

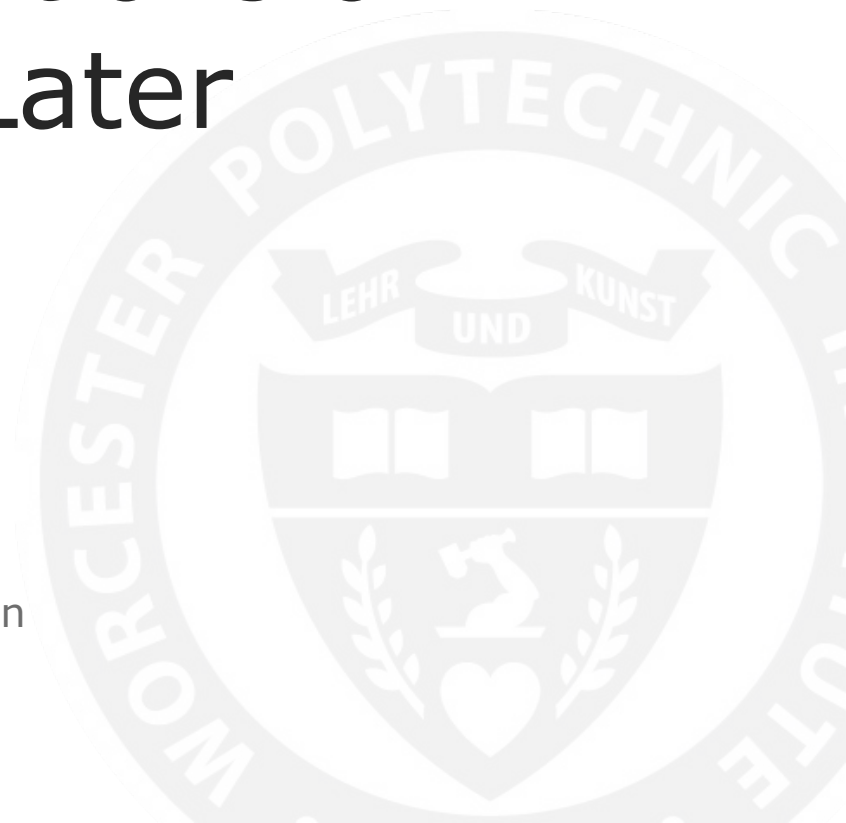
WPI

Calendar Visualizations of Money Earlier or Later Questions

By Yahel Nachum

Major Thesis Advisor: Professor Daniel Reichman

Thesis Reader: Professor Neil Heffernan



Acknowledgements



Professor Daniel Reichman



Professor Lane Harrison



Professor Ravit Heskiu



Professor Neil Heffernan

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Peter Cordone



Yiren Ding

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Lastly, but most importantly, Caroline Muirhead, my wife.





LIFE CHANGES

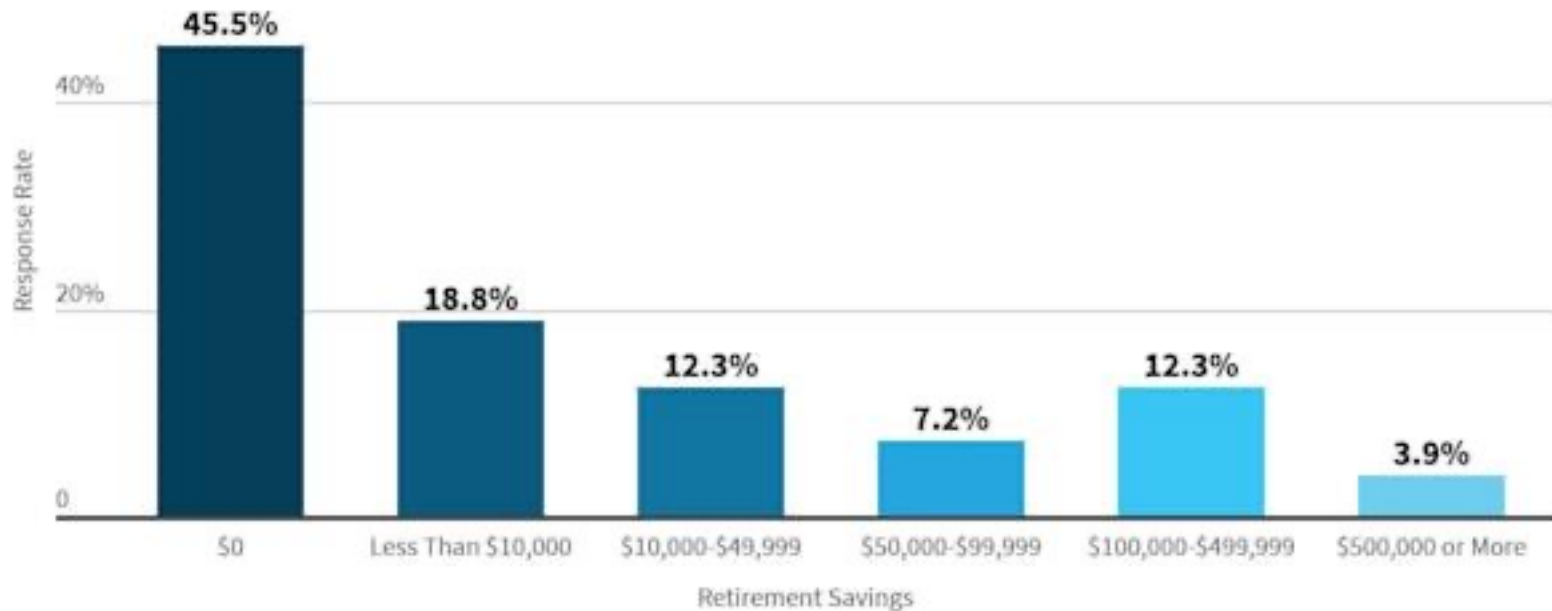
Are you saving enough for retirement? Odds are, probably not

PUBLISHED MON, APR 11 2022•9:30 AM EDT | UPDATED MON, APR 11 2022•3:40 PM EDT

Andrew Osterland

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Most Americans Do Not Have Enough Savings For Retirement



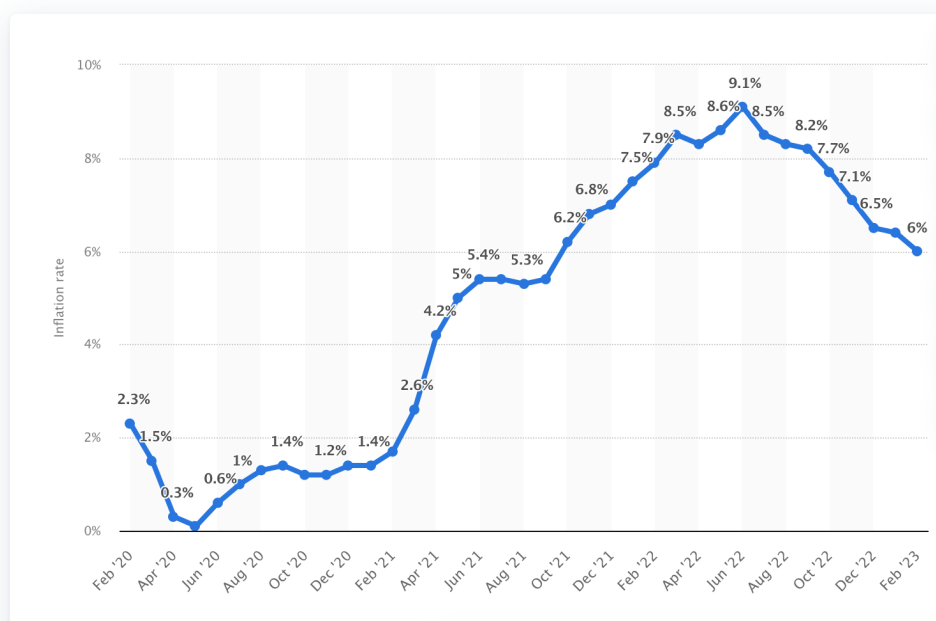
Last updated Sept. 17, 2019



Inflation Makes Saving Money More Difficult

statista 

Monthly 12-month inflation rate in the United States from February 2020 to February 2023



The Boston Globe

Silicon Valley Bank collapsed at unprecedented speed. Can Washington prevent another viral bank run?

By [Jim Puzzanghera](#) Globe Staff, Updated April 2, 2023, 3:53 p.m.



Why Do People Struggle To Save Money?

- Low-income earners



- Poor financial decisions



Why Do People Struggle To Save Money?

- Low-income earners



- **Poor financial decisions**



Delayed Gratification Is An Important Skill



VS



Goal of project: Find ways to encourage people to delay gratification and save money



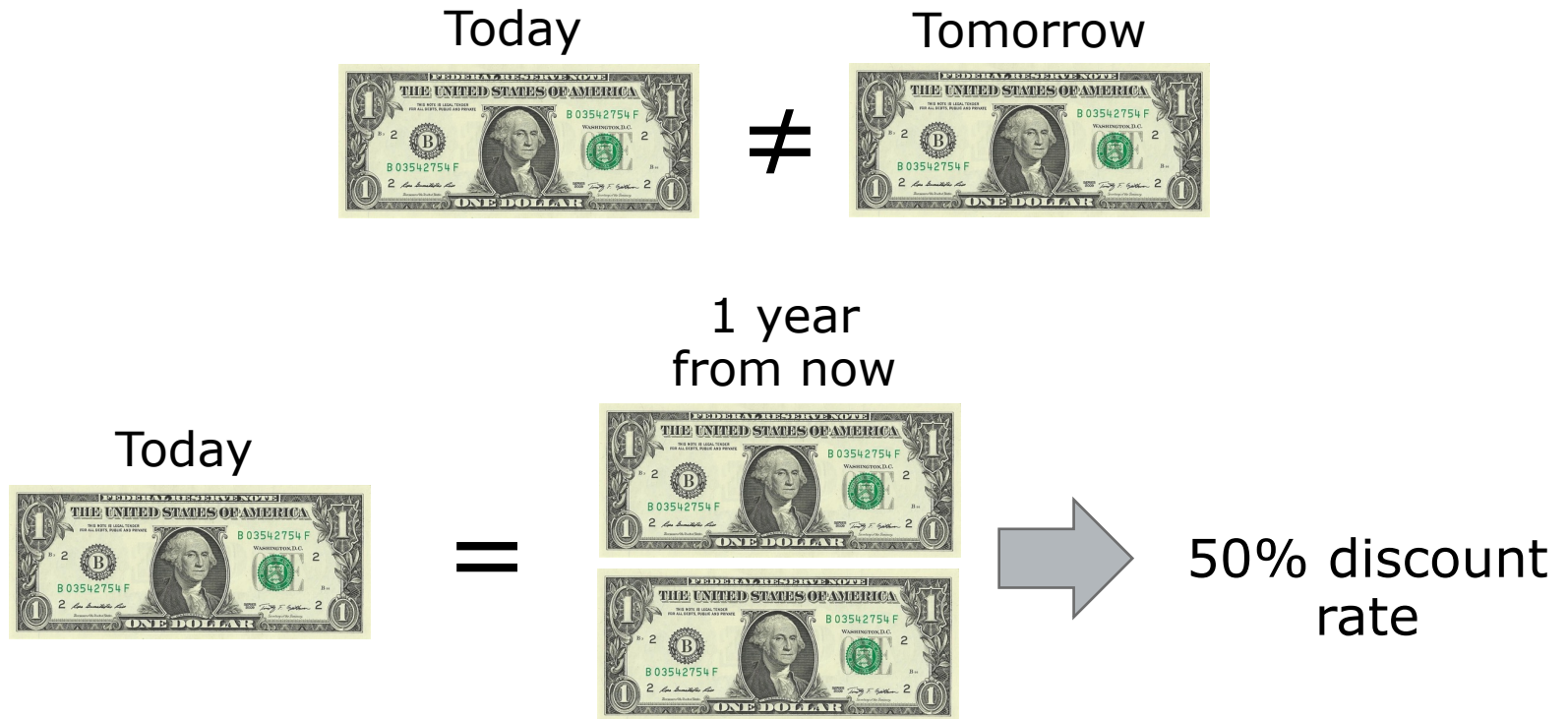
We Can Study How People Save Money Through Money Choice Questions

