

ONLINE APPENDIX FOR:
DISENTANGLING SUBOPTIMAL UPDATING:
STRUCTURE, SEQUENCING, AND COMPLEXITY

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1 Instructions

1.1 Common Instructions

The instructions shown in this subsection were seen by participants regardless of their treatment. These initial instructions aimed to familiarize participants with the mechanism through which they submitted their posteriors.

Figure 1: Initial Instructions I

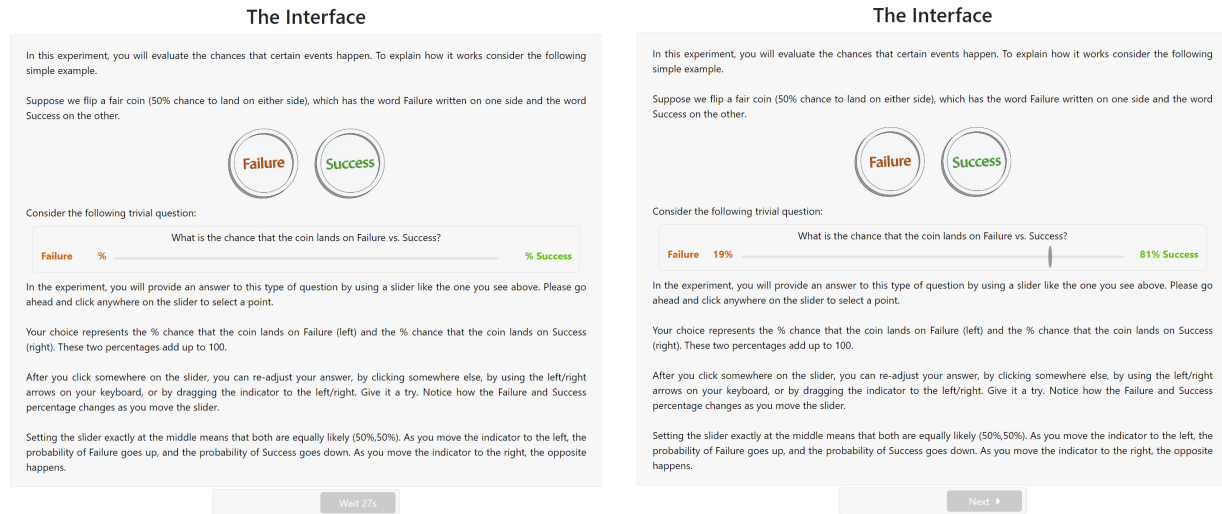
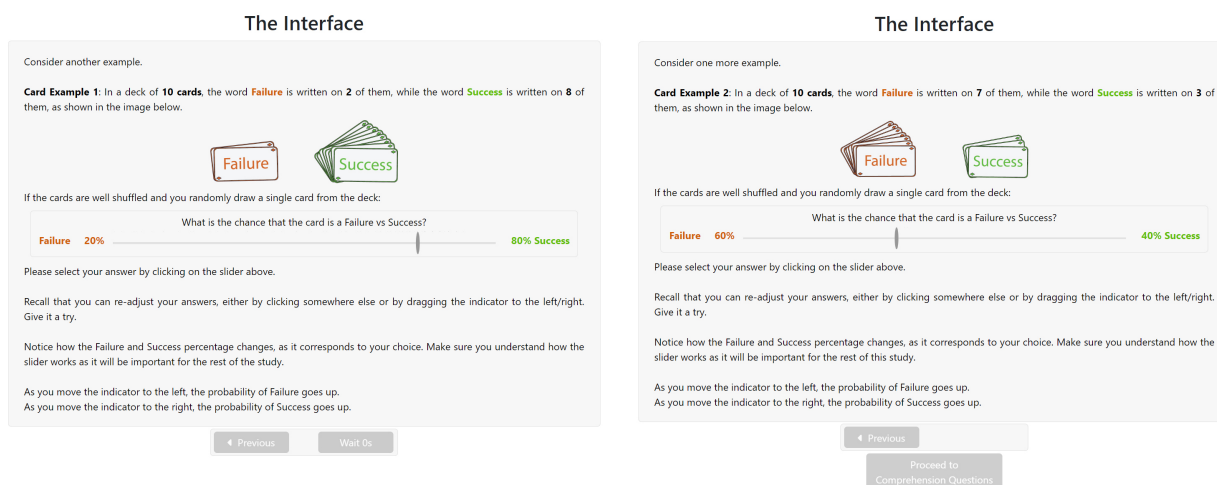


Figure 1 shows the initial page presented to the participants. To ensure that participants spend time internalizing the information, the *Next* button was made available only after a countdown of 30 seconds.¹ On this, and every other page, there is initially no indicator on the slider via which participants submit their probabilities. We made this decision to prevent participants from being anchored. The indicator and accompanying probabilities show up only after participants click somewhere on the slider. Compare the left (before clicking) and right (after clicking) screenshots in Figure 1.

