Calendar Visualizations of Money Earlier or Later Questions

by

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Abstract

With the past year of high inflation and the recent increasing unpredictability of the future economic market, making the right financial choice is important. People struggle with delayed financial gratification, making it difficult to save. If given the choice between receiving a financial reward at an earlier or later date, the reward on the later date would need to be larger for the options to appear equivalent; the percent change between the earlier and later reward amounts is the discount rate. In the field of economics, textual questions have been used to research different aspects of discounting and financial decision-making. Independently, the field of visualizations has shown that layouts and interaction styles affect decision-making. Through the novel conversion of textual financial questions into calendar visualizations, we explore the effects of visualization on discounting by designing and implementing a modular survey in React and hosting it on Amazon Web Services. We found no general difference between a textual and a calendar visualization. In only two out of the eight questions we found a difference in choice or timing.

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Yiren Ding, a PhD. student in Professor Lane Harrison's visualization lab, deserves a thank you as well for his help setting up and running the Prolific experiments that led to the final results presented in this thesis.

Lastly, and most importantly, I would like to thank Caroline, my wife, that encouraged me to work the long, but fruitful, nights and weekends around full-time work to finish my master's degree, with a thesis nonetheless, in order to make the most of my master's program education.

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Chapter 1

Introduction

The Consumer News and Business Channel (CNBC) reported that only half of Americans have enough savings to retire (Osterland, 2022). With the recent spike in inflation from 1.4% in 2020 to well over 6% for the past two years (CoinNews, 2023) will make it harder for people to save. Saving money is a key part of financial success, and therefore, retirement. Unfortunately, many people struggle to save money, in part, due to poor financial decisions.

The core motivation for this research lies in helping people make better financial decisions. Nudging them to the more optimal choice, in theory, should put them in a better situation for maximizing the utility of their hard-earned cash. The goal of this research is to identify visualization motifs that influence people to save money.

People struggle with delayed gratification (Ainslie, 1975). However, being able to delay gratification is an important life skill. For example, the Stanford Marshmallow Experiment found that children that were able to delay their gratification were able to be more successful in life (Shoda, Mischel, & Peake, 1990). In the initial study they gave children the option of a smaller, immediate reward or a larger later reward (Mischel & Ebbesen, 1970). After a few years they followed up with the children

and assessed their academic success. They found that the children that were able to forgo the immediate, smaller reward and wait for the larger, later reward ended up as more academic successful teenagers (Shoda et al., 1990).

Similar to the Stanford Marshmallow Experiment, adults frequently encounter delayed gratification decisions around money and monetary decision-making can be complicated. If given a choice between receiving $10 today or $15 tomorrow, most people would take the $15 tomorrow, given such a short waiting period. However, if the delay for the $15 was 10 years, rather than one day, the best decision would be to take $10 today. With a conservative estimated return on investment of just 7%, receiving $10 now is better since this investment could grow to $20 within 10 years. This simple example highlights how money value changes temporally, altering what is considered a good financial decision. Asking participants if they would rather receive money now or later is a widely researched area in economics that strives to study how people view their money and financial decision making. Later this scenario was coined as a Money Earlier or Later (MEL) question (Ericson, White, Laibson, & Cohen, 2015).

In previous research, MEL questions have always been presented textually to study participants. Furthermore, it has been shown that the style of question presentation affects a person's choice on MEL questions, such as using delays or dates to communicate when the money will be received. Another well-known method to influence decision making is data visualization in the form of charts and diagrams. Visualizations influence people to make higher quality decisions. Even small changes in visualization have been shown to affect the decision that a person will make (Jianu & Laidlaw, 2015).

The idea of a calendar has existed for thousands of years (BBC, 2013) and many people still utilize calendars today to plan and schedule events in the future. It

seems that a calendar would be an intuitive visualization to convert these textual MEL questions given the long history and familiarity of the format. By converting the MEL word questions into calendar visualizations, we hope to affect the decision making of our research participants and uncover which visualization techniques will nudge people to make more optimal financial decisions.