- Money decision making (now vs later)
- Previous Money Earlier or Later (MEL) research

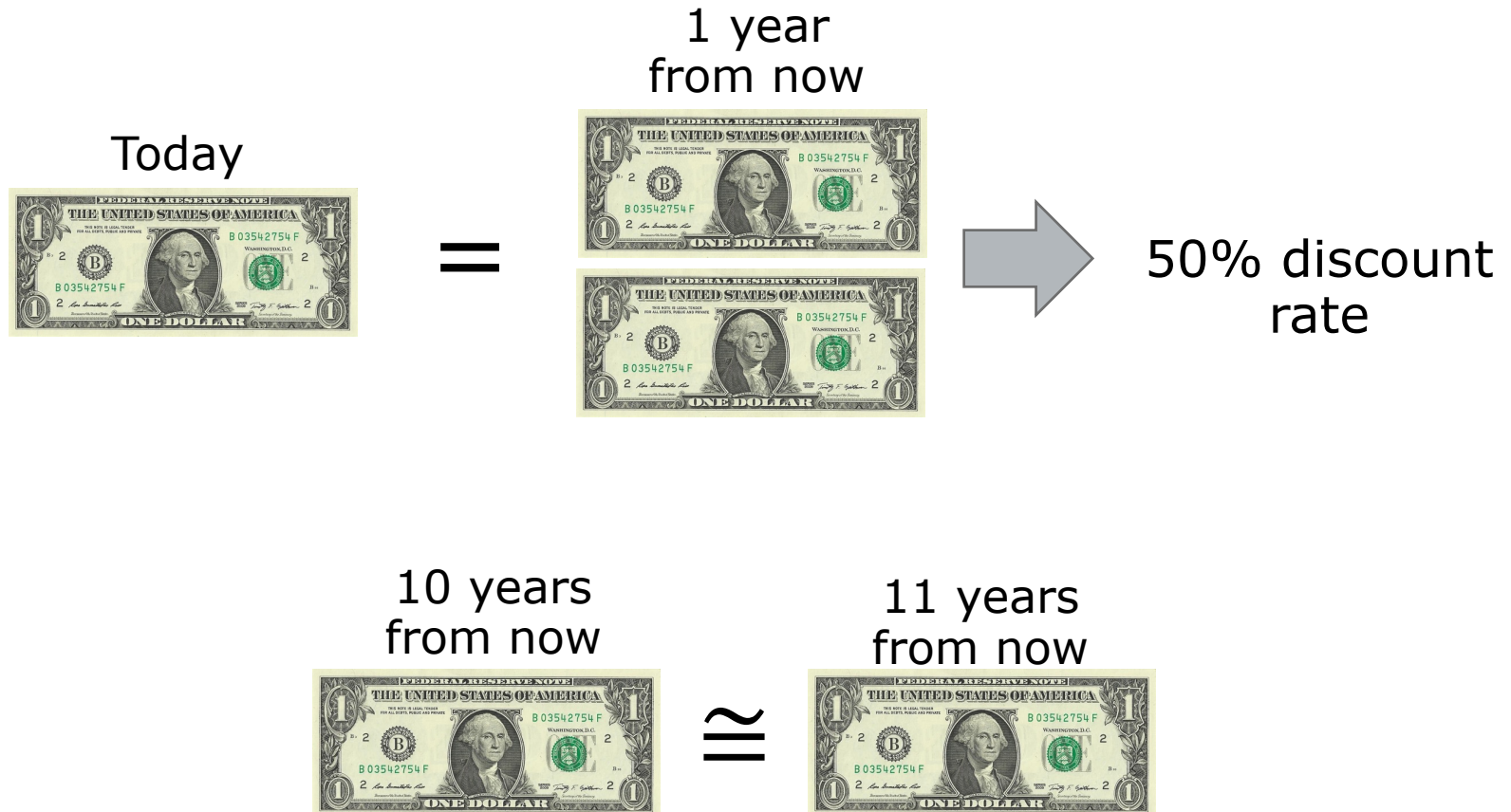
Would you like to receive \$100 on May 1st, 2023 or \$150 on May 1st, 2033

Would you like to receive \$100 on May 1st, 2023 or \$150 on May 2nd, 2023

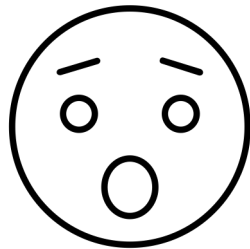
Discount Rate



The Discount Rate Is Not Constant Across Time

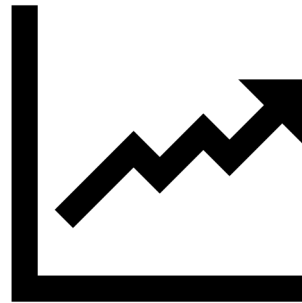


Reasons For Discounting



Emotions

- Instant gratification
- Anxiety about future

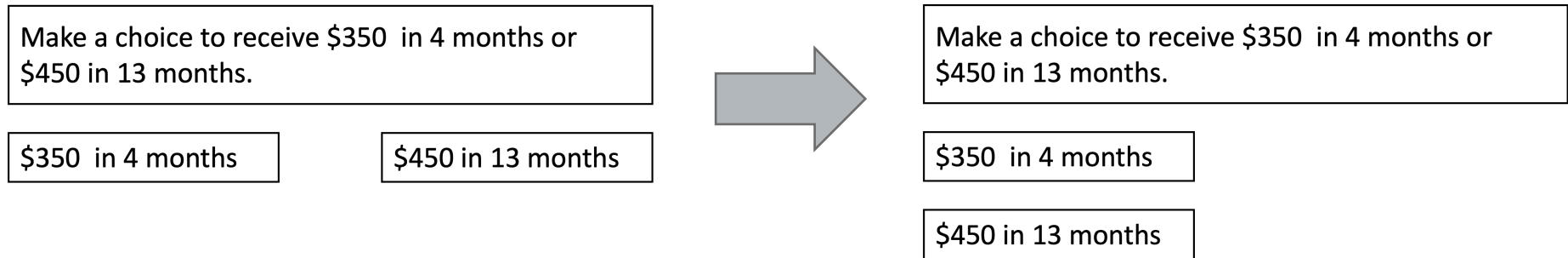


Inflation



Utility

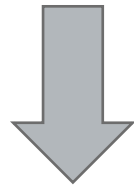
Layout Of Choices Affects Discounting



discount rate 

Wording Of Choices Affects Discounting

\$10 dollars in a month



\$10 dollars on May 20th, 2023

discount rate

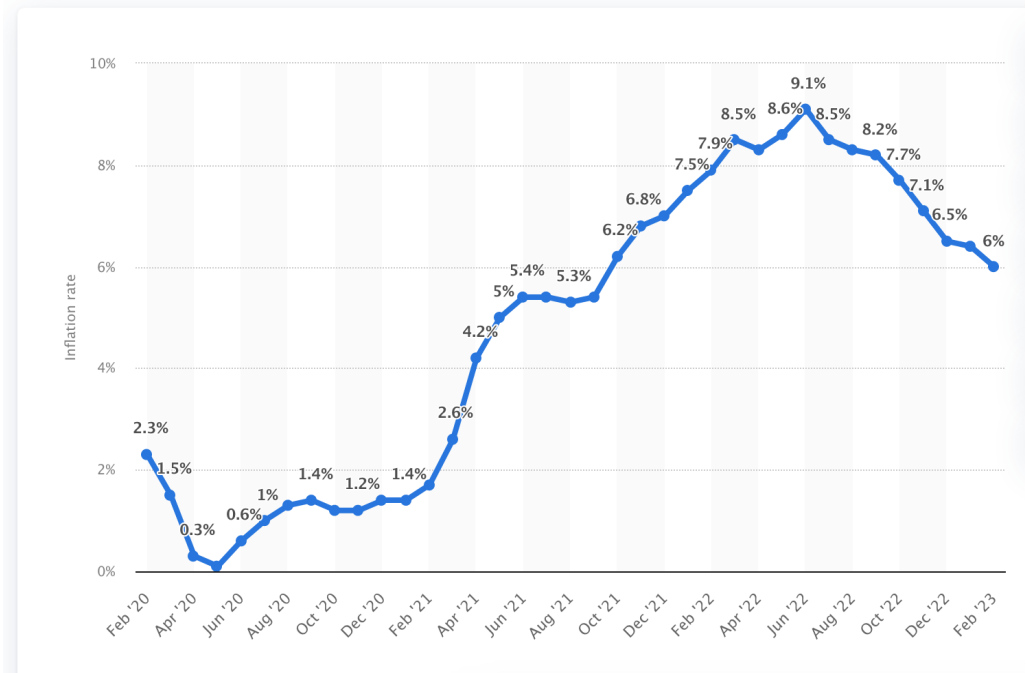


Visualizations Help People Understand Data

| Year | Month | Monthly Inflation Rate |
|------|-------|------------------------|
| 2020 | Feb | 2.3% |
| 2020 | Mar | 1.5% |
| 2020 | Apr | 0.3% |
| 2020 | May | 0.1% |
| 2020 | Jun | 0.6% |
| 2020 | Jul | 1.0% |
| 2020 | Sep | 1.4% |
| 2020 | Nov | 1.2% |
| 2021 | Jan | 1.4% |
| 2021 | Mar | 2.6% |
| 2021 | Apr | 4.2% |
| 2021 | May | 5.0% |
| 2021 | Jun | 5.4% |
| 2021 | Aug | 5.3% |
| 2021 | Oct | 6.2% |
| 2021 | Nov | 6.8% |
| 2022 | Jan | 7.5% |
| 2022 | Feb | 7.9% |
| 2022 | Mar | 8.5% |
| 2022 | May | 8.6% |
| 2022 | Jun | 9.1% |
| 2022 | Jul | 8.5% |
| 2022 | Sep | 8.2% |
| 2022 | Oct | 7.7% |
| 2022 | Nov | 7.1% |
| 2022 | Dec | 6.5% |
| 2023 | Feb | 6.0% |



Monthly 12-month inflation rate in the United States from February 2020 to February 2023



Converting Text To Visualizations Improved Economic Decisions

Would you like a:

