USING ADAPTIVE EXPERIMENTS IN POLICY RESEARCH

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Introduction

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Randomized control trials (RCTs) represent one of the biggest methodological shifts in public policy research.

- Classical impact evaluations (RCTs, experiments) are designed to estimate the average treatment effect.
- In many policy-making contexts where experiments are used:

~~*"What is the effect of a given policy on outcome(s)?"*~~
~~or *"Should this program be implemented?"*~~

"Which of these possible alternative programs should we implement for the best outcome?"

"How should this program be implemented?"

→ Goal of analytical work in many operations contexts: among a set of possible approaches, choose those that best achieve project objectives.

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Example: what is the best method to contact rice farmers to enroll them into a free agricultural extension service?

Precision Agriculture for Development

- Collaboration with **PAD**
  - Promote custom farming methods in developing countries
  - Here: rice farming in India
- Aim to enroll >1m rice farmers into customized advice service by mobile phone
- Choose between different possible call designs/formats
- Outcome: success = did the farmer pick up the phone and answer enrollment questions?

Logo by PAD.

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Example II: How can we design automated calls to inspire parents to practice reading with their first graders?

- Collaboration with NewGlobe's Bridge International Kenya
  - Around 100 schools in Kenya, 2000 first graders
- Goal: get parents to regularly read with their kids at home (2x/week)
- Method: automated calls (IVR) read by a local voice actor.
  - Choose between 6 call variants with different exercise prompts and instructions.
- Outcome: average reading fluency (correct words per minute)

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Adaptive Experiments for Policy Research

- ***"Which of these possible alternative programs should we implement?"***

→ "Policy Choice Problem"

→ Objective: choose the best out of several program variants *after* the experiment

- Other objectives might be:
  - → Achieve best possible outcomes *during* experiment ("multi-arm bandit problem")
  - → Hybrids: balance learning for after the experiment, and giving the best treatment to as many participants as possible
  - → Learn treatment effect and best treatment for different types of recipients … and so on.

Often, a "standard RCT" is not a good fit.

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Adaptive Experiments for Policy Research

- **In this talk:** use the “policy choice” example and trial with PAD to demonstrate how adaptive experiments work (Kasy & Sautmann, 2021)
- **Key feature**: carry out the experiment in “waves” – learn as you go – adjust the experiment in later waves to achieve objective as quickly as possible.
- **Growing use of adaptive designs:**
  - Identify and apply successful strategies to help refugees in Jordan find jobs (Caria, Gordon, Kasy, Osman, Quinn, Teytelboym, 2020)
  - *Encourage best-practices adoption for Covid-19 with informational SMS (Bahety et al., 2021)*
  - Increase the uptake of long-acting contraceptives in Cameroon (Athey, Baird, Jamison, McIntosh, Őzler, Sama; ongoing)

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The Policy Choice Problem

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Conducting an experiment in waves to pick one out of several policy (treatment) options.

- **Imagine the following situation:**
  - Experiment is (or can be) conducted in waves
  - Three or more treatment options
  - Outcome *Y*: binary, success (1) or failure (0) [for now]

Precision Agriculture for Development

  - *In PAD India example:*
    - *Treatments: contacting mobile phones at different times and with or without a text message sent ahead of time*
    - *Success: the respondent answers a set of enrollment questions.*

- **Policy choice problem: after experiment, we want to pick the option with the highest expected success rate, or equivalently, the highest average *Y*.**

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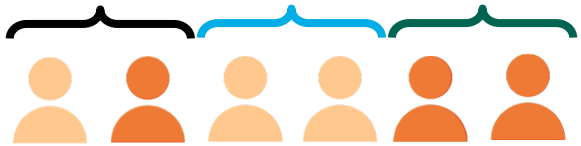
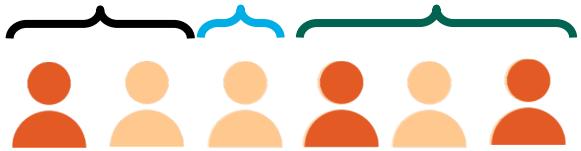
What does adaptive sampling mean in this setting?

- Assign units to treatment arms at the start of the wave.
- Observe outcomes in each arm.



- Given what was learned, in the next wave, assign units to arms for optimal continued learning about what the best option is.
- Observe outcomes again…. etc.



Typically, from wave 2 onwards, it's not the best choice to assign the same number of units to each arm.

Exploration sampling: an algorithm for the optimal(*) adaptive treatment assignment for policy choice.