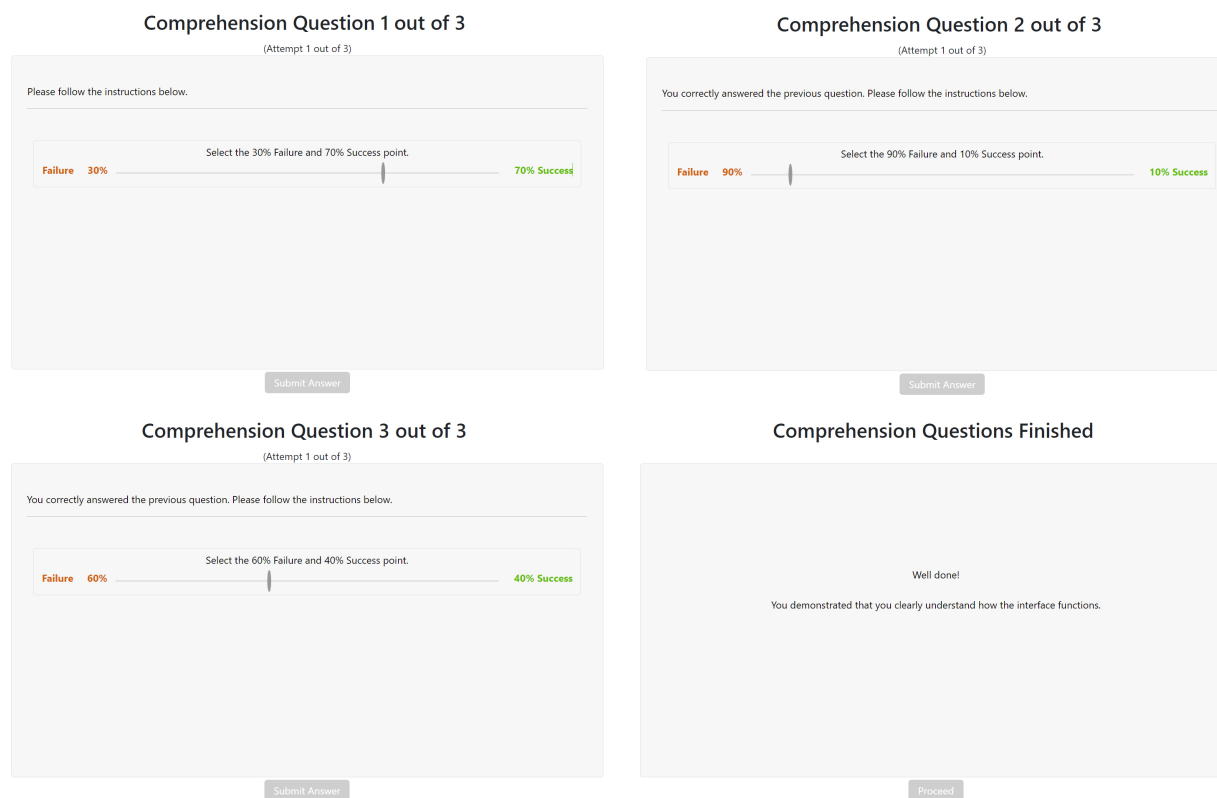
¹Compare buttons on the bottom of the left and right screenshots shown in Figure 1. The left screenshot is taken 3 seconds after the page was loaded, whereas the right screenshot is taken after at least 30 seconds.

Figure 2: Initial Instructions II



Instructions continue by giving participants two more examples and reminding them how the mechanism works; see Figure 2. After these examples, participants are invited to start a simple comprehension test to ensure they know how to use the slider properly, see Figure 3.

Figure 3: Initial Instructions II



If participants submitted wrong answers more than twice, they were not allowed to continue the study. Successful participants continued with treatment-specific instructions.

1.2 Baseline Treatment Instructions

Figure 4: Baseline Treatment Instructions

Instructions

Details of the Main Question

The experiment consists of several rounds.

In each round, a project will be selected randomly from a pool of projects (with each project having the same probability of being selected).

Within this pool of projects, **85%** of projects are Failures while **15%** are Successful.

Your task is to evaluate the chance that the project that was randomly selected is a Failure vs. Success.

To aid your evaluation, the computer will run a test on the selected project.

Test Accuracy is **80%** which means that:

- If the project is a Success the signal will be Positive with 80% probability and Negative with 20% probability.
- If the project is a Failure the signal will be Negative with 80% probability and Positive with 20% probability.

We will ask you to submit two evaluations:

- If the test is Positive, what is the chance that the project is a Success vs. Failure?
- If the test is Negative, what is the chance that the project is a Success vs. Failure?

Instructions

Details of the Main Question

Here is how it will look like.

If the test is **Positive**
what is the chance that the project is a Failure vs Success?

Failure % % Success

If the test is **Negative**
what is the chance that the project is a Failure vs Success?

Failure % % Success

Once more, you can click, drag, or re-click anywhere on the interval to choose the chance of Failure vs Success that you think is correct in each question.

In the actual round, once you make both decisions a **Submit** button will appear.
When you click the **Submit** button you will no longer be able to change your answers.

Instructions

Prior Information

Throughout the experiment you will be reminded of the information regarding the chances of Failed and Successful projects as well as the accuracy of the test. In particular you will see the box below.

Prior Information:

- 85% of Projects are Failures; 15% of Projects are Successful.
- Test Accuracy is 80% which means that:
 - If the project is a Success the signal will be Positive with 80% probability and Negative with 20% probability.
 - If the project is a Failure the signal will be Negative with 80% probability and Positive with 20% probability.