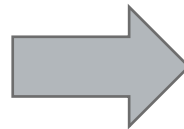
50% chance
of receiving \$100

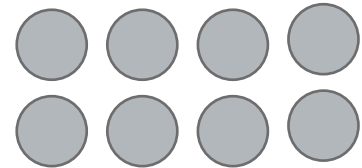
and

50% chance
of receiving \$0

or

100% chance
of receiving \$45

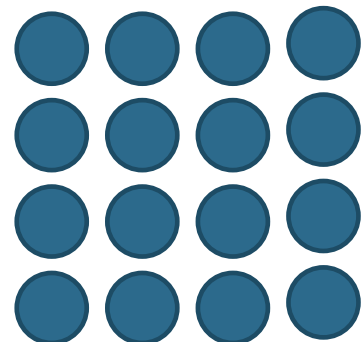



chance of
receiving \$100

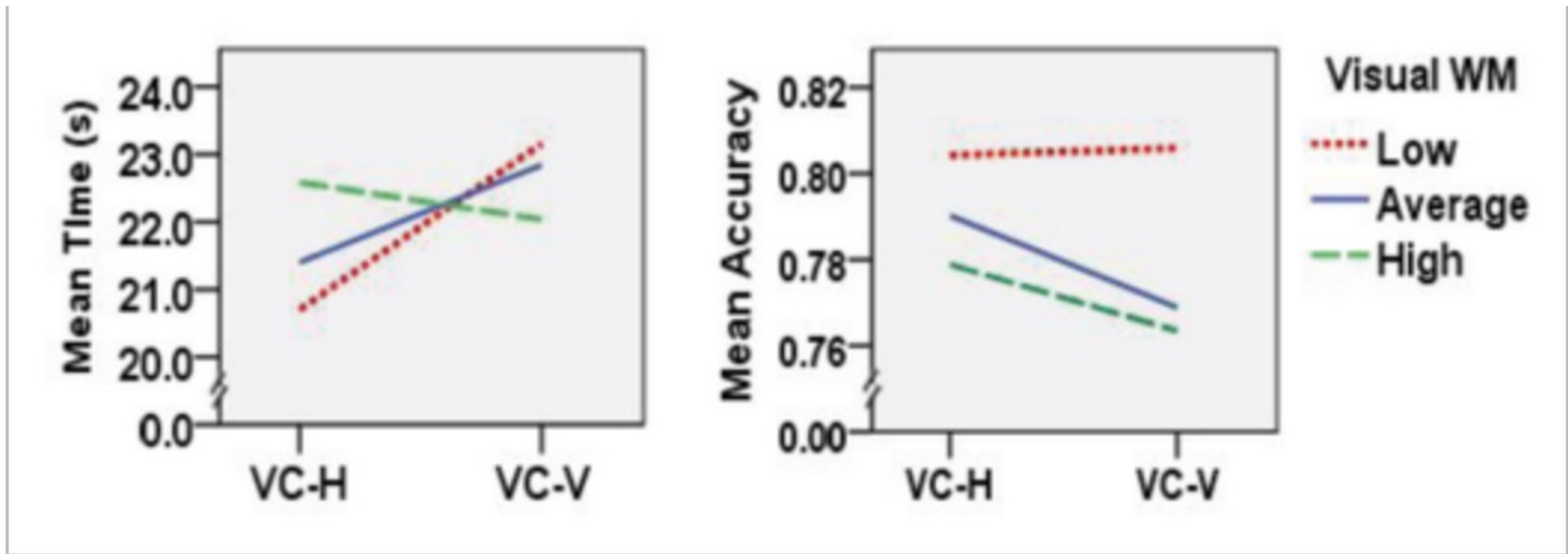
and

chance of
receiving \$0

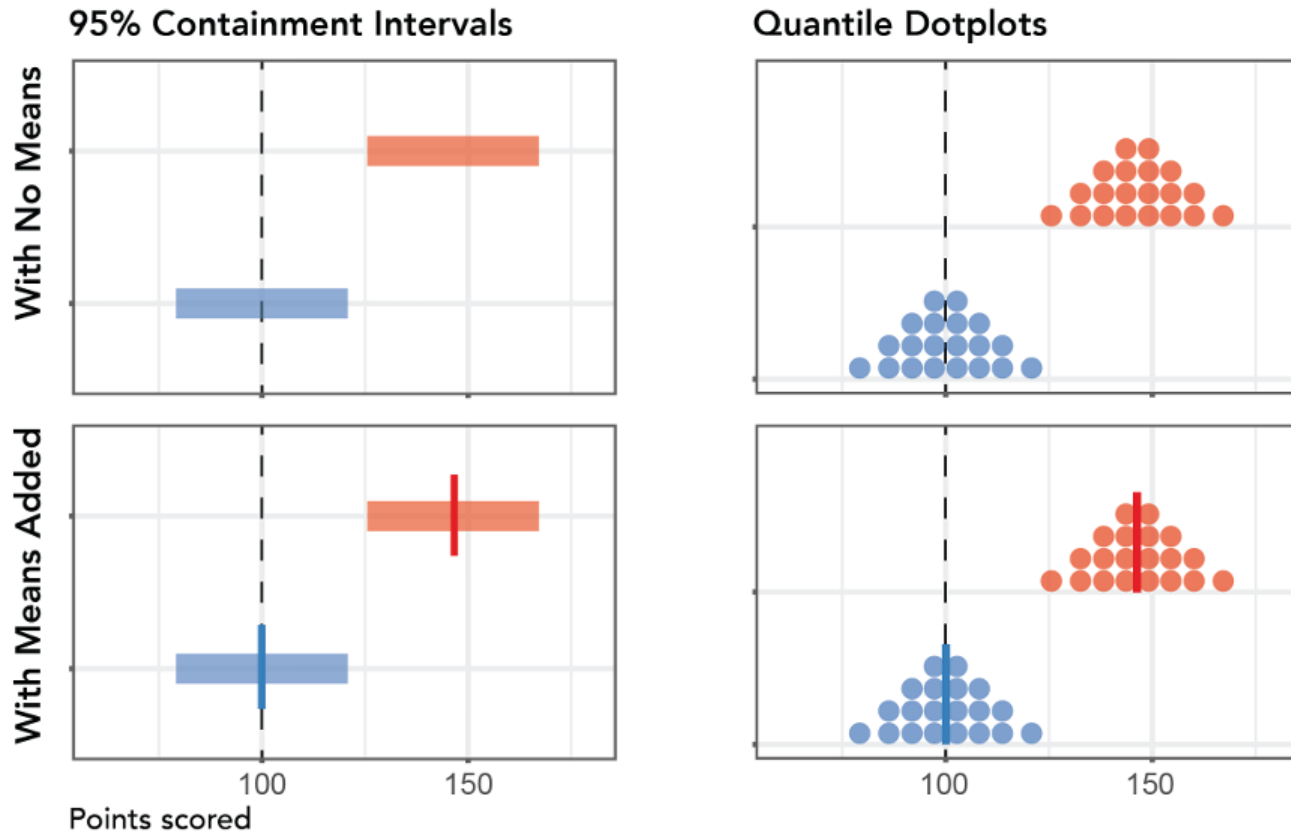
or


chance of
receiving \$45

Layouts Can Have Unique Effects Across Participants



Theory Does Not Always Work In Practice

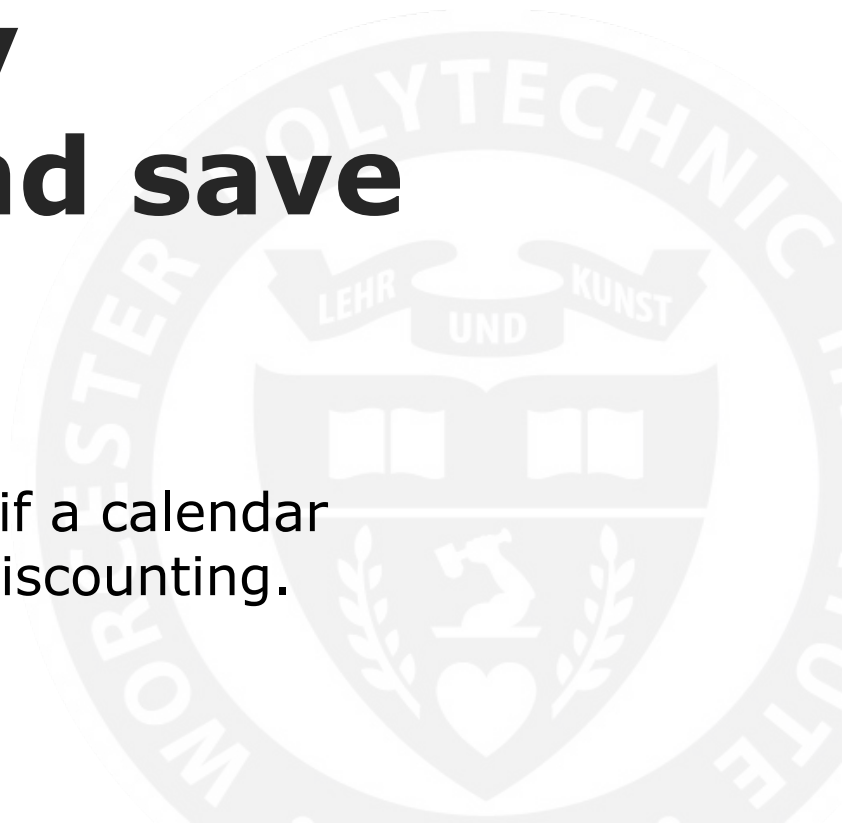


Calendars Are The Most Common Type Of Timeline Visualization



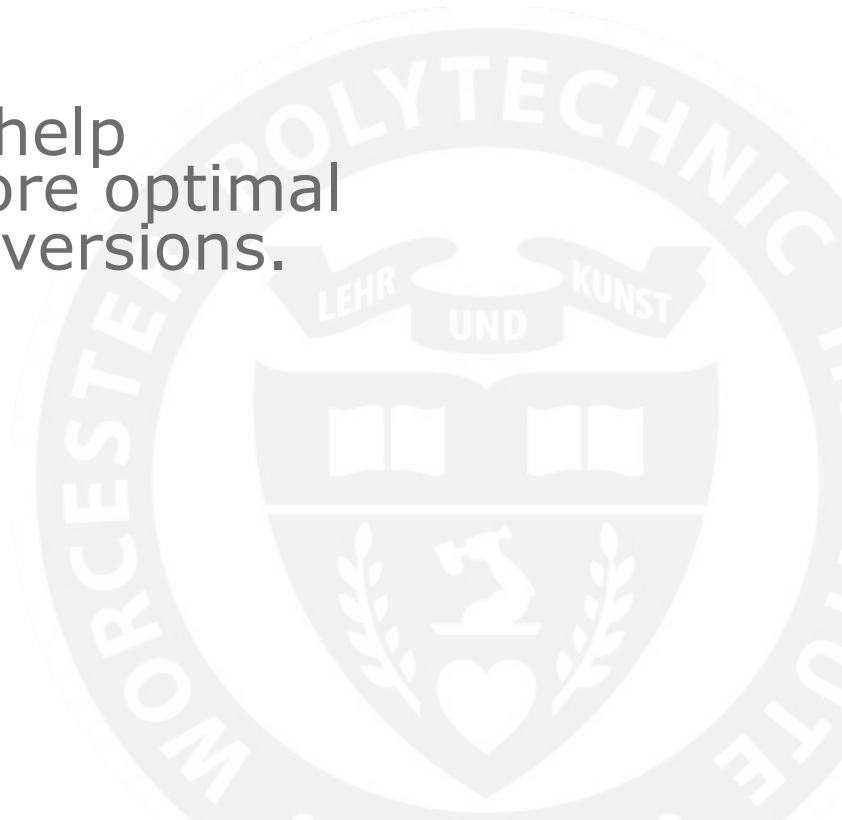
Goal of project: Find ways to encourage people to delay gratification and save money

More specifically, we want to see if a calendar visualization can affect people's discounting.



Hypothesis

Calendar visualizations will help participants to make the more optimal choice compared to textual versions.