- It is possible to calculate the optimal assignment in each wave exactly.
- However, with larger samples and many treatment arms, it's computationally infeasible to do so.
- **In policy choice problem: use an algorithm called *Exploration Sampling*(**)**
  - Approximation of the optimal assignment
  - Builds on current estimated probability *p* that a given policy arm is the optimal choice – assignment proportional to *p(1-p)*.
- ***Exploration sampling* demonstrably improves learning, that is, it picks the best option faster and more reliably.**
  - Different algorithms for other learning objectives.

(*) *Technically, the algorithm is constrained optimal (subject to half the sample being assigned to the best treatment, which in turn is a "robust" condition relative to other choices).*

(**) *Derived from the "multi-arm bandit" literature, which has coined the "exploration-exploitation trade-off."*

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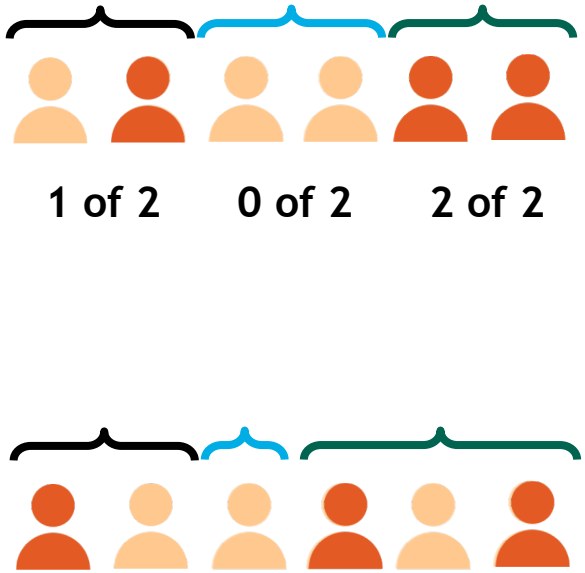
Exploration sampling makes assignment decisions based on Bayesian updating about which treatment has highest success rate.

- Assignment in wave 1 with 3 arms: p = 1/3
  → *assign 1/3 at start*
- Observe outcomes
- Calculate probability *p* for each treatment that it is the optimal option (Bayesian updating) (*)
- Exploration sampling to assign subjects to arms: arm sizes proportional to *p(1-p)*
- Etc.



Key property: since we primarily want to distinguish the best performing options, it's optimal to assign a greater share of units to treatments with high success rates.

** Note: we are skipping a few details here.*

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The Properties of Exploration Sampling

- Bulk of the theoretical paper: optimality properties of exploration sampling as the sample (hypothetically) grows large.
- Simulations show that it performs well in small samples, too.
- As the experiment goes on, the sample shares assigned to different treatment arms converge:
  - Best arm: ½ of the sample
  - Other arms: fixed shares, just right to maximize speed of learning which is the best arm.
- **Results of the form:**
  - "with probability *p,* arm *x* has the highest possible outcome" or
  - "the average 'loss' from choosing each arm is … and x has the smallest loss."

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Exploration Sampling in the Real World

Picture: PAD

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What is the best method to contact rice farmers to enroll them into a free agricultural extension service?

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- Recall: PAD would like to enroll >1m rice farmers into customized advice service by mobile phone
- Outcome: did the farmer respond to five questions? [Yes = success/1]
- Waves of 600 farmers called through automated service; total of 10K calls
- Six tested treatment arms:
  - Call in the morning or evening
  - For each: 24 hours, 1 hour, or no text message beforehand

Logo: PAD

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Exploration sampling dashboard: results from wave 1 of the experiment

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Exploration sampling dashboard: results from wave 2 of the experiment