Feedback

At the end of each round, once you submit your answers, you will see the actual test result, and whether the project was a Failure or Success.

This information will be summarized at the bottom of the screen in a table, which will keep track of the outcomes of all rounds that you have previously played.

Instructions

Rounds

You will play a total of 20 rounds. Rounds are independent of each other.

You will receive \$5 for completing the experiment.

In addition, you have a 20% chance of receiving a bonus payment of \$20. If you are selected to receive the bonus payment the computer will randomly select one of the 20 rounds. Each round is equally likely to be chosen. Your answers in the randomly selected round will determine whether you receive the bonus or not, as will be described shortly.

Whether you are selected to receive the bonus payment and which round counts for your bonus will be determined at the end of the experiment. **Therefore, it is in your best interests to do your best in every single round, because that might be the round that determines your bonus!**

Important: The prior information, i.e., the fraction of Failure and Success Projects and the Test Accuracy, is the same in every round. Moreover, rounds are completely independent of each other and your submitted guesses do not influence the chances of a randomly selected project being a success or a failure or the test results.

If you are confident in your answer, you can continue to submit the same answers as you move through the rounds. However, if, given the feedback, you have a new evaluation, naturally, you can change your answers.

Instructions

How Payments are Calculated

In every question of this type, you will use the slider to indicate the probabilities of Failure and Success.

Let X represent your chosen probability of Failure, and consequently $100 - X$ will be your chosen probability of Success.

After you submit your choice of X , the program will generate a number from 0 to 100, with each number being equally likely. Call this number Y . Your chosen number X , the randomly generated number Y , and whether the outcome is Failure or Success will determine your chances of winning \$20. If Y is greater than or equal to X , you will win \$20 with $Y\%$ chance. If Y is less than X , you will win \$20 if the outcome is Failure.

Given this payment scheme, it is always in your best interest to choose X that represents your best evaluation of the chance that Failure and Success will happen.

The important thing to remember is that we have chosen the payment scheme so that it is always in your best interest to honestly report your best evaluation of the chance that Failure and Success happens.

Instructions

Summary

- You will play a total of 20 rounds.
- All rounds are the same in terms of Failure/Success probabilities and test accuracy.
- Rounds are completely independent of each other, that is, the outcomes of previous rounds do not affect the chances that the next project is a Failure or Success.
- To maximize your payment, given the test result, you should give your best evaluation of the chance that the project is a Failure vs. Success.
- If you are confident in your answer, you can continue to submit the same answer.
- If given the feedback you have a new evaluation, naturally, you can change your answer.

This is the end of Instructions.
To proceed click the Begin Study button.

Begin Study

1.3 Simultaneous Treatment Instructions

Figure 5: Simultaneous Treatment Instructions

Instructions

Details of the Main Question

The experiment consists of several rounds.

In each round, a project will be selected randomly from a pool of projects (with each project having the same probability of being selected).

Within this pool of projects **50%** of projects are Failures while **50%** are Successful.

Your task is to evaluate the chance that the project that was randomly selected is a Failure vs. Success.

To aid your evaluation, the computer will run two tests on the selected project.

Test 1 Accuracy is **85%** which means that:

- If the project is a Success the signal will be Positive with 85% probability and Negative with 15% probability.
- If the project is a Failure the signal will be Negative with 85% probability and Positive with 15% probability.

Test 2 Accuracy is **80%** which means that:

- If the project is a Success the signal will be Positive with 80% probability and Negative with 20% probability.
- If the project is a Failure the signal will be Negative with 80% probability and Positive with 20% probability.

We will ask you to submit evaluations given both test results.

◀ Previous Next ▶

Instructions

Details of the Main Question

Here is how it will look like.

If Test 1 is **Positive**
and Test 2 is **Positive**

what is the chance that the project is a Failure vs Success?

Failure %% Success

If Test 1 is **Positive**
and Test 2 is **Negative**

what is the chance that the project is a Failure vs Success?

Failure %% Success

Once more, you can click, drag, or re-click anywhere on the interval to choose the chance of Failure vs Success that you think is correct in each question.

For each question make sure to read Test 1 and Test 2 results carefully, as they may change from round to round.

In the actual round, once you make both decisions a **Submit** button will appear. When you click the **Submit** button you will no longer be able to change your answers.

◀ Previous Next ▶

Instructions

Prior Information

Throughout the experiment you will be reminded of the information regarding the chances of Failed and Successful projects as well as the accuracy of the test. In particular you will see the box below.

Prior Information:

- 50% of Projects are Failures; 50% of Projects are Successful.
- Test 1 Accuracy is 85% which means that:
 - If the project is a Success the signal will be Positive with 85% probability and Negative with 15% probability.
 - If the project is a Failure the signal will be Negative with 85% probability and Positive with 15% probability.
- Test 2 Accuracy is 80% which means that:
 - If the project is a Success the signal will be Positive with 80% probability and Negative with 20% probability.
 - If the project is a Failure the signal will be Negative with 80% probability and Positive with 20% probability.

Feedback

At the end of each round, once you submit your answers, you will see the actual test result, and whether the project was a Failure or Success.

This information will be summarized at the bottom of the screen in a table, which will keep track of the outcomes of all rounds that you have previously played.

◀ Previous Next ▶

Instructions

Rounds

You will play a total of 20 rounds. Rounds are independent of each other.