High Level Overview Of Methods

1. Designed a survey with word questions and calendar visualizations
2. Implemented the survey in React
3. Ran the survey on Proflic, gathered data, and analyzed

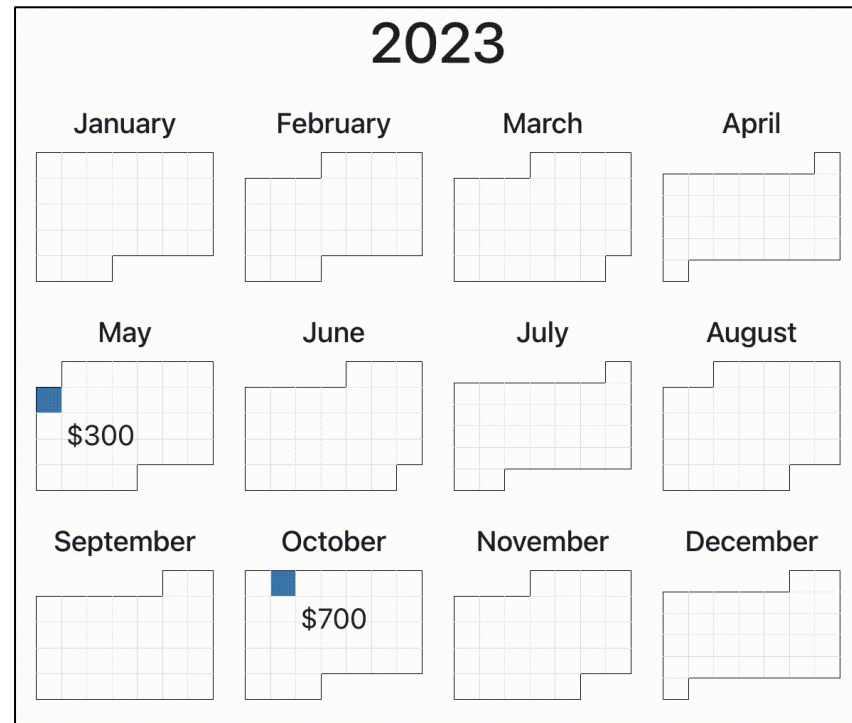
Word Version Of MEL Question

Make a choice to receive \$300 on May 7th, 2023 or \$700 on October 2nd, 2023.

\$300 on May 7th, 2023

\$700 on October 2nd, 2023

Calendar Version Of MEL Question

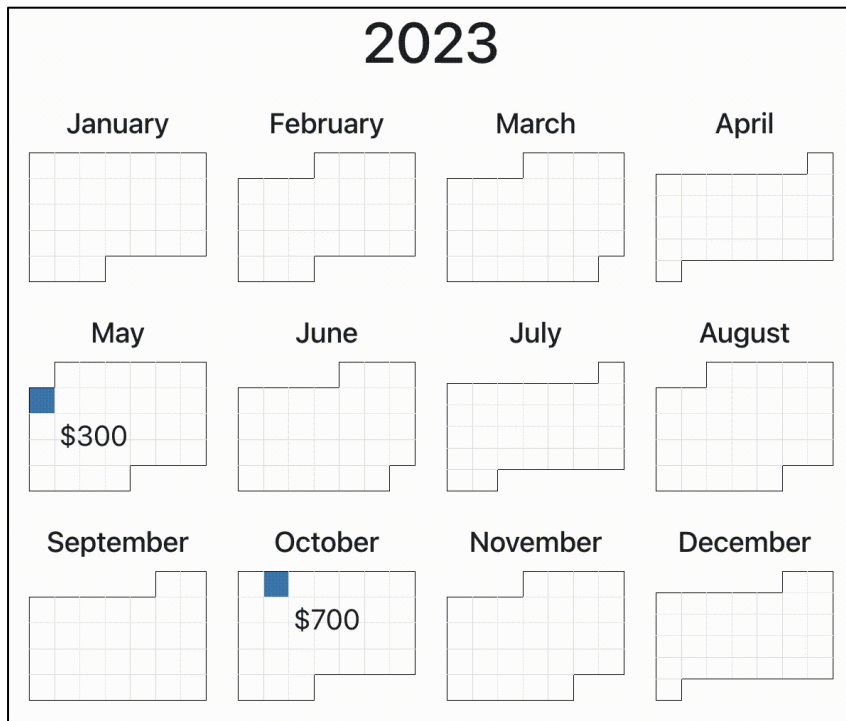


Comparing The Two Conditions

Make a choice to receive \$300 on May 7th, 2023 or \$700 on October 2nd, 2023.

\$300 on May 7th, 2023

\$700 on October 2nd, 2023



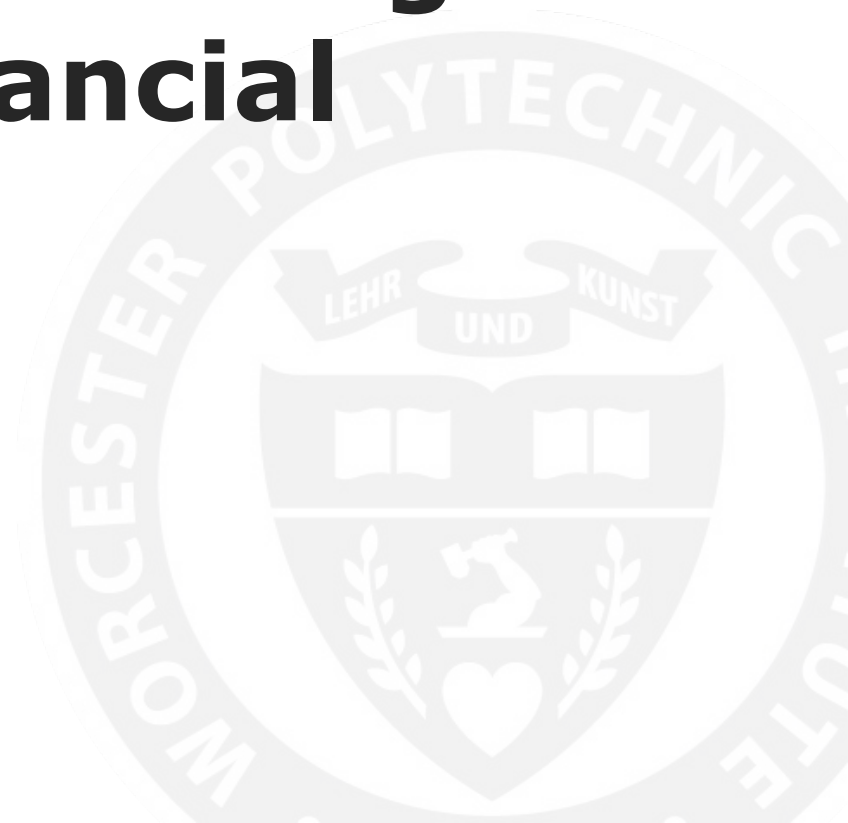
Which visualization would steer you towards the later option?

Picking Amounts And Dates

- Read et al. [13] paper on dates vs delays
- Conversion from British Pounds to USD
- Converted dates (randomly)

| Question | Earlier | | Later | |
|----------|---------|-----------------------------------|---------|-----------------------------------|
| | Amount | Date | Amount | Date |
| 1 | \$350 | April 10 th , 2023 | \$430 | September 8 th , 2023 |
| 2 | \$490 | July 24 th , 2023 | \$700 | December 6 th , 2023 |
| 3 | \$720 | May 21 st , 2023 | \$1,390 | July 29 th , 2023 |
| 4 | \$840 | June 15 th , 2023 | \$1,120 | September 26 th , 2023 |
| 5 | \$32 | August 6 th , 2023 | \$39 | November 14 th , 2023 |
| 6 | \$45 | May 29 th , 2023 | \$70 | September 17 th , 2023 |
| 7 | \$66 | September 12 th , 2023 | \$110 | November 8 th , 2023 |
| 8 | \$77 | July 30 th , 2023 | \$118 | October 15 th , 2023 |

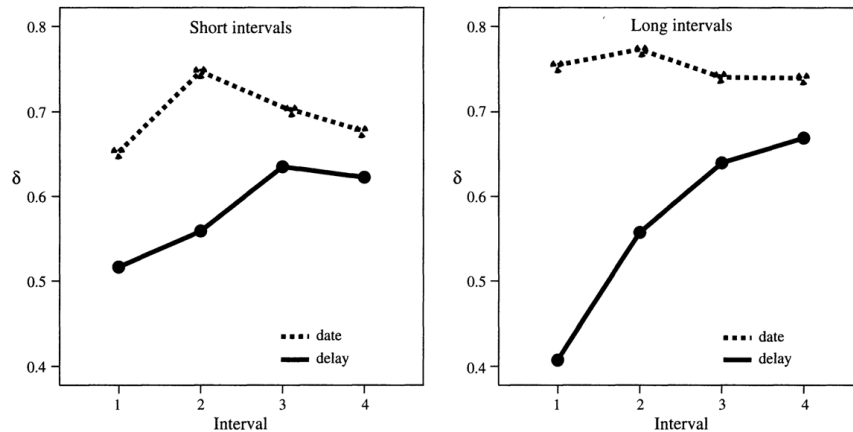
**How am I determining
the optimal financial
choice?**



Defining The Optimal Choice

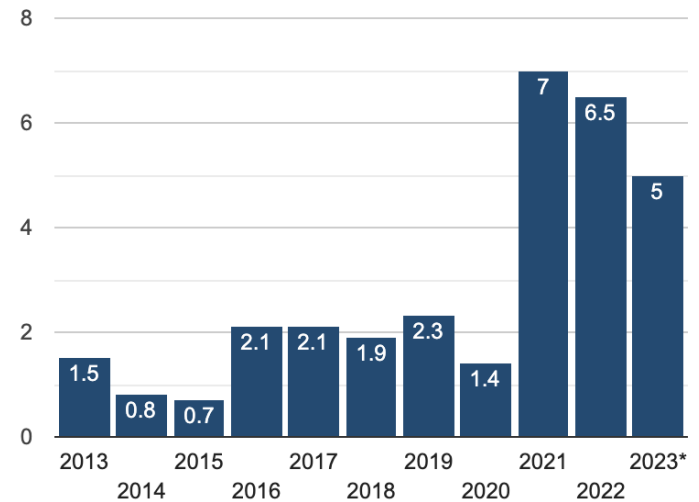
- Read et al. [13] paper on dates vs delays
 - $\sim 60\%$ discount rate
- Current Inflation 6%
- Discount rate of 166%

Figure 1 Experiment 5



Notes. Values of δ measured for intervals of the same length but varying in onset, under both date and delay descriptions. Interval 1 ranges from $t_1 \rightarrow t_2$, interval 2 from $t_2 \rightarrow t_3$, and so on.