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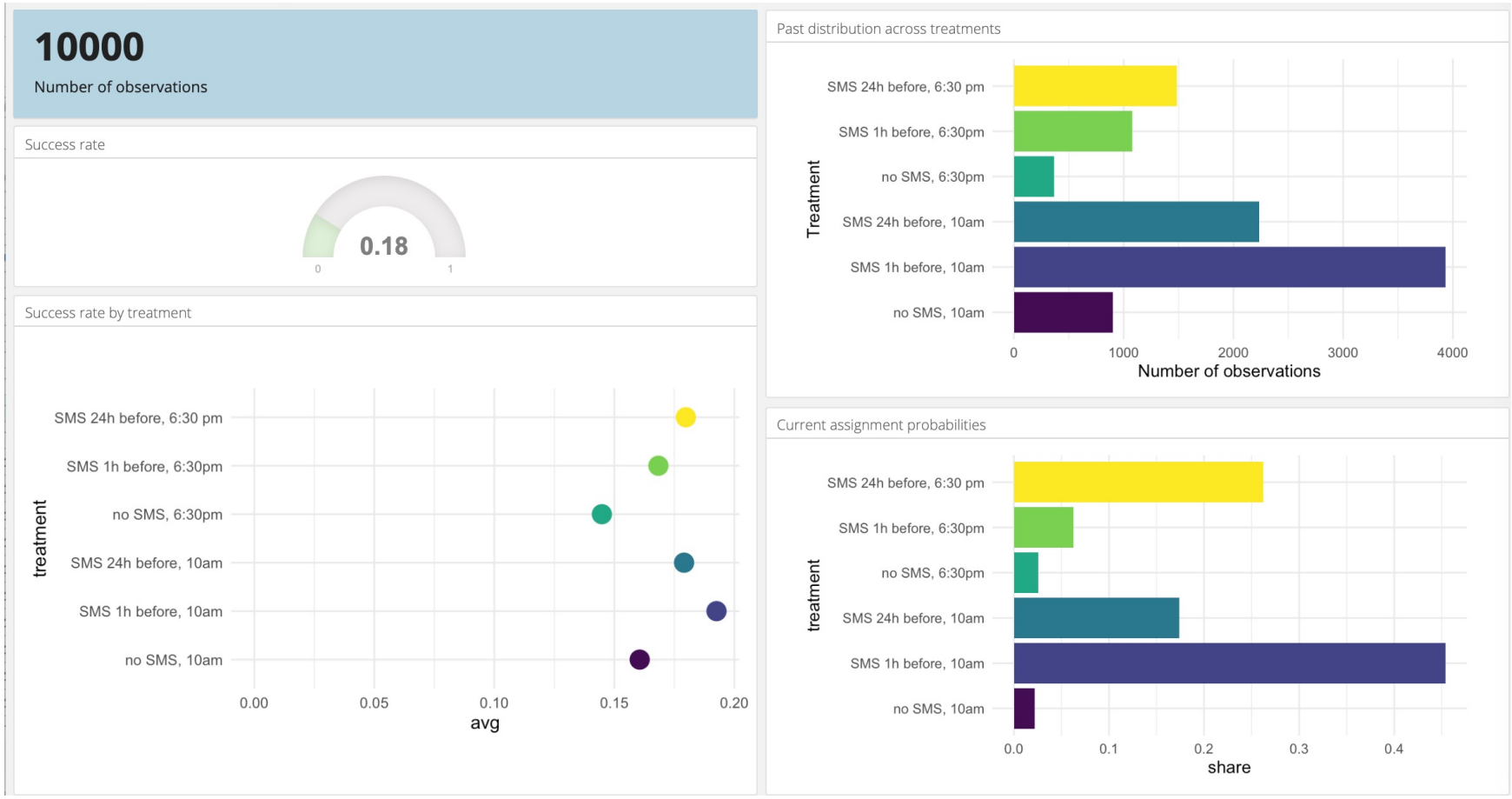
Exploration sampling dashboard: results at the end of the experiment