You will receive \$5 for completing the experiment.

In addition, you have a 20% chance of receiving a bonus payment of \$20. If you are selected to receive the bonus payment the computer will randomly select one of the 20 rounds. Each round is equally likely to be chosen. Your answers in the randomly selected round will determine whether you receive the bonus or not, as will be described shortly.

Whether you are selected to receive the bonus payment and which round counts for your bonus will be determined at the end of the experiment. **Therefore, it is in your best interests to do your best in every single round, because that might be the round that determines your bonus!**

Important: The prior information, i.e., the fraction of Failure and Success Projects and the Test Accuracy, is the same in every round. Moreover, rounds are completely independent of each other and your submitted guesses do not influence the chances of a randomly selected project being a success or a failure or the test results.

If you are confident in your answer, you can continue to submit the same answers as you move through the rounds. However, if given the feedback, you have a new evaluation, naturally, you can change your answers.

◀ Previous Next ▶

Instructions

How Payments are Calculated

In every question of this type, you will use the slider to indicate the probabilities of Failure and Success.

Let X represent your chosen probability of Failure, and consequently $100 - X$ will be your chosen probability of Success.

After you submit your choice of X , the program will generate a number from 0 to 100, with each number being equally likely. Call this number Y . Your chosen number X , the randomly generated number Y , and whether the outcome is Failure or Success will determine your chances of winning \$20. If Y is greater than or equal to X , you will win \$20 with $Y\%$ chance. If Y is less than X , you will win \$20 if the outcome is Failure.

Given this payment scheme, it is always in your best interest to choose X that represents your best evaluation of the chance that Failure and Success will happen.

The important thing to remember is that we have chosen the payment scheme so that it is always in your best interest to honestly report your best evaluation of the chance that Failure and Success happens.

◀ Previous Next ▶

Instructions

Summary

- You will play a total of 20 rounds.
- All rounds are the same in terms of Failure/Success probabilities and test accuracies.
- Rounds are completely independent of each other, that is, the outcomes of previous rounds do not affect the chances that the next project is a Failure or Success.
- To maximize your payment, given the test results, you should give your best evaluation of the chance that the project is a Failure vs. Success.
- If you are confident in your answer, you can continue to submit the same answer.
- If given the feedback you have a new evaluation, naturally, you can change your answer.

This is the end of Instructions.
To proceed click the Begin Study button.

◀ Previous **Begin Study**

2 Interface

2.1 Baseline Treatment Interface

We present various screenshots of the interface presented to participants in the baseline treatments at different stages of the study. We highlight important features below.

Figure 7: Baseline Treatment Interface

The figure displays six screenshots of the 'Probability Evaluation' interface at various stages of the study. Each screenshot includes the following elements:

- Prior Information:**
 - 85% of Projects are Failures; 15% of Projects are Successful.
 - Test Accuracy is 80% which means that:
 - If the project is a Success the signal will be Positive with 80% probability and Negative with 20% probability.
 - If the project is a Failure the signal will be Negative with 80% probability and Positive with 20% probability.
- Probability Evaluation Questions:**
 - Positive Test:** "If the test is **Positive** what is the chance that the project is a Failure vs Success?"
 - Negative Test:** "If the test is **Negative** what is the chance that the project is a Failure vs Success?"
- Sliders:** Horizontal sliders for Failure (left, red) and Success (right, green) percentages.
- Buttons:** 'Proceed', 'Submit Evaluation', and 'Next Round'.
- Feedback:** "The Test was Negative." and "The Project was a Failure." (shown in Round 17).
- History Table (Round 17):**

Round	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Signal	N	P	N	N	P	P	P	N	N	N	P	P	N	N	N	P
Project	F	F	F	F	F	S	S	F	F	F	S	S	F	F	S	S

- As clarified in the instructions, throughout the experiment, at the top, participants see information regarding the prior probability of successful/failed projects as well as the signal

accuracy.

- As clarified in the instructions, when asked “*If the test is Positive/Negative, what is the chance that the project is a Failure vs. Success?*” there is initially no indicator on the slider. We made this decision to prevent participants from being anchored. Only after they click somewhere on the slider does the indicator and the accompanying probabilities show up. For a concrete example, compare the top right and middle left screenshots in [Figure 7](#).
- After clicking the “Submit Evaluation” button, participants were informed about the particular realized value of the signal and whether the project was a Failure or Success. See the middle right screenshot above.
- The realized signals and project outcomes from previous rounds are summarized in a table at the bottom of the interface. See bottom left for an example in Round 2 and bottom right for an example in Round 17. We keep track of past outcomes to shut down possible effects that imperfect recall may have.

2.2 Simultaneous Treatment Interface

The image displays two screenshots of the 'Probability Evaluation' interface for Round 1. Both screenshots show a 'Prior Information' section with the following text:

- 50% of Projects are Failures; 50% of Projects are Successful.
- Test 1 Accuracy is 85% which means that:
 - If the project is a Success the signal will be Positive with 85% probability and Negative with 15% probability.
 - If the project is a Failure the signal will be Negative with 85% probability and Positive with 15% probability.
- Test 2 Accuracy is 80% which means that:
 - If the project is a Success the signal will be Positive with 80% probability and Negative with 20% probability.
 - If the project is a Failure the signal will be Negative with 80% probability and Positive with 20% probability.