Chapter 2

Background

2.1 Discounting in MEL questions

A discount rate is the rate at which a reward is devalued as time goes on. This means that if we give a person $10 now and their discount rate is 20% every year, then they would have to be offered $12 a year from now in order to perceive it as an equivalent option. Samuelson first proposed his discounted-utility (DU) model in 1937 where the core variable in his model was a constant discount rate of the participant (Frederick, Loewenstein, & O'Donoghue, 2002). Afterwards, inconsistencies were brought up against the DU model, such as hyperbolic discounting, where studies showed that the discount rate does not stay consistent over a choice time period, but instead decreases. This hyperbolic discounting means that if given an smaller, earlier choice and a larger, later choice, where the earlier is chosen as more desirable, pushing these choices out into the far future makes the participant switch to the later option since they do not mind the wait anymore (Angeletos, Laibson, Repetto, Tobacman, & Weinberg, 2001). Even with the DU model inconsistencies, the discount rate remains, to this date, a highly researched variable in economic decision

making.

Previous research has found multiple possible reasons a person might discount. One reason is that people crave instant gratification and prefer to receive rewards immediately, while pushing off costs or work to a later date (O'Donoghue & Rabin, 1999). Another reason is that people make decisions clouded by their emotions, ultimately leading to bad choices (Loewenstein, 1996).

Interestingly, small differences in phrasing and textual positioning can affect a person's discount rate. Describing the time in MEL questions using either dates or delays affects the discounting rate of research participants. Specifying dates such as "October 21st, 2005" resulted in lower discounting than when general delays, such as "in 2 months from now", were given. One possible reason for this difference is that dates are usually more similar and concrete to each other than delays. This provides evidence that the presentation of the amounts and times has a strong effect on the discounting decisions of the participants. (Read, Frederick, Orsel, & Rahman, 2005)

The spatial representation of questions also impacts participants answers. When presenting the questions vertically (Fig. 1), participants are shown to discount less, while the horizontal display focused their attention more on a hypothetical timeline axis that spans from left to right (Fig. 2). (Romero, Craig, & Kumar, 2019)

Make a choice to receive $350 in 4 months or $450 in 13 months.

$350 in 4 months

$450 in 13 months
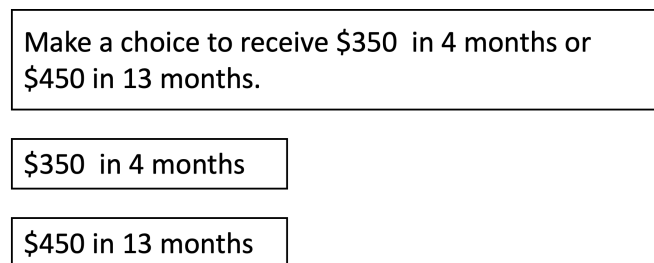
Figure 1: A textual MEL question where choices are presented vertically.

Make a choice to receive $350 in 4 months or $450 in 13 months.

$350 in 4 months $450 in 13 months
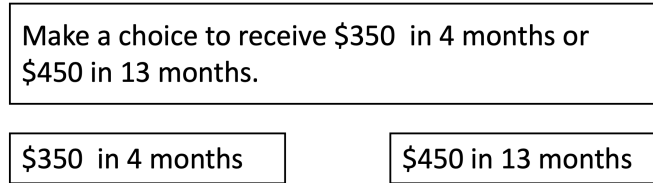
Figure 2: A textual MEL question where the choices are presented horizontally.

2.2 Visualizations affect decision-making

Visualizations can have a strong effect on decision making of research participants. Even small changes in the interface of visualizations can change a participant's decision when analyzing data. These small tweaks can make users interact and analyze the data for longer and in more detailed ways which can result in participants making more well-informed decisions (Jianu & Laidlaw, 2015). Additionally, many other aspects of decision making are improved by visualizations such as the speed and quality of a decision (Eberhard, 2021). When combining visualizations with data interaction there can also be an increase to the accuracy and confidence in a financial decision (Tang, Hess, Valacich, & Sweeney, 2011).