Chart: United States Annual Inflation Rates (2013 to 2023)



How To Calculate Optimal Behavior

$$\text{diffDays} = \text{days until later date} - \text{days until earlier date}$$

$$\text{diffProportion} = \frac{\text{diffDays}}{365 \text{ days in a year}}$$

$$\text{rateDiscount} = 1 + 1.66 \text{ calculated discount rate} * \text{diffProportion}$$

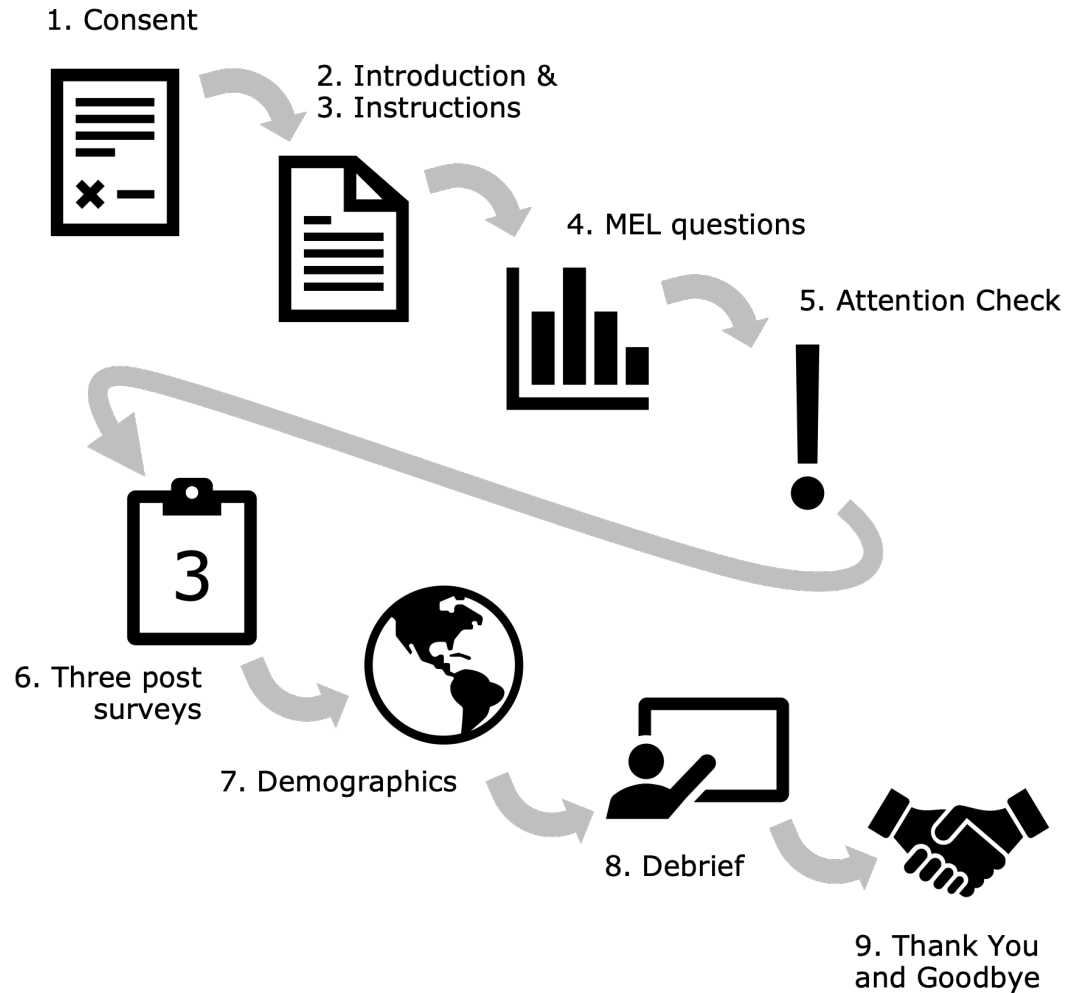
$$\text{equivalent later amount} = \text{earlier amount} * \text{rateInflation} * \text{rateROI}$$

$$\text{optimal choice} = \begin{cases} \text{earlier,} & \text{for equivalent later amount} > \text{later amount} \\ \text{later,} & \text{otherwise} \end{cases}$$

Optimal Behavior With Our MEL Values

| Question | Earlier | | Later | | Optimal Choice |
|----------|---------|-----------------------------------|---------|-----------------------------------|----------------|
| | Amount | Date | Amount | Date | |
| 1 | \$350 | April 10 th , 2023 | \$430 | September 8 th , 2023 | Earlier |
| 2 | \$490 | July 24 th , 2023 | \$700 | December 6 th , 2023 | Earlier |
| 3 | \$720 | May 21 st , 2023 | \$1,390 | July 29 th , 2023 | Later |
| 4 | \$840 | June 15 th , 2023 | \$1,120 | September 26 th , 2023 | Earlier |
| 5 | \$32 | August 6 th , 2023 | \$39 | November 14 th , 2023 | Earlier |
| 6 | \$45 | May 29 th , 2023 | \$70 | September 17 th , 2023 | Later |
| 7 | \$66 | September 12 th , 2023 | \$110 | November 8 th , 2023 | Later |
| 8 | \$77 | July 30 th , 2023 | \$118 | October 15 th , 2023 | Later |

Flow Of Survey



3 Post Surveys To Get Descriptive Statistics

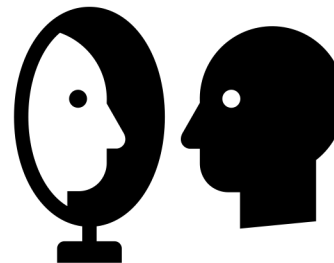
- Experience



- Financial Literacy

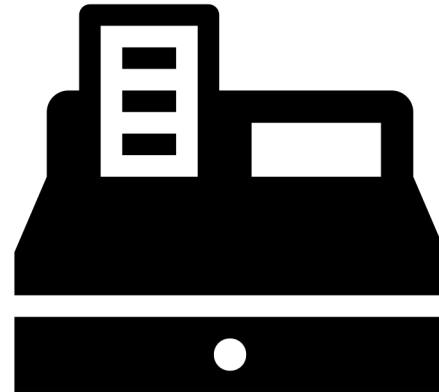


- Sense of Purpose



Participants Were Paid Fairly For Their Time

- 10 minute survey
- \$3 per participant
- \$18 per hour equivalent



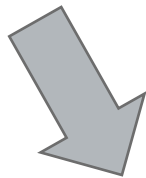
Overview Of How We Implemented The Survey

- React application
 - Reuse components
 - Integrate third-party modules
 - Host webpage and data storage online
 - Continuously test throughout development



Reusing Components In React

Interactive
Example in
Instructions

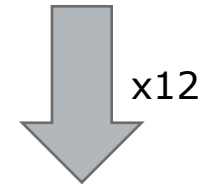


MEL Presentation

Set of 8 MEL
Questions

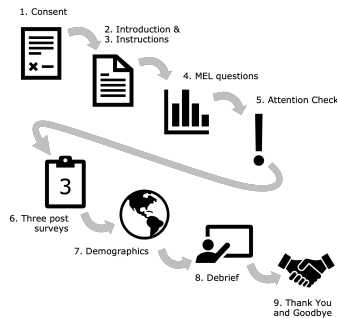
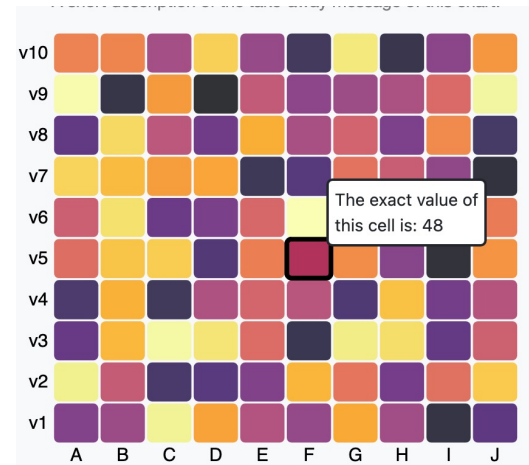
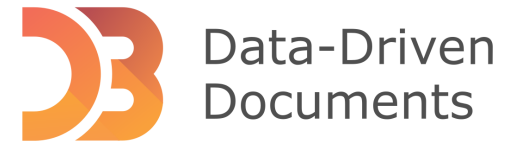