The left screenshot shows a 'Proceed' button at the bottom. The right screenshot shows two conditional questions with sliders:

If Test 1 is **Negative** and Test 2 is **Positive**
what is the chance that the project is a Failure vs Success?

Failure % _____ % Success

If Test 1 is **Negative** and Test 2 is **Negative**
what is the chance that the project is a Failure vs Success?

Failure % _____ % Success

Probability Evaluation (Round 1)

Prior Information:

- 50% of Projects are Failures; 50% of Projects are Successful.
- Test 1 Accuracy is 85% which means that:
 - If the project is a Success the signal will be Positive with 85% probability and Negative with 15% probability.
 - If the project is a Failure the signal will be Negative with 85% probability and Positive with 15% probability.
- Test 2 Accuracy is 80% which means that:
 - If the project is a Success the signal will be Positive with 80% probability and Negative with 20% probability.
 - If the project is a Failure the signal will be Negative with 80% probability and Positive with 20% probability.

If Test 1 is **Negative** and Test 2 is **Positive**
 what is the chance that the project is a Failure vs Success?

Failure 58% 42% Success

If Test 1 is **Negative** and Test 2 is **Negative**
 what is the chance that the project is a Failure vs Success?

Failure 97% 3% Success

Probability Evaluation (Round 1)

Prior Information:

- 50% of Projects are Failures; 50% of Projects are Successful.
- Test 1 Accuracy is 85% which means that:
 - If the project is a Success the signal will be Positive with 85% probability and Negative with 15% probability.
 - If the project is a Failure the signal will be Negative with 85% probability and Positive with 15% probability.
- Test 2 Accuracy is 80% which means that:
 - If the project is a Success the signal will be Positive with 80% probability and Negative with 20% probability.
 - If the project is a Failure the signal will be Negative with 80% probability and Positive with 20% probability.

Probability Evaluation (Round 2)

Prior Information:

- 50% of Projects are Failures; 50% of Projects are Successful.
- Test 1 Accuracy is 85% which means that:
 - If the project is a Success the signal will be Positive with 85% probability and Negative with 15% probability.
 - If the project is a Failure the signal will be Negative with 85% probability and Positive with 15% probability.
- Test 2 Accuracy is 80% which means that:
 - If the project is a Success the signal will be Positive with 80% probability and Negative with 20% probability.
 - If the project is a Failure the signal will be Negative with 80% probability and Positive with 20% probability.

If Test 1 is **Positive** and Test 2 is **Positive**
 what is the chance that the project is a Failure vs Success?

Failure 3% 97% Success

If Test 1 is **Positive** and Test 2 is **Negative**
 what is the chance that the project is a Failure vs Success?

Failure 44% 56% Success

Previous Rounds' Outcomes

Round	1
Signal 1	N
Signal 2	N
Project	F

P(Positive), N(Negative), S(Success), F(Failure)

Probability Evaluation (Round 17)

Prior Information:

- 50% of Projects are Failures; 50% of Projects are Successful.
- Test 1 Accuracy is 85% which means that:
 - If the project is a Success the signal will be Positive with 85% probability and Negative with 15% probability.
 - If the project is a Failure the signal will be Negative with 85% probability and Positive with 15% probability.
- Test 2 Accuracy is 80% which means that:
 - If the project is a Success the signal will be Positive with 80% probability and Negative with 20% probability.
 - If the project is a Failure the signal will be Negative with 80% probability and Positive with 20% probability.

If Test 1 is **Negative** and Test 2 is **Positive**
 what is the chance that the project is a Failure vs Success?

Failure 57% 43% Success

If Test 1 is **Negative** and Test 2 is **Negative**
 what is the chance that the project is a Failure vs Success?

Failure 96% 4% Success

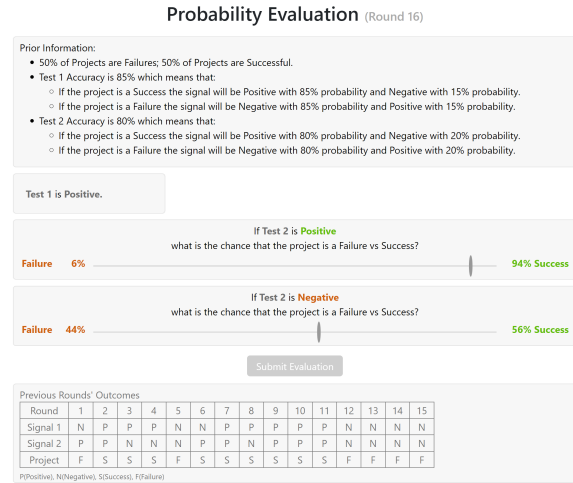
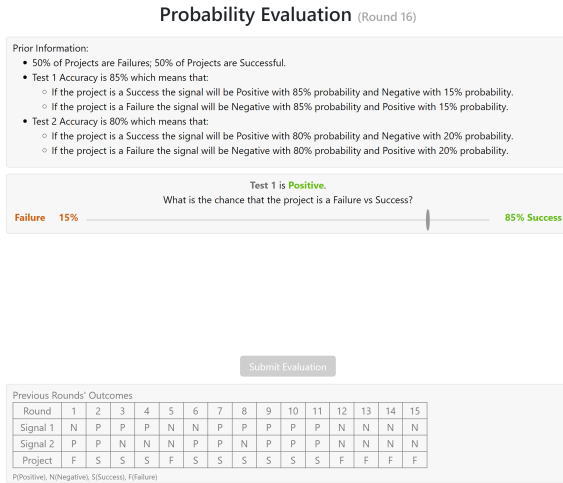
Previous Rounds' Outcomes