Some research has been conducted into transforming uncertain financial payout questions into visualizations. An example of these uncertain financial payout questions would ask if participants would prefer a fifty-fifty percent chance between winning $200 or $0, or a guaranteed payout of $95. These questions were transformed into icon arrays and other visualizations by visually showing the percentages associated with the amounts that could be won. Icon arrays were found to steer participants into the most optimal choice when compared to other visualizations and the word version. (Bancilhon, Liu, & Ottley, 2020)

Unfortunately, visualizations do not always have the same general effect across

the entire population. Sometimes different visualization layouts have unique effects on each individual study participant such as horizontal versus vertical layouts. Horizontal layouts have been shown to better help people who have low visual working memory (Conati, Carenini, Hoque, Steichen, & Toker, 2014). While, conversely, a general effect was found with vertical textual layouts making people discount less during MEL questions (Romero et al., 2019). These two findings might suggest that a combination of personal characteristics and universal general trends might be at odds with one another when trying to affect a participant's decision outcome using visualizations and layouts.

Another important aspect of creating visualizations is to choose the best visualization for the data and analysis in question. A bar chart might be more appropriate in some circumstances than a pie chart depending on what kinds of comparisons and correlations are important to display. Even visualization theory, when applied in practice, is not guaranteed to help steer participants towards the optimal answer. Visualizations have to be tailored to the way people behave, because sometimes showing all the right information still leads people to the wrong conclusions. (Kale, Kay, & Hullman, 2021)

Chapter 3

Novelty and Hypothesis

The research we conducted utilized MEL questions to assess the discount rate of participants. However, unlike in previous research, we evaluated the effect of converting the MEL questions into visual questions to see how visualization impacts the discount rate. We hypothesized that calendar visualizations of MEL questions would help participants to make a more optimal choice compared to textual versions. We hypothesized this, in part, because there is a documented effect of visualizations on decision-making (Jianu & Laidlaw, 2015) (Eberhard, 2021) (Tang et al., 2011). As for predicting that the calendar would have a positive effect on financial choices, we predicted this because we thought that a calendar may help the reader interpret the timeline of the question more easily. Calendars are commonly used, and therefore, simple to understand for study participants. We believed that the familiarity with calendar formats combined with a calendar's ability to help people understand timelines, would improve financial decision-making.

Chapter 4

Methodology

In order to test our hypothesis, we ran an experiment to see if changing the presentation of the MEL question affected the discounting rate in participants. We defined the exact conditions we would test, word versus single-year calendar, chose the dates and amounts we would present, defined what we considered optimal behavior, decided on a discounting metric, designed the flow of the entire survey, and implemented the system in order to conclude if our hypothesis had any validity.

4.1 Visual Design of Experiment Questions

4.1.1 Word Baseline

We designed a word version of the MEL questions that would be used as a baseline to compare against. This condition would explicitly prompt the participant, in text, the scenario and allow them to choose using a radio button between the earlier or later choice that they would want to receive. This presentation can be seen in Figure 3. We went with a horizontal layout of the choices because it seemed more natural to fill in the space left to right. Comparing it to a vertical layout the spacing of

the choices up to down would have made an awkward looking narrow visual on a contrasting landscape layout computer screen. As for the visual styling, the color scheme, and the interaction of selecting a choice was all designed to be as similar to the calendar condition so that the only differences measured would be due to the visualization of the questions.

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

Figure 3: A MEL question presented in a word form. The earlier option shown here is to receive \$350 on Monday, April 10$^{\text{th}}$, while the later option would be to receive \$430 on Friday, September 8$^{\text{th}}$.

4.1.2   Visualization

We decided that an intuitive visualization to convert these textual MEL questions would be a calendar. One strong reason for this choice was that a calendar is a well-known format that people are familiar with for planning future events.

Visualizing these MEL questions into a calendar view presented a certain challenge, we would have to show the time in-between the amounts. There is only so much screen real-estate at our disposal. As the difference between the earlier and later dates gets larger, this forces us to visualize more days and months on the screen, and subsequently, smaller shapes and text must be used to convey this difference. We experimented with different visual layouts in order to decide what length of time would make sense to display. A single-month, a two-year, and a single-year calendar were quickly sketched out and considered.