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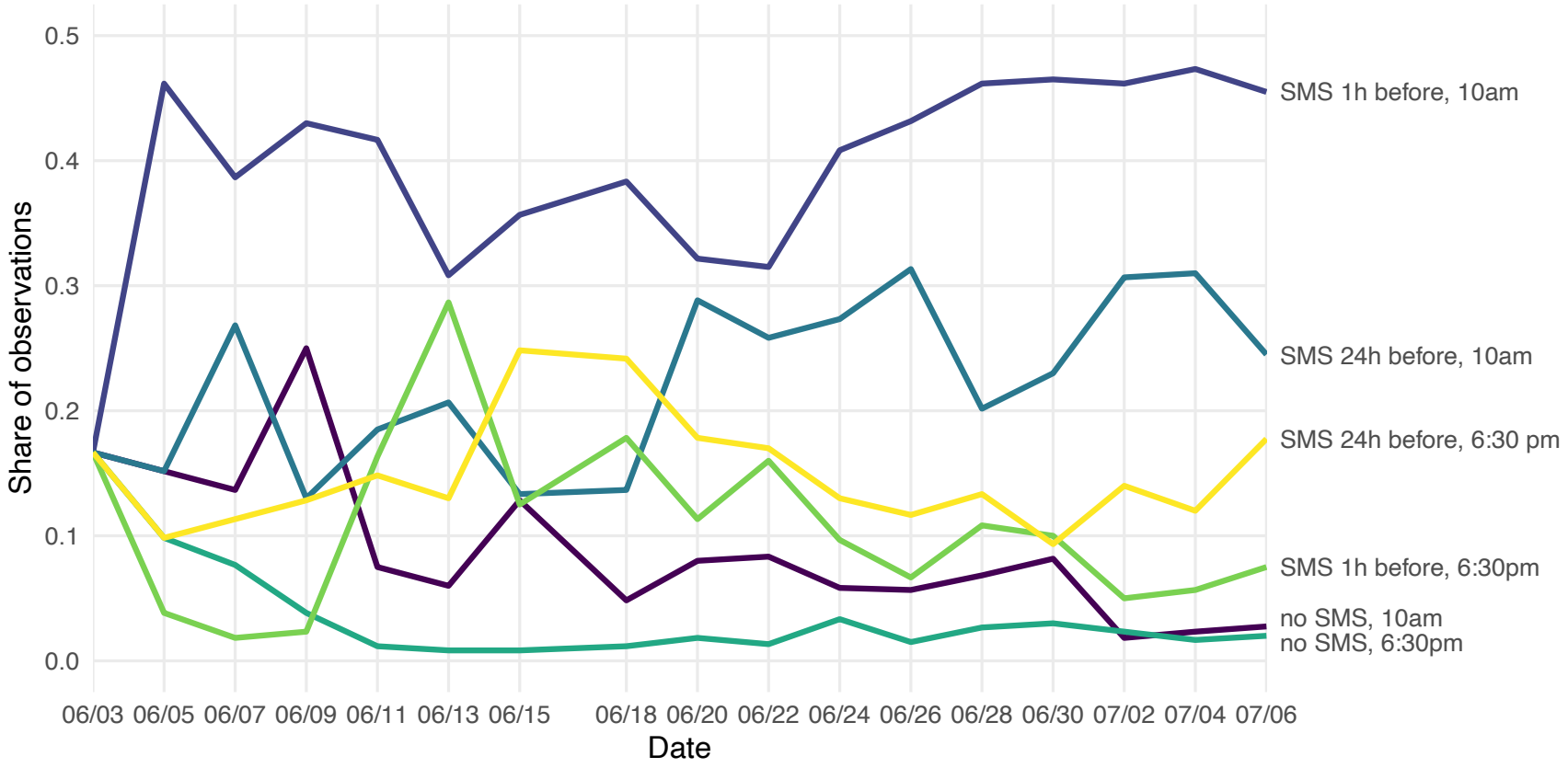
Exploration sampling dashboard: variation in treatment assignment over time



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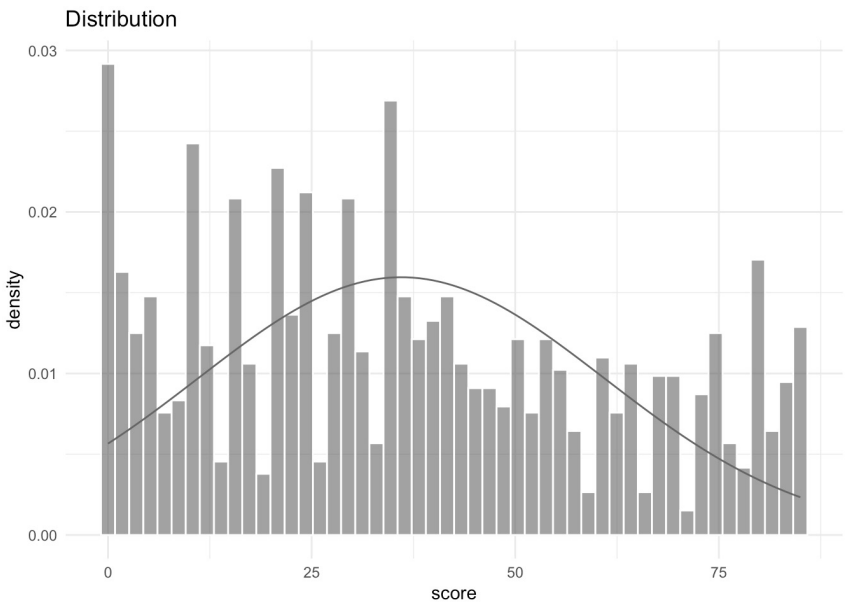
Adaptive experiment in Kenya: promoting home reading practice for improving reading fluency

- First graders in Kenyan schools
- Baseline: endterm exam of term 2
- Biweekly calls with reading exercises from ”basic” to “advanced”, building on 3rd term text book
- At start of term 3 (May 10): randomly assign half of all children into one of 7 treatment arms, varying:
  - **Difficulty**: ”Leveling by baseline” vs. fixed sequence of exercises vs. parental choice
  - **Mode of instruction:** guided by a voice actor on the call, or giving parents exercises to do offline.
  - **Control group** with no calls
- After midterm (June): update “probability optimal” *p* based on midterm scores; assign second half of the sample using Exploration Sampling.



