAS 2019]

Herding Effect



Discussion

- We have discussed the incentive design problem for financial incentives and non-financial incentives such as badges and attention.
- What are the other types of incentives you think we can utilize to promote human-in-the-loop computation?
 - Reputation, access to information, recommendation accuracy, etc
- How do you model and analyze the incentives?
 - Players, actions, payoff? What's the equilibrium?
 - How to perform the design?

Proper Scoring Rules

Incentivizing Truthful Reports About Probabilities

- Example scenarios:
 - Ask a weather forecaster: will it rain tomorrow?
 - Ask a political researcher: will Trump win 2020 election?
 - Ask a Microsoft employer: will the new version of Office be shipped on time?
- Want to obtain forecasts about future events
- How do we make sure we obtain **truthful** reports?

Incentivizing Truthful Reports

- Setting
 - Consider a rational agent with linear utility for cash
 - Suppose there are n mutually exclusive and exhaustive states of the world $\Omega = \{w_1, w_2, \dots, w_n\}$ (e.g., Sun, Rain, Snow)
 - p_i is the subjective belief of the agent that state w_i will occur
- Question
 - How do we motivate this agent to tell us her beliefs about the likelihood of each state?

Scoring Rules

- A scoring rule rewards an agent $S(\vec{r}, w)$ when her reported distribution is \vec{r} and the realized outcome is w

Scoring Rules

- Let's consider a linear scoring rule

$$S(\vec{r}, w_i) = r_i$$

- If a risk-neutral agent believes the probability for Rain and Sun are
 $\vec{p} = (0.7, 0.3)$

What report should the agent provide?

Scoring Rules

- A scoring rule rewards an agent $S(\vec{r}, w)$ when her reported distribution is \vec{r} and the realized outcome is w
- A scoring rule is called *proper* if the agent maximizes her utility by providing truthful report

$$\vec{p} = \operatorname{argmax}_{\vec{r}} \sum_{i=1}^n p_i S(\vec{r}, w_i)$$

- A scoring rule is *strictly proper* if honestly reporting is the **unique** maximizer.

Examples of Strictly Proper Scoring Rules

- Quadratic scoring rule (Brier score):

$$S(\vec{r}, w_i) = r_i - \frac{1}{2} \sum_j r_j^2$$

We can verify this by taking the gradient of the expected payoff

- Affine transformation of the proper scoring rule is still proper.

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VERIFICATION OF FORECASTS EXPRESSED IN TERMS OF PROBABILITY

GLENN W. BRIER

U. S. Weather Bureau, Washington, D. C.
[Manuscript received February 10, 1950]

Examples of Strictly Proper Scoring Rules

- Logarithmic scoring rule:

$$S(\vec{r}, w_i) = \log r_i$$

We can verify this by taking a gradient of the expected payoff

- In logarithmic scoring rule, the score for outcome w_i only depends on the report r_i and not r_j for $j \neq i$

More examples?

- How do we construct a strictly proper scoring rule?
- How many strictly proper scoring rules are there?

Characterization of Proper Scoring Rules

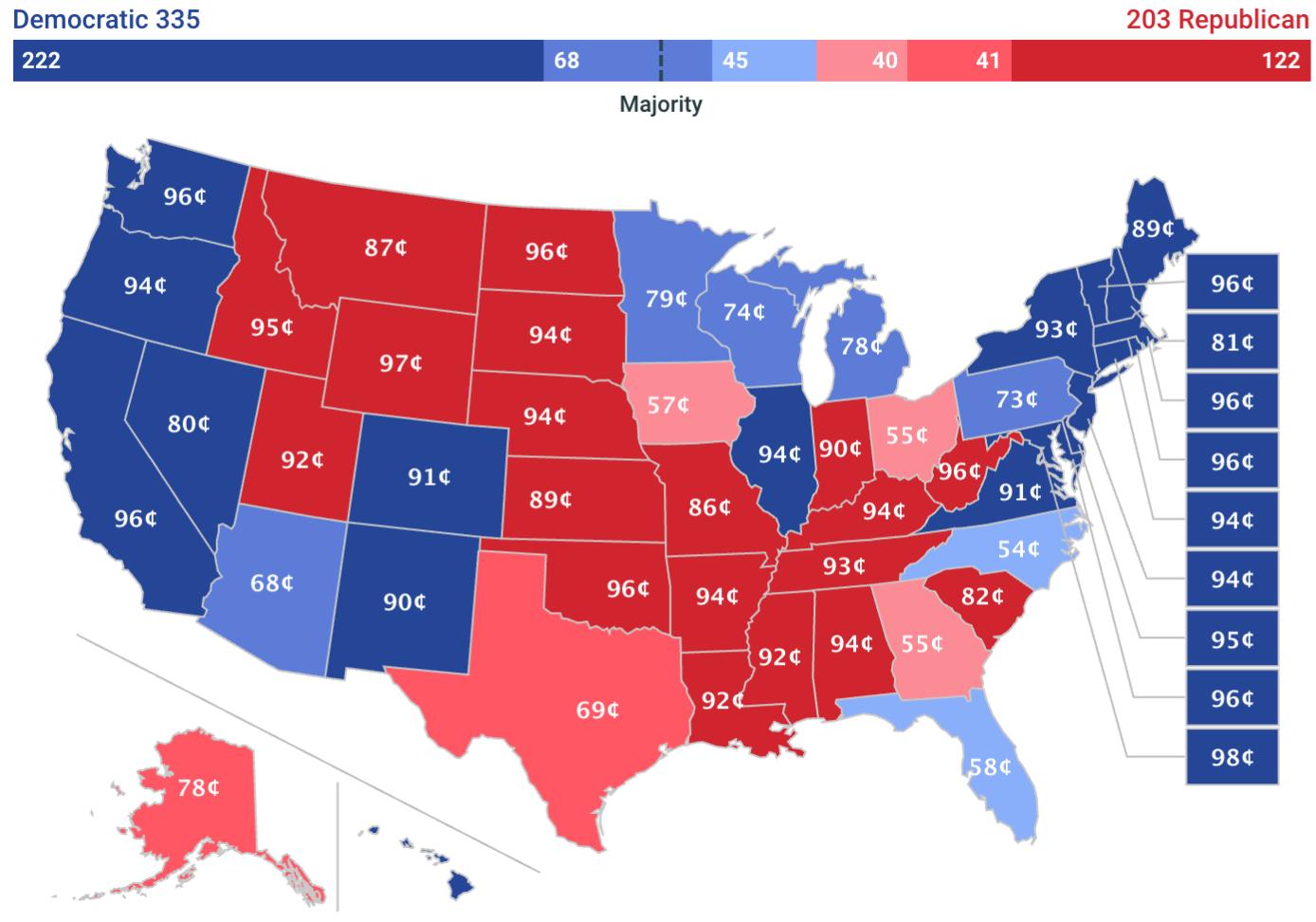
- Connections between convex functions and proper scoring rules.
- A scoring rule $S(\vec{r}, w_i)$ is (strictly) proper if and only if