The single-month calendar made it very simple to display the individual days and the amounts fit comfortably in the day it was to be received. The biggest

issue with the single-month calendar design was that it seemed to not give long enough of a time period to produce interesting choice scenarios. Since there was at most thirty-one days of difference between receiving the amounts, the amount dollar values would have to have a smaller difference between them to allow for some difference in response in participants.

When considering the two-year calendar, it was an attractive choice because of the long period of time that was at our disposal to set the different dates of the amounts. The two-year period would easily allow us to offer amounts that would be over one thousand dollars, and have a larger difference between the amounts. This ease of larger amounts and differences comes from being able to apply the discount rate across a longer time period so that both choices are just as attractive as a smaller amount and difference in a proportionally shorter time period. An issue that was apparent with the two-year calendar during early consideration was that the twenty-four months had to be displayed in an unusual format. The usual format for a calendar is that a single year be displayed in three rows of four months each. Instead a visually-pleasing, two-year calendar seemed to require four rows of six months each. When comparing this to the single-year calendar, the two-year calendar seemed too unfamiliar and made the screen too busy with the twenty-four months as opposed to the twelve months.

In the end, we decided that a single-year calendar would be the most appropriate because of its familiar length of time and it gives us a large enough time period to present interesting discounting questions. The next issue we had to solve was how to style this calendar. With 365 days to display on the single-year calendar, the days would be small enough that the amount text would not comfortably fit inside the date. In order to display the text comfortably large enough, we chose to display the amount next to the day and color the day blue to indicate it differently from

the surrounding days. Another way we made the text easier to read was that we lighten the month grid of days so that the overlayed text would be more legible without other lines cutting across that text as much. The final single-year calendar visualization can be seen in Figure 4.

2023

Figure 4: A MEL question presented in a single-year calendar form. The earlier option shown here is to receive $350 on Monday, April 10th, while the later option would be to receive $430 on Friday, September 8th.

4.1.3 Visual Similarity of Word and Calendar Questions

Great care was taken to make the conditions as similar to one another in many respects so that the only possible affecting factor would be the difference in presentation of the choices, word or calendar view. Much of the surrounding survey text,

before and after the MEL questions are exactly the same, and only a handful of words are different in order to give condition specific instructions. The sharp corner styling, blue color scheme, and click/hover interaction for selecting a choice is the same as well between the word and calendar conditions as to not have that affect a participant's decision.

4.1.4   MEL Questions Amounts and Dates

The amounts for the earlier and later questions were taken from another paper that used two different wordings for the time of the questions, delay and dates (Read et al., 2005). This paper was able to show that discounting was higher in the delay wording and lower in the date wording. We hope to improve on this date wording by converting it to a visualization. The amounts from that paper were converted from British Pounds to United States Dollars and adjusted for the inflation rate between the time of that study, 2003, and the start of this thesis, 2022. The dates were then adjusted to fit in a single-year calendar view and made sure to be in the future by the time that the participants would take the survey, April 5th, 2023. Dates were randomly picked between a starting range of April 8th, 2023, and ending range of December 31st, 2023. Table 1 contains the earlier and later dates and the amounts associated with those dates that were presented across both conditions in our experiment.

4.2   Defining The Optimal Behavior

To decide on what was considered an optimal choice we took the average discount rate found in the dates versus delays phrasing of MEL questions paper (Read et al., 2005). They found an average discount rate of about 60%. We then multiplied this

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

Table 1: The list of amounts and dates for the earlier and later choices for the eight questions that would be studied in this experiment between a word condition and a single-year calendar visualization.

$$
\begin{aligned}
diffDays &= days \ until \ later \ date - \text{days until earlier date} \\
diffProportion &= \frac{diffDays}{365 \ days \ in \ a \ year} \\
rateDiscount &= (1 + 1.66 \ calculated \ discount \ rate * diffProportion \\
equivalent \ later \ amount &= earlier \ amount * rateDiscount \\
optimal \ choice &= \left\{ \begin{array}{lr} earlier, & \text{for } equivalent \ later \ amount > later \ amount \\ later, & otherwise \end{array} \right\}
\end{aligned}
$$

Figure 5: The calculations used to determine the optimal choice per MEL question.

discount rate by the proportion of U.S. inflation between the average of 2021 and 2022, and 2003 (CoinNews, 2023), the year the date/delay paper (Read et al., 2005) was conducted. This gives us a current estimated discount rate of 166% based on the proportion of inflation over the years. Using the equations shown in Figure 5, we have calculated the optimal choice for each question when taking into account this discount rate, as shown in Table 2.