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Conclusion

Adaptive experimental methods can put “tinkering” or piloting on a formal footing.

- Similar to “A/B testing”
- Adaptivity can respond flexibly to past learning

Key advantages:

- **The learning process and resulting decision are replicable and empirically rigorously founded.**
- **For policy choice: more participants benefit from the best treatment options during the experiment.**

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What are possible applications?

- **Suitable environments:**
  - outcome realized and observed between waves
  - treatment assignment is flexible from wave to wave
  - For exploration sampling: focus on outcomes *after* the experiment
- **Promising applications:**
  - Education applications: use “wave” structure of grades/terms; particularly important to get to the best treatment in few waves.
  - Technology solutions – treatment assignment pushed centrally to devices; outcomes instantly recorded
  - Intermediate outcomes, such as participation/delivery rate, uptake: quick feedback, uptake is a necessary condition for impact
  - Testing survey methods -- e.g., pilot to find the best question format; then implement the best option in full roll-out

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Outlook

- **Ongoing work**: resolve practical open questions, such as how to choose the sample size, using applications like the IVR calls in Kenya
  - Allow for stratification/blocking
  - Deal with unusual outcome distributions, trends, etc.
- An RSB grant to apply exploration sampling, especially in education contexts – with Daniel Rodriguez and Bruno Esposito
- Web-app for trying this out (or implementing it!) at https://maxkasy.shinyapps.io/exploration_sampling_dashboard/

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Thank you!

Many thanks to Elizabeth Bond, creator of the representative meeple.

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Appendix: Simulations

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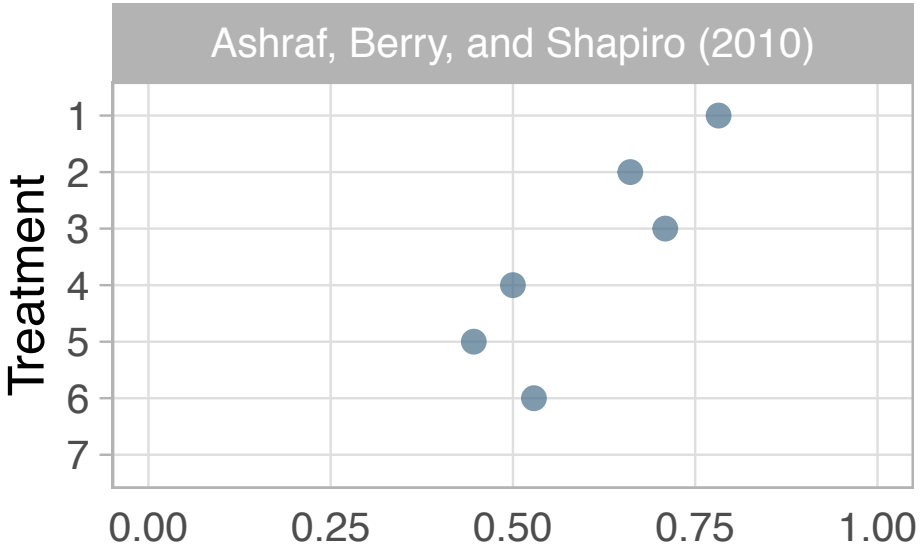
Application I: simulations with data from existing experiments to compare performance of different assignment rules.

- Use data from an experiment with several treatments and pretend it is the "truth" in order to test exploration sampling.
- Ashraf, Berry, and Shapiro (2010):
  - Vary price of water disinfectant Clorin from Kw 300 to Kw 800
  - Outcome of interest: probability of purchase



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Exploration sampling performs best among assignment methods, and performance increases as the number of waves increases.

Ashraf, Berry, and Shapiro (2010)

Statistic	2 waves	4 waves	10 waves
Average policy regret			
exploration sampling	0.0017	0.0010	0.0008
expected Thompson	0.0022	0.0014	0.0013
non-adaptive	0.0051	0.0050	0.0051
Units per wave	502	251	100

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