Single-year
Calendar

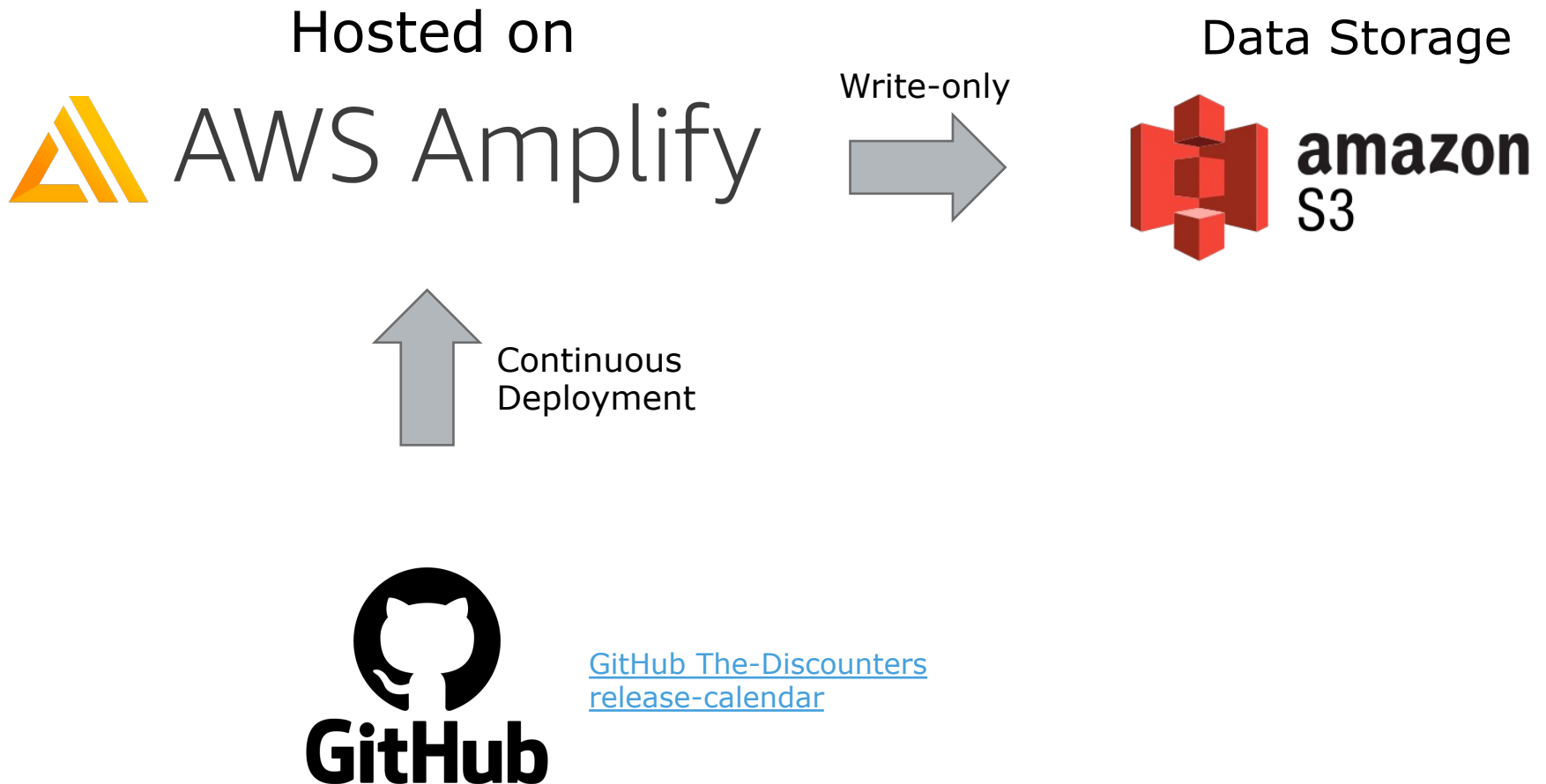


Single-month
calendar

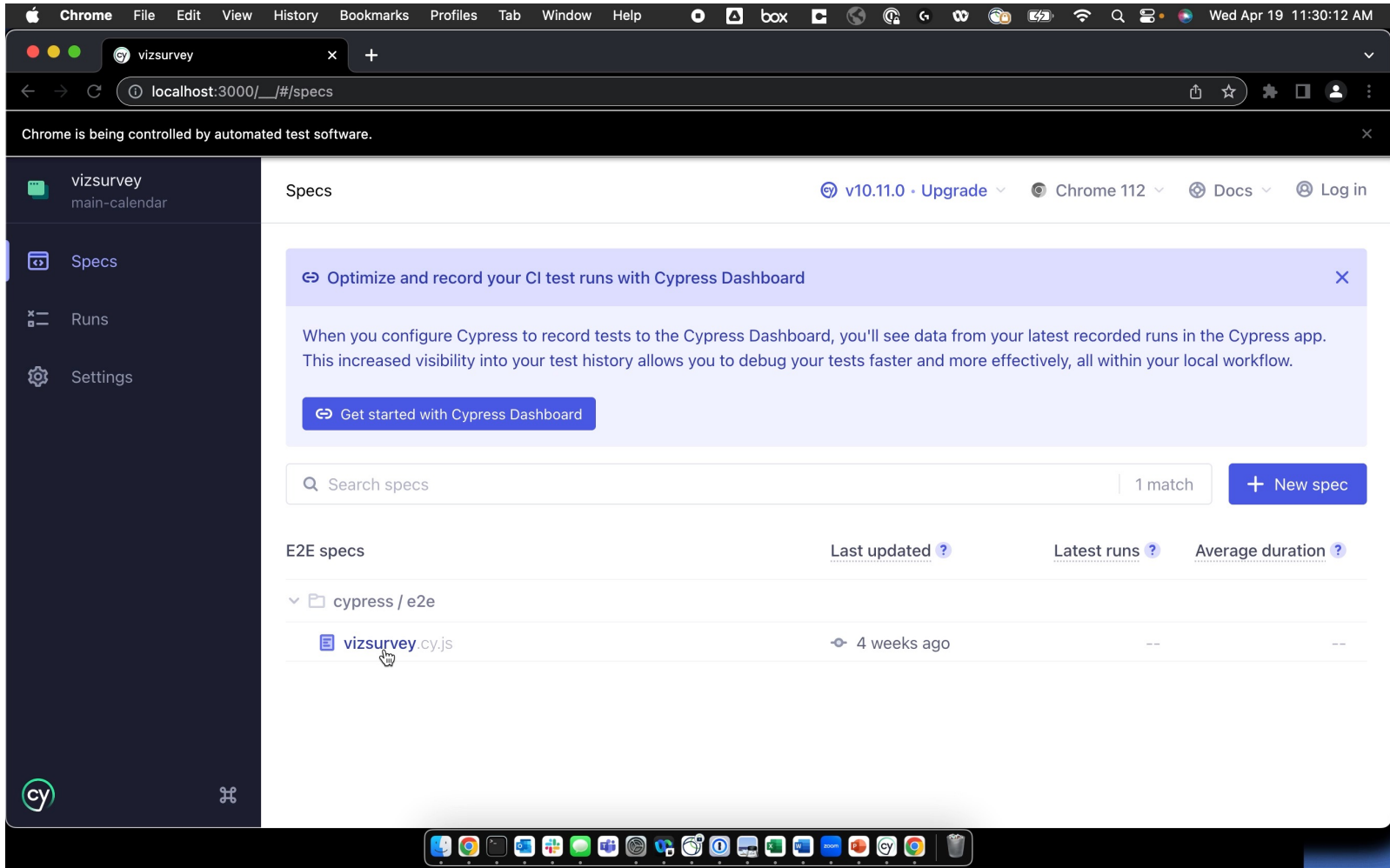
Third-party Modules We Integrated With



Hosting And Data Storage On



Continuous Testing With



The screenshot shows the Cypress Dashboard interface in a Chrome browser window. The browser address bar shows `localhost:3000/___/#/specs`. The dashboard has a dark sidebar on the left with navigation options: `vizsurvey main-calendar`, `Specs`, `Runs`, and `Settings`. The main content area is titled `Specs` and includes a version indicator `v10.11.0 · Upgrade`, browser info `Chrome 112`, and user options `Docs` and `Log in`. A purple banner at the top contains the text: `Optimize and record your CI test runs with Cypress Dashboard` and a `Get started with Cypress Dashboard` button. Below this is a search bar with `Search specs` and a `+ New spec` button. A table of E2E specs is displayed with columns for `Last updated`, `Latest runs`, and `Average duration`. The table shows a folder `cypress / e2e` and a file `vizsurvey.cy.js` updated `4 weeks ago`.

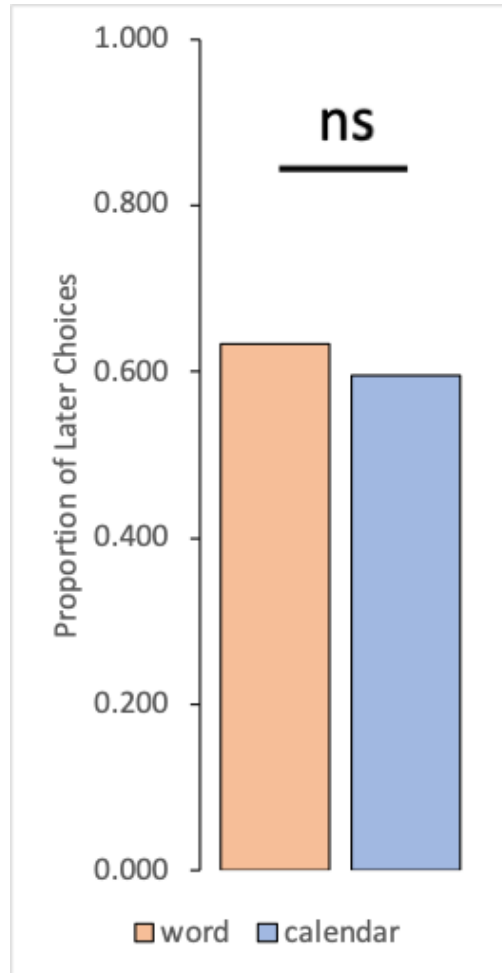
| E2E specs | Last updated ? | Latest runs ? | Average duration ? |
|-------------------|----------------|---------------|--------------------|
| ▼ cypress / e2e | | | |
| 📄 vizsurvey.cy.js | 🕒 4 weeks ago | -- | -- |

Data Collection & Analysis

- Between-subject design
 - Worded version using dates
 - Single-Year Calendar
- Prolific
 - April 5th, 2023
 - 60 U.S. participants
 - 30 word
 - 30 calendar