Question	Optimal Choice
1	Earlier
2	Earlier
3	Later
4	Earlier
5	Earlier
6	Later
7	Later
8	Later

Table 2: The optimal choice for each MEL question. This was determined by taking into account the average discount rate found in the date/delay paper, 60%, (Read et al., 2005) and the proportion between current and past inflation. The current U.S. inflation rate was taken as an average of the past two years. The past inflation rate was taken from 2003 (CoinNews, 2023), the year the date/delay paper (Read et al., 2005) was conducted. The equations used can be seen in Figure 5.

4.3   Entire Survey Design

4.3.1   Post Surveys

Three post surveys were chosen to be administered in order to know if our sample populations across the conditions were similar. If they were found to be similar, any differences in our findings would have more validity since the cause of the difference would be more likely due to the different MEL presentations rather than the difference between the sample populations.

Experience

In the experience post survey, participants would be asked eight questions about what they thought of the survey they had just taken. We chose these questions in order to determine if there was differences in how participants felt about the condition such as instruction clarity, or mental effort taken to make the decision

between the two conditions. The questions asked the participants if they enjoyed the questions, found the instructions clear, understood what the questions were asking, if the questions were presented clearly, if they were able to imagine the money choices as real, if the money choices were easy to make, if they would like these money choices to be presented in their real life using the condition they had undergone, and lastly, if they invested mental effort in the questions they answered. They would be presented with a multiple-choice response for each question and could answer with "not at all or very slightly", "a little", "moderately", "quite a bit", or "extremely".

Financial Literacy

In the financial literacy post survey, participants would be asked three questions about mathematical financial calculations. We chose questions that would help us determine if participants understood different calculations around inflation and long-term investments, such as a savings account. The questions asked participants about the amount of money in their savings account after a certain period of time with a specific interest rate applied, the combined effect of inflation and a savings account interest rate on their money, and lastly, generally well-known financial advice between investing in a single company stock versus a stock mutual fund. For each question there was a single correct answer, an option to respond "do not know", and one or more incorrect answers to choose from.

Sense of Purpose

In the sense of purpose post survey, participants were asked six questions about how they felt about their life and their purpose in it. This post survey was chosen since there has been a link found between net worth, which could be due to discounting,

and a sense of purpose (Hill, Turiano, Mroczek, & Burrow, 2016). We chose the questions from a study that researched and developed a Sense of Purpose Scale (Sharma, Yukhymenko-Lescroart, & Kang, 2018). We did not want to exhaust participants with all thirty questions, so we picked only the top six questions across the different factors and communalities reported in their Table 3. We used the same 5-point Likert-type scale, which allowed participants to response to each question with: "strongly disagree", "disagree", "neural", "agree", or "strongly agree".

4.3.2 Demographics

We decided it would be good to collect some general demographics on our sample populations. We would collect six different pieces of data: the country that the participant lived in, their familiarity with data visualizations, their age, their current profession, their gender, and their current employment status. Responses for the country of residence and data visualization familiarity were given as pre-filled drop-down boxes. The age and current profession were open-answered text boxes. The gender and current employment were pre-filled drop-down boxes with the option to self-describe using an open-answer text box, if desired.

4.3.3 Attention Check

An attention check question was added to the survey in order to weed out participants that were blindly selecting options in order to get paid. We found a high-quality attention check that was simple, quick, and only measured attention and not any another aspect of the participant, such as memory (Rosenzweig, Edelman, & Moss, 2022). This attention check question would simply ask the participant to select a certain response from the set of multiple choices. We reused the top-rated example asking participants to select the option that stated, "strongly agree". We

did, however, remove the text explicitly stating it was an attention check so that low-quality participants would not immediately recognize this an important question to get correct and only pay enough attention on this question to get compensated.