$$S(\vec{r}, w_i) = G(\vec{r}) - \sum_{j \neq i} G'_j(\vec{r}) p_j + G'_i(\vec{r})$$

where $G(\vec{r})$ is a (strictly) convex function, $G'(\vec{r})$ is a subgradient of G at \vec{r} , and $G'_i(\vec{r})$ is its i -th component.

Connection to Prediction Market

Which party will win the Electoral College?



Connection to Prediction Markets

Goal:

Incentivize ***multiple*** agents to share their beliefs, and find a way to ***aggregate*** these beliefs into a unified prediction

1. Could use one scoring rule per agent, but not clear how to aggregate
2. Market itself is an aggregation mechanism (use final price as the prediction). However, standard stock-market-style trading might encounter issues for less popular predictions (market is too *thin*).

Market Scoring Rules

- See Hanson's papers in the optional readings of the Prediction Market lecture
- Intuitions: a “sequentially shared scoring rule”
 - An automatic market maker
 - Market maintains a vector of predictions $\vec{r}^{(t)}$
 - If a trader changes the vector from $\vec{r}^{(t)}$ to $\vec{r}^{(t+1)}$ and the outcome is w_i , the trader obtains reward

$$S(\vec{r}^{(t+1)}, w_i) - S(\vec{r}^{(t)}, w_i)$$

- Under some conditions:
 - Agents truthfully report their beliefs
 - The prediction will converge

Market Scoring Rules

- The connection to convex optimization opens up an interesting line of research in the design of efficient market maker...

Oct 22 Application: Prediction Markets

[Student Presentation #4]

Required

[The Promise of Prediction Markets](#), K.J. Arrow et. al., Science. 2008

[Results from a Dozen Years of Election Futures Markets Research](#). Berg et al. 2001.

Please read both. The first one is a two-page non-technical paper (you may skip the 2nd page of the first paper).

Optional

Empirical reports:

[Prediction Without Markets](#). Goel et al. EC 2010.

[Using Prediction Markets to Track Information Flows: Evidence from Google](#).

Cowgill, Wolfers, and Zitzewitz. 2008.

[Prediction Markets](#). Wolfers and Zitzewitz, The Journal of Economic Perspectives 2004.

Automatic market makers

[Logarithmic Market Scoring Rules for Modular Combinatorial Information Aggregation](#). Hanson. Journal of Prediction Markets 2007.

[Combinatorial Information Market Design](#). Hanson. Information Systems Frontier 2003.

A [blogpost](#) by David Pennock that discusses how to implement market scoring rules as a market maker.

- We won't cover too much on prediction markets. In case you are interested, below are a few more papers to follow up:
 - [A New Understanding of Prediction Markets Via No-Regret Learning](#). Chen and Vaughan. EC 2010.
 - [An Optimization-Based Framework for Automated Market-Making](#). Abernethy, Chen, and Vaughan. EC 2011.
 - and more (the papers by these authors)

Very Brief Intro of Peer Prediction

See more discussion in Assignment 3

Eliciting Truthful Reports

- Scoring rule relies on the “truth” to be revealed in the future
- What if there is no ground truth (or the ground truth is hard to obtain)
 - Do you like this movie?
 - Peer grading in MOOCs
- Output agreement:
 - Randomly pick two persons
 - If their reports match, reward them 1, otherwise reward 0
 - Truthful reporting is not an equilibrium (you are encouraged to report the majority’s opinion)

Peer Prediction

- How to fix the issue?
 - Assume knowledge about the report distribution, re-weighting the rewards to make sure truthful reporting is a equilibrium
- Drawbacks:
 - Require knowledge of the prior
 - There are usually multiple equilibrium (including naïve bad ones...)
- Still an ongoing research area
 - Some nice theoretical results, however there is little practical success so far

Related Course

- The course on peer grading at Northwestern by Jason Hartine.
 - <https://sites.northwestern.edu/hartline/eecs-497-peer-grading/>