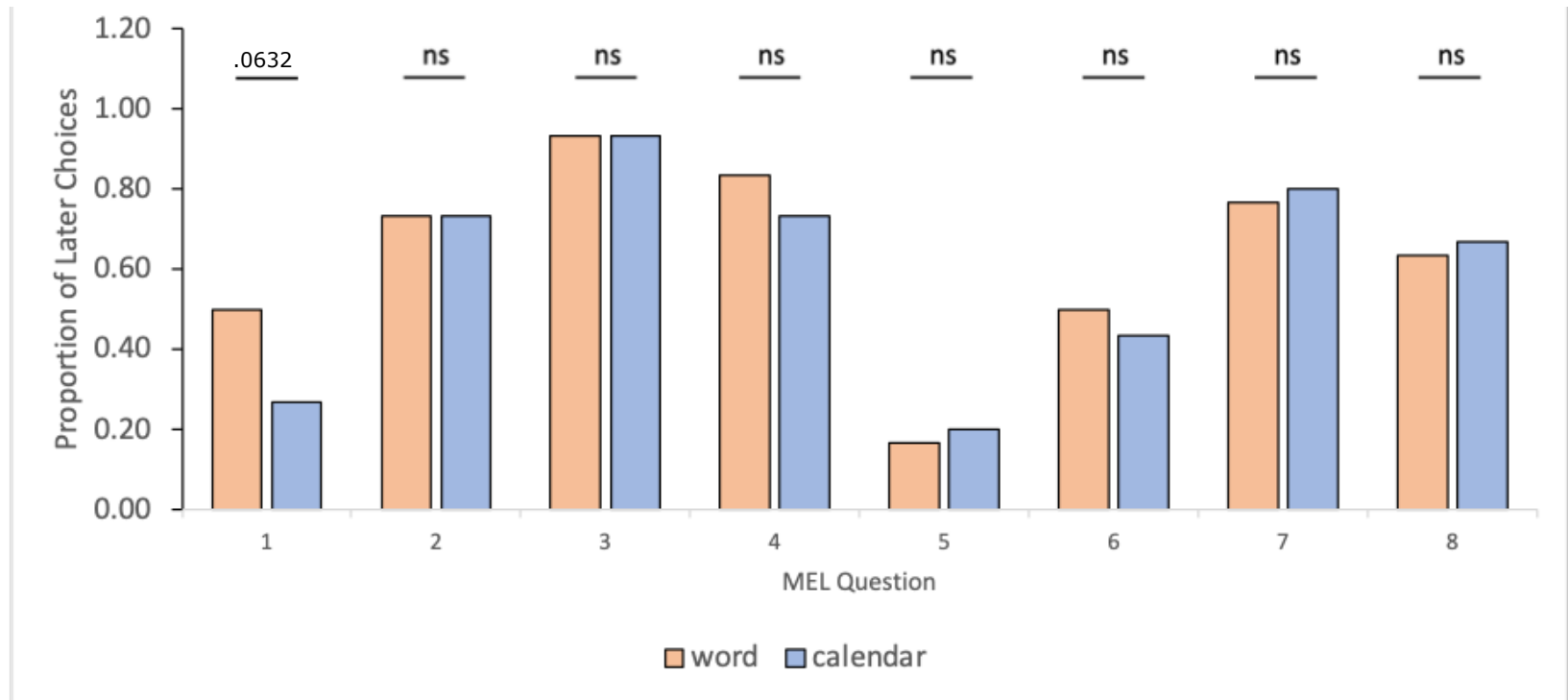


No General Difference In Discounting



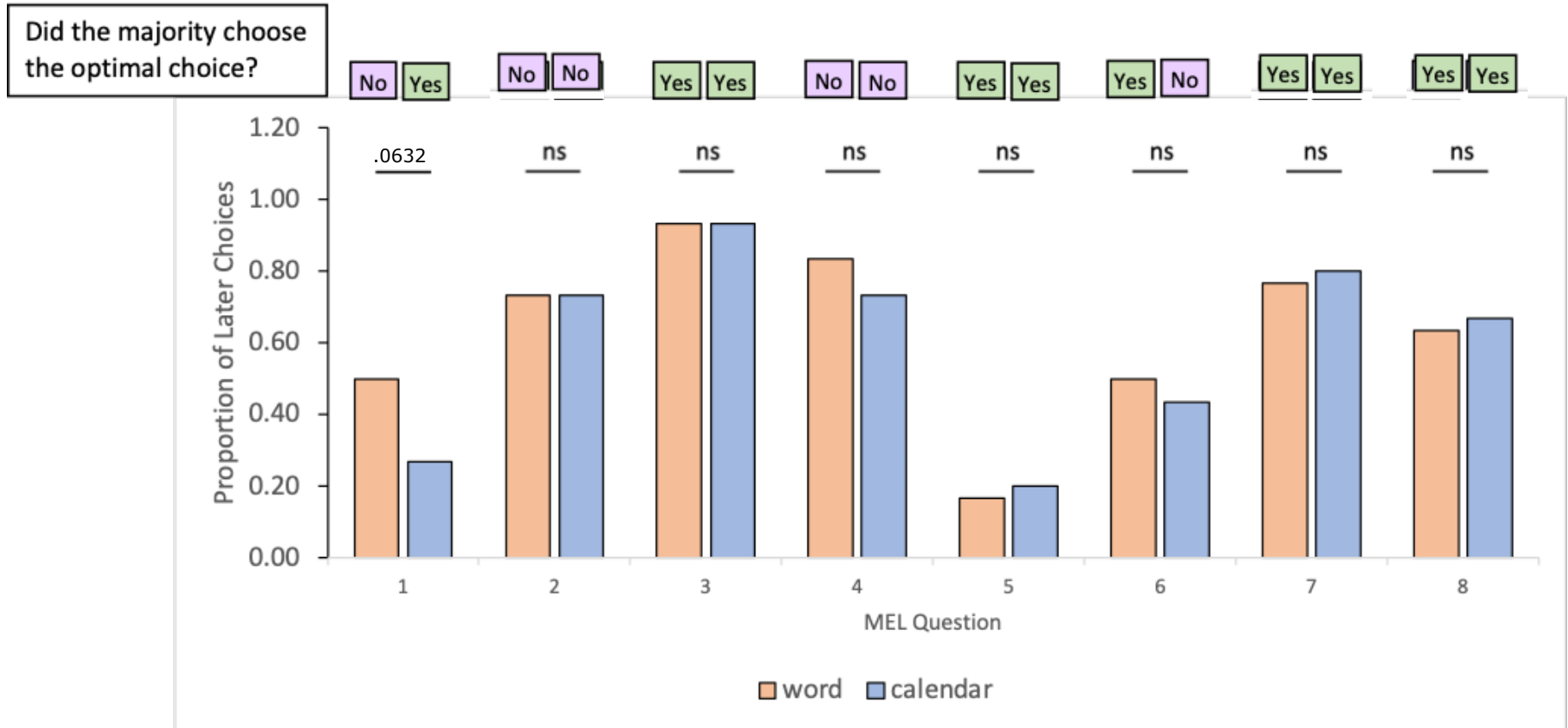
Chi-square test
of independence

First MEL Question Showed The Biggest Difference



Chi-square test
of independence

Responses Of Participants Compared To Optimal Choices



Chi-square test of independence

Amounts Compared To Participant's Responses

Did the majority choose the optimal choice?

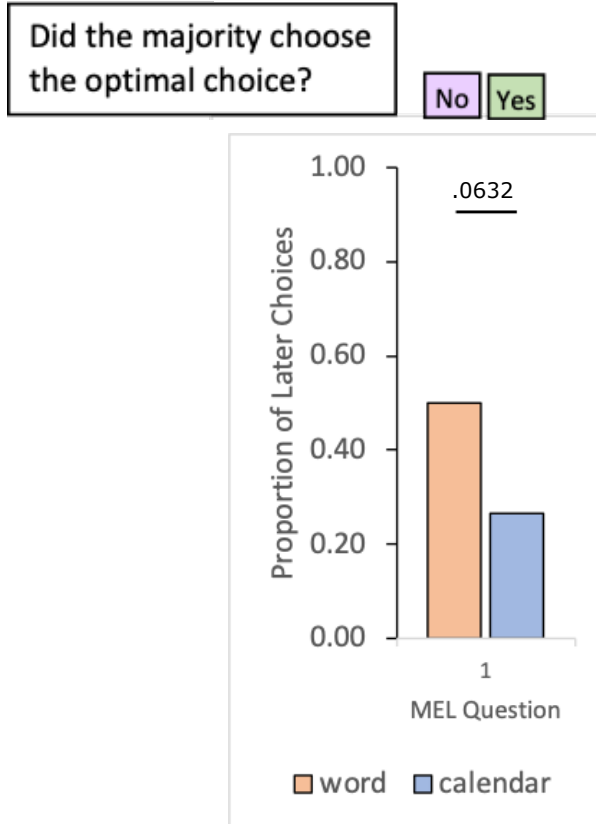
| Question | Earlier | | Later | | Optimal Choice | Did the majority choose the optimal choice? | |
|----------|---------|-----------------------------------|---------|-----------------------------------|----------------|---|----------|
| | Amount | Date | Amount | Date | | Word | Calendar |
| 1 | \$350 | April 10 th , 2023 | \$430 | September 8 th , 2023 | Earlier | No | Yes |
| 2 | \$490 | July 24 th , 2023 | \$700 | December 6 th , 2023 | Earlier | No | No |
| 3 | \$720 | May 21 st , 2023 | \$1,390 | July 29 th , 2023 | Later | Yes | Yes |
| 4 | \$840 | June 15 th , 2023 | \$1,120 | September 26 th , 2023 | Earlier | No | No |
| 5 | \$32 | August 6 th , 2023 | \$39 | November 14 th , 2023 | Earlier | Yes | Yes |
| 6 | \$45 | May 29 th , 2023 | \$70 | September 17 th , 2023 | Later | Yes | No |
| 7 | \$66 | September 12 th , 2023 | \$110 | November 8 th , 2023 | Later | Yes | Yes |
| 8 | \$77 | July 30 th , 2023 | \$118 | October 15 th , 2023 | Later | Yes | Yes |

First MEL Question

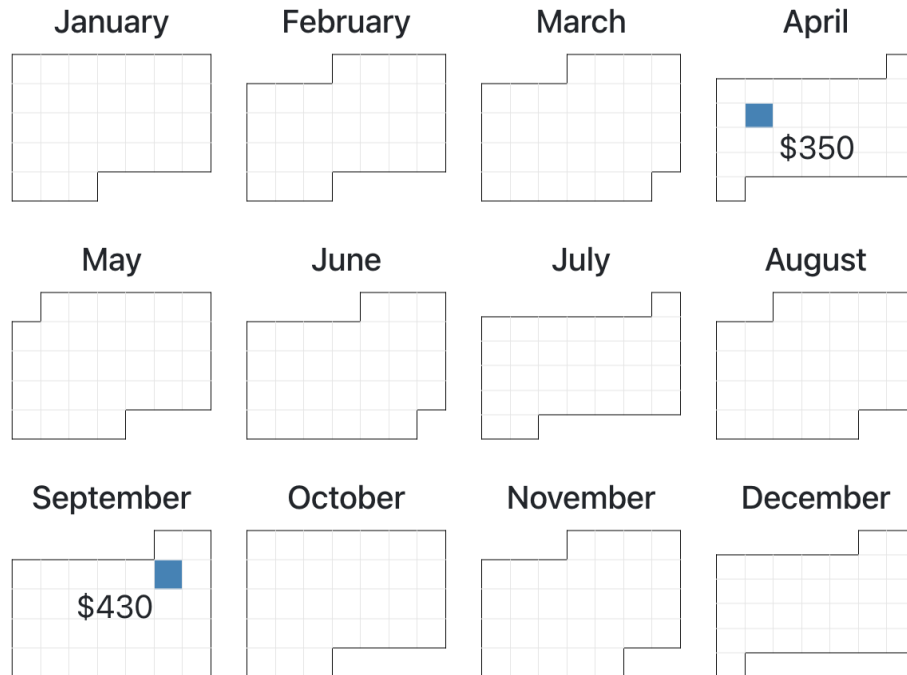
Make a choice to receive \$350 on April 10th, 2023 or \$430 on September 8th, 2023.