4.3.4 Payment

Payment would be given to participants to attract them to take the survey and compensate them for their time. We decided that payment would only be given to the participants that completed the survey and passed the attention check question. Underpayment would cause issues with the selection bias since a lower payment would either not attract enough participants or would only attract participants that would blindly click through to the end in order to get paid. Likewise, too high of a payment would also cause selection bias since people might try too hard on the survey in order to make up for the compensation amount they would receive. We calculated a conservative estimate of time it would take for participants to complete the entire survey as ten minutes. We decided that three dollars would be an appropriate payment. This would be equivalent to an eighteen dollar an hour job which is higher than the minimum wage in the United States in 2023.

4.3.5 Survey Flow

Participants completing the survey would go through nine general steps: 1. Consent, 2. Introduction, 3. Instructions, 4. MEL questions, 5. Attention check, 6. Demographics, 7. Three different post surveys, 8. Debrief, and lastly 9. Thanking them and goodbye. These steps are depicted in a visual flowchart in Figure 6.
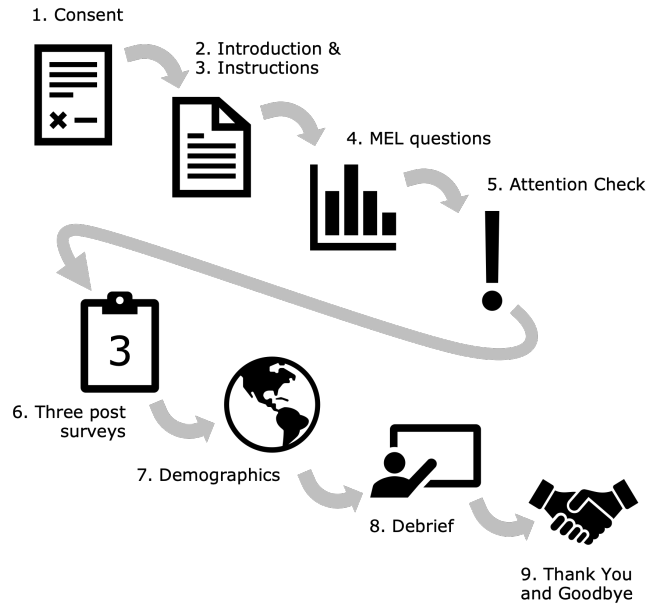
Figure 6: Visual representation of the flow of the survey. The survey had the following steps: 1. Consent, 2. Introduction, 3. Instructions, 4. MEL questions, 5. Attention check, 6. Three different post surveys, 7. Demographics, 8. Debrief, and lastly 9. Thanking them and goodbye.

1. Consent

When participants are initially sent to the survey link, they would first consent to being a part of this experiment. On the consent page they would be given a brief introduction, so as not to give them too much information on the research and unintentionally influence their decision making. This introduction would just say that we were going to give them hypothetical questions about receiving different amount of money at different times. Participants were told that they would have additional questions after the main survey to see how their experience was and other questions about themselves. They were told that it should take about ten minutes to complete. They would also be told that they should expect minimal to no risks by

completing this survey. We reminded them at the end of the consent page that all the amounts in the questions were hypothetical and that they would be compensated $3 if they completed the survey. At the bottom of the consent page was a checkbox that they would have to select and agree to in order to continue.

2. General Instructions

Since the consent page had a lot of text, participants would be presented with a much shorter page that gave them general instructions about the survey and reminded them of the structure. They were told that they would answer a set of money choice questions, followed by three post surveys about their experience as well as answering some questions about themselves. Lastly, they were told they would be given a full explanation about the study at the end of the survey and given a code that they would have to present in Prolific in order to get paid.

3. Condition-specific Instructions

After the general set of instructions, they would be given a specific set of instructions based on the condition they were randomly assigned. Participants were reminded that the amounts in the questions were hypothetical, but that we ask that they treat them as if they were monetary decisions they were making in real life. In this set of instructions, they would see an animated graphics interchange format (GIF) showing them how to make their selection and explained in text how to make a selection. In the word condition, they were told that they would have to select the radio button with the amount and date that they chose to receive. In the calendar condition, they were asked to select the