Round	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Signal 1	N	P	N	N	N	P	N	N	P	N	P	N	P	N	P	N
Signal 2	N	N	N	N	N	P	P	N	P	N	N	P	N	P	N	N
Project	F	S	F	F	F	S	F	F	S	F	S	F	S	S	F	S

P(Positive), N(Negative), S(Success), F(Failure)

- Most of the design choices are unchanged from the Baseline treatment. However, in the simultaneous treatment, participants received both signals at the same time.

2.3 Sequential Treatment Interface



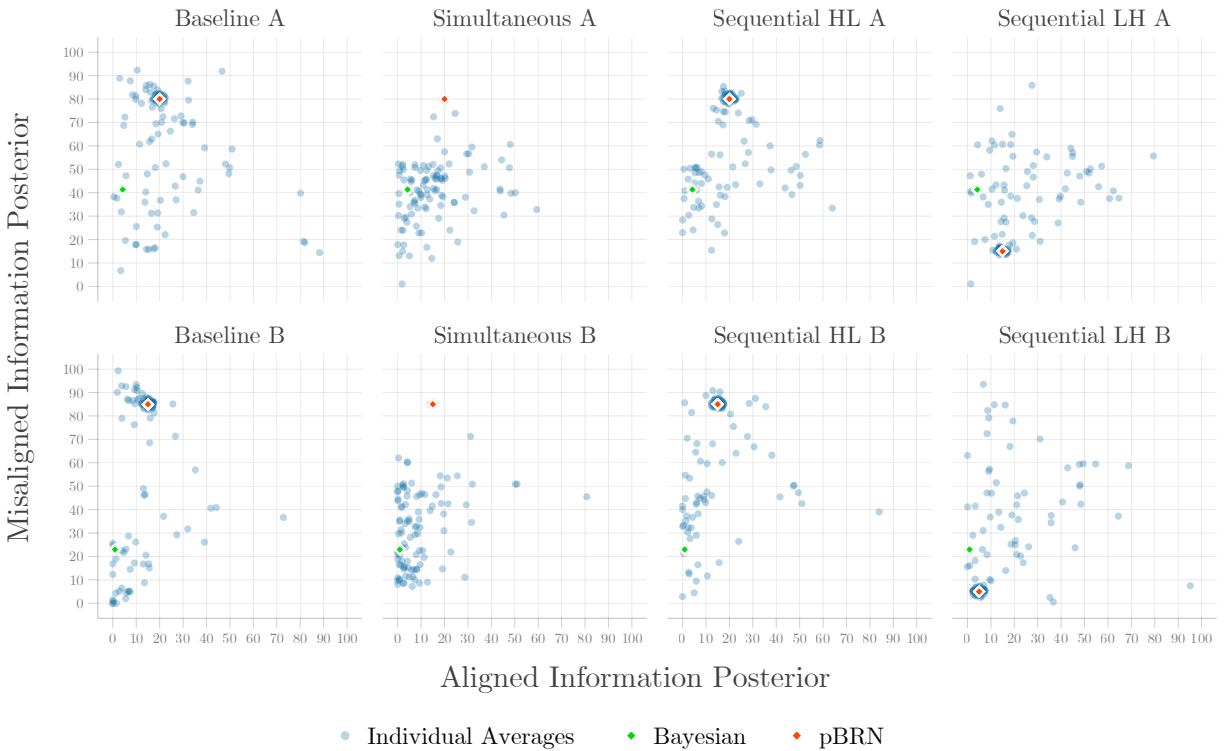
- Once more, most of the design choices are unchanged from the previous treatments. However, in the sequential treatment, participants received signals sequentially. Upon receiving the first signal, their posterior probability was elicited. Afterward, participants stated their posteriors conditional on the realized value of the second signal.
- The interface displays the outcome of the first signal when participants make choices conditional on the outcome of the second signal.

3 Related Data Analysis

3.1 Individual Level Analysis

Figure 8 displays the counterpart of Figure 9 in the main text, utilizing data from the last five rounds only.

Figure 8: Average Individual Choices: Last Five Rounds

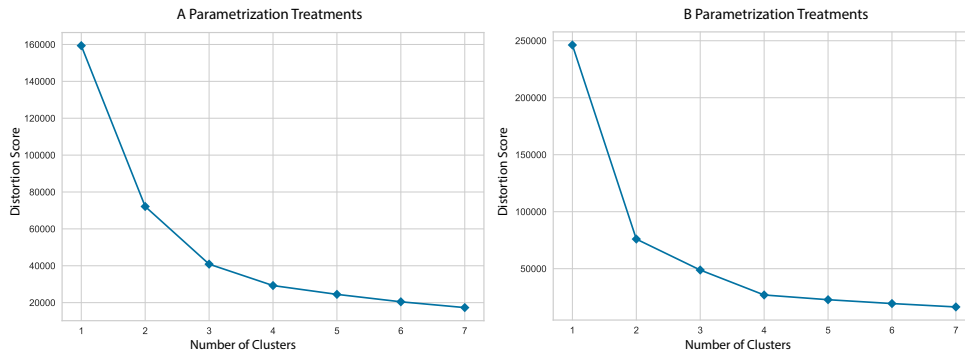


Notes: To help distinguish the large amount of data bundled on the pBRN level, we apply a jitter of 1.5 magnitude. This jittering perturbs the datapoint no further than a distance of 1.5 from the initial value. The top(bottom) row displays data across treatments under parametrization A(B).