\$350 on April 10th, 2023

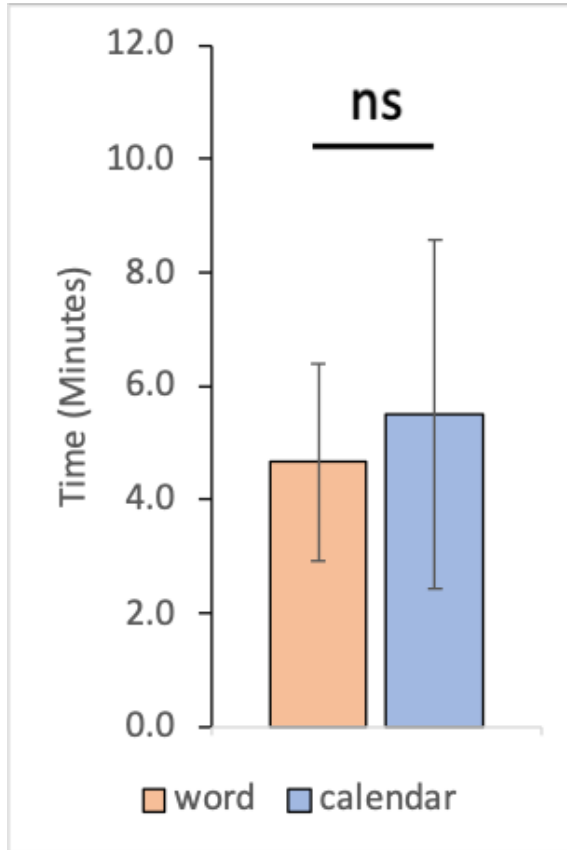
\$430 on September 8th, 2023



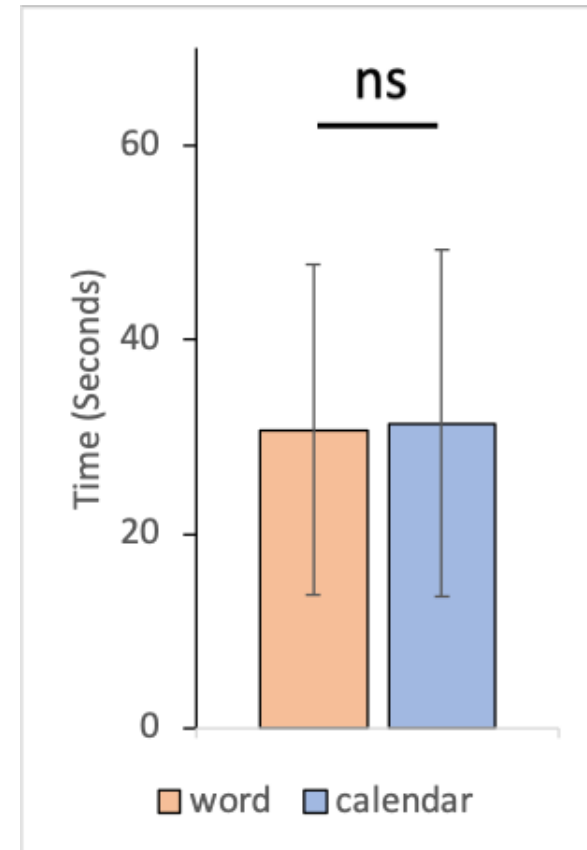
2023



No General Difference In Time To Complete Survey



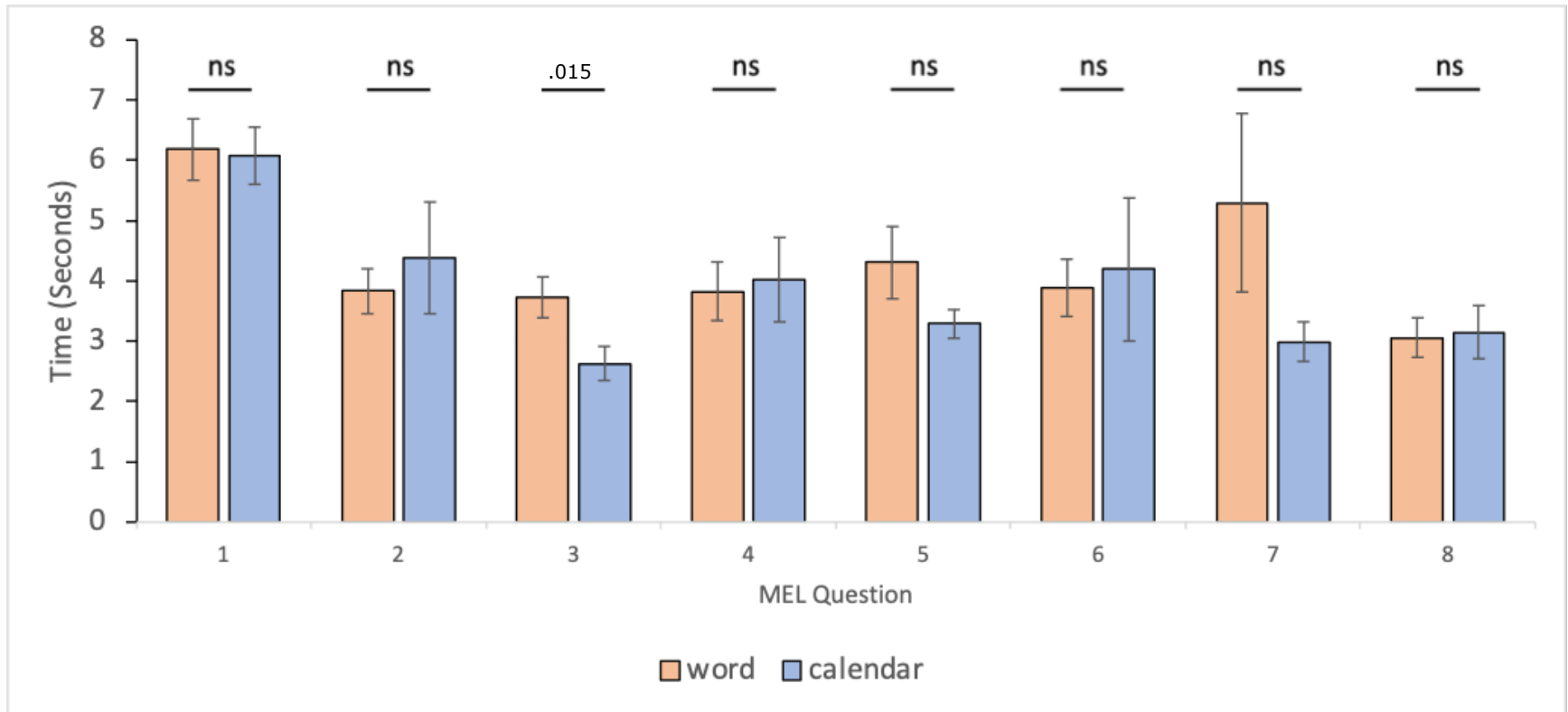
Entire Survey



MEL Question Section

Two-tailed,
homoscedastic T-test

Third Question Showed A Difference In Time



Two-tailed,
homoscedastic T-test

Third MEL Question

Make a choice to receive \$720 on May 21th, 2023 or \$1,390 on July 29th, 2023.

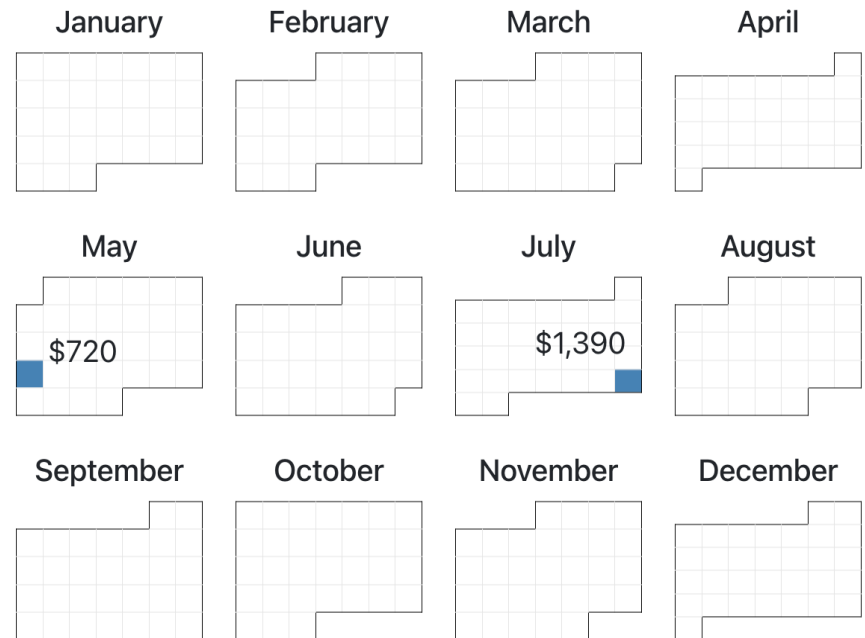
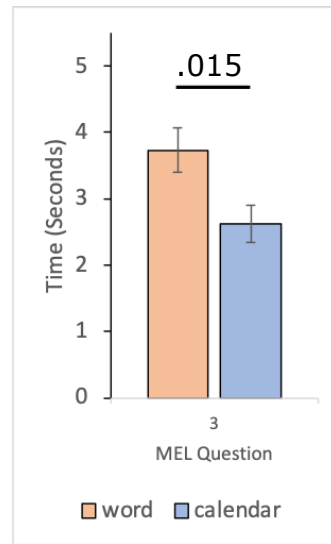
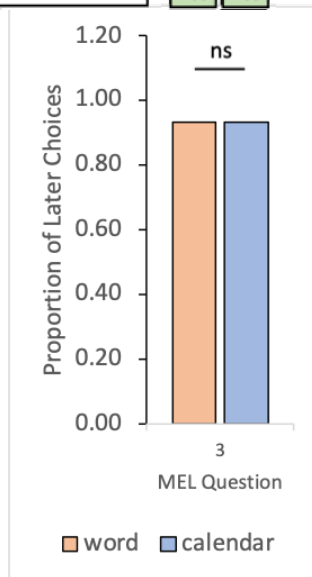
\$720 on May 21th, 2023

\$1,390 on July 29th, 2023

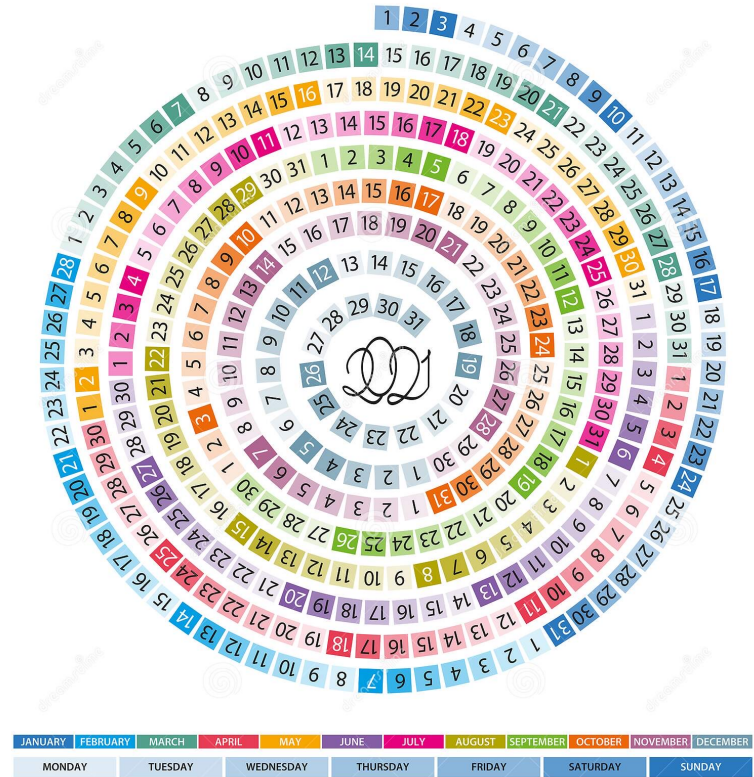
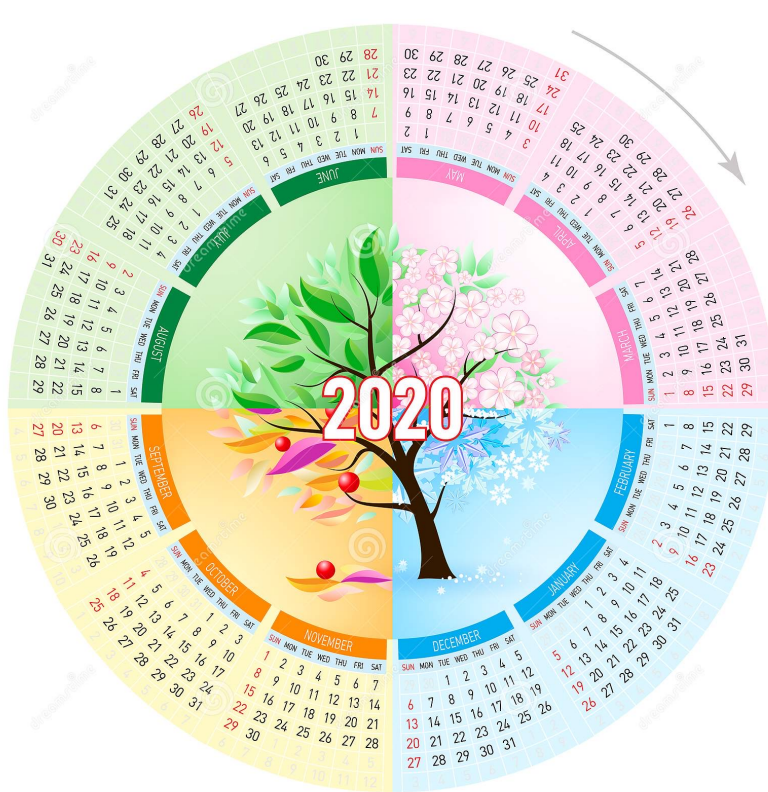
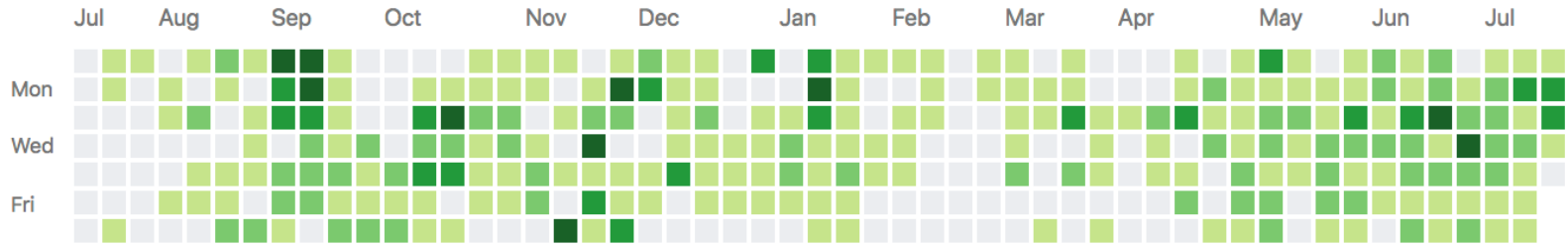
2023

Did the majority choose the optimal choice?

Yes Yes



Future Work



Conclusions

- Did not find a significant effect across general discounting or timing
- We did find significant effects across 2 specific questions in regards to discounting and timing



Thank You

Citations

- [1] A. Osterland, “Are you saving enough for retirement? odds are, probably not,” Apr 2022. [Online]. Available <https://www.cnbc.com/2022/04/11/are-you-saving-enough-for-retirement-odds-are-probably-not.html>.
- [2] S. R. Department, “United states inflation rate, by month 2022,” Sep 2022. [Online]. Available <https://www.statista.com/statistics/273418/unadjusted-monthly-inflation-rate-in-the-us/>.
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