3.2 Classifying Types

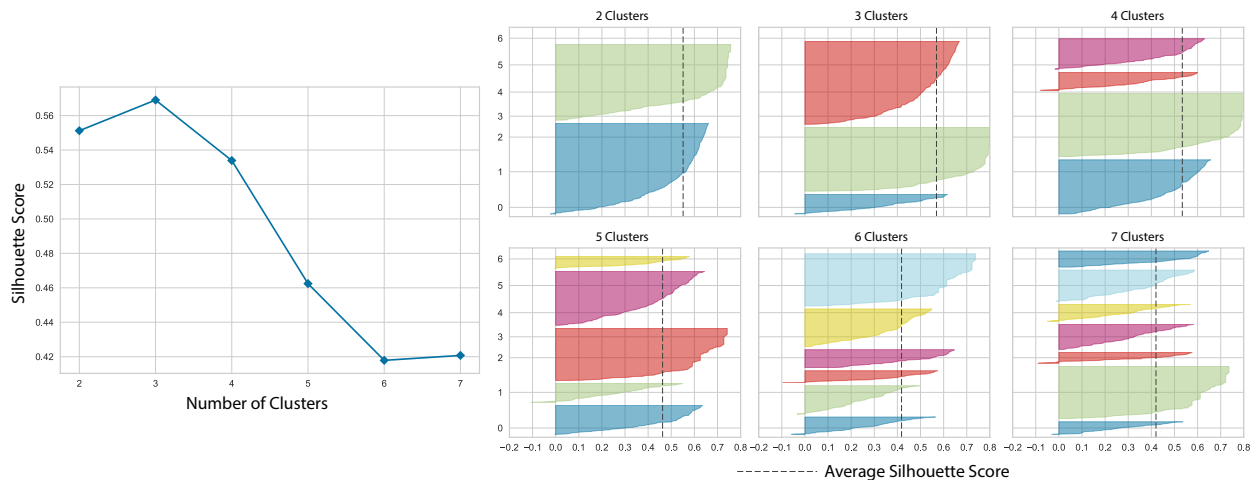
The elbow method is a way to determine the optimal number of clusters in a dataset for k-means clustering. It works by plotting the sum of squared distances between each point and the centroid of its cluster against the number of clusters used. The plot looks like an arm, and the elbow point on the arm represents the best number of clusters to use. This is because the elbow point is where adding more clusters does not significantly improve the clustering results. The elbow method helps to select an appropriate number of clusters for k-means clustering, avoiding underfitting or overfitting the data. The graphs shown in Figure 9 reveal that the elbow method recommends three clusters for parametrization A, while for parametrization B, the score is somewhat ambiguous between two, three, and four clusters. We supplement our calculations by determining the optimal number of clusters via the silhouette method.

Figure 9: Distortion Score Elbow for K-Means Clustering



The silhouette method is a way to evaluate the quality of clustering results in a dataset. It works by measuring how similar an observation is to its own cluster compared to other clusters. The silhouette score ranges from -1 to 1, with higher values indicating better clustering results. A score of 1 indicates that the observation is well-matched to its own cluster and poorly-matched to other clusters. A score of -1 indicates the opposite, while a score of 0 indicates that the observation is equally similar to its own cluster and other clusters. The silhouette method calculates the average silhouette score of all observations in the dataset and uses this as a measure of how well the data is clustered. The method can be used to compare different clustering methods or to select the best number of clusters to use in a k-means clustering analysis. By selecting the number of clusters that maximizes the silhouette score, the method can help improve the accuracy and reliability of the clustering results. The graphs shown in Figure 10 reveal that the silhouette score is maximized under three clusters.

Figure 10: Silhouette Scores For K-Means Clustering



We thus decide to proceed with the clustering exercise with three clusters.

4 Pilot Data

4.1 Estimated Means

We ran two pilot studies under parametrization A for the Baseline and Simultaneous treatment. In [Table 1](#), we compare the estimated mean from Baseline A and Simultaneous A with the estimated means in their corresponding pilot treatments. The variable *Constant* captures the estimated mean in the regular session, whereas the variable *Pilot* captures the difference of the estimated mean from this value in the pilot treatment. As can be seen, regardless of the error clustering level, the difference is never statistically significant.

Table 1: Estimated Means

	Baseline A			Simultaneous A		
	No C	Ind C	Ind C + Last 5	No C	Ind C	Ind C + Last 5
<i>Constant</i>	63.79*** (0.595)	63.79*** (1.971)	60.43*** (2.428)	41.65*** (0.384)	41.65*** (0.987)	40.29*** (1.295)
<i>Pilot</i>	0.434 (1.041)	0.434 (3.680)	5.911 (4.285)	1.001 (0.667)	1.001 (1.740)	1.483 (2.382)
<i>N</i>	3000	3000	750	3020	3020	755

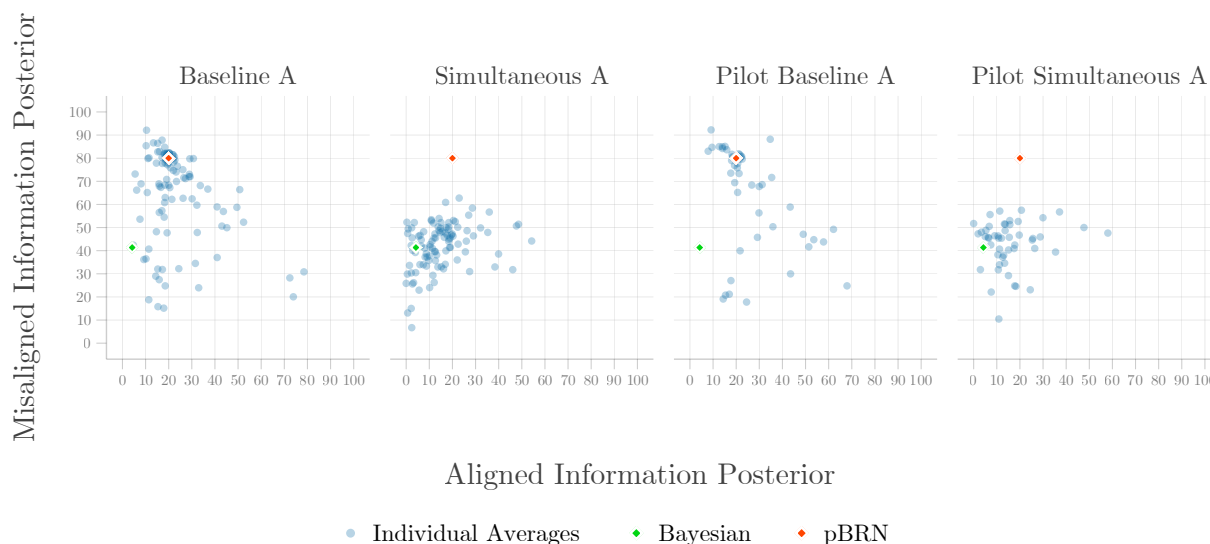
Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.2 Individual Level Analysis

In [Figure 11](#), we plot the individual level data for Baseline A and Simultaneous A, as well as their corresponding pilot treatments.

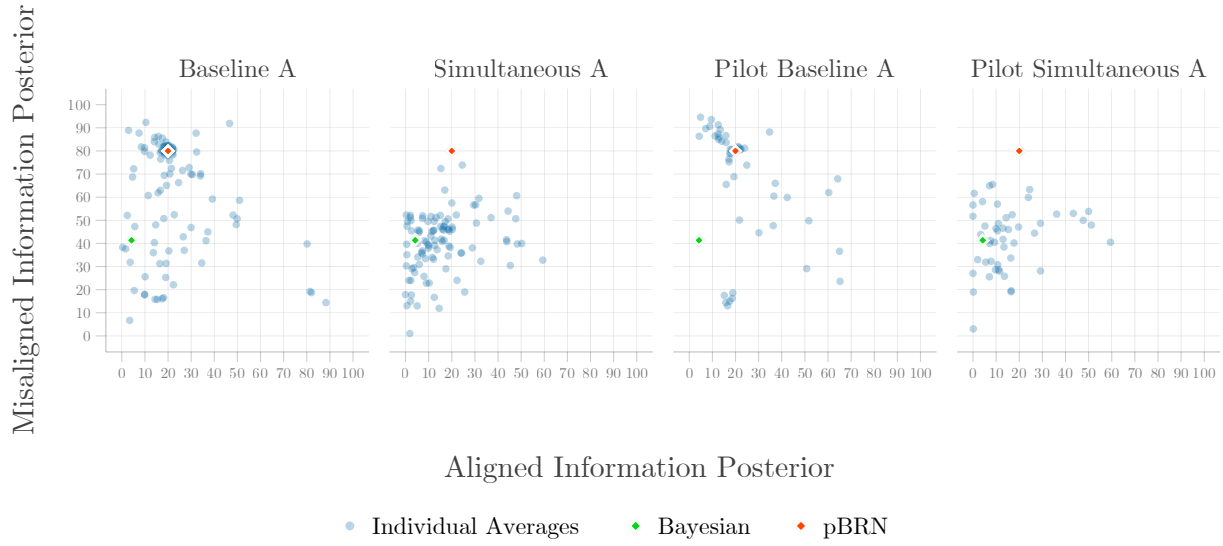
Figure 11: Average Individual Choices



Notes: To help distinguish the large amount of data bundled on the pBRN level, we apply a jitter of 1.5 magnitude. This jittering perturbs the datapoint no further than a distance of 1.5 from the initial value.

In [Figure 12](#), we do the same utilizing data from the last five rounds only.

Figure 12: Average Individual Choices: Last Five Rounds



Notes: To help distinguish the large amount of data bundled on the pBRN level, we apply a jitter of 1.5 magnitude. This jittering perturbs the datapoint no further than a distance of 1.5 from the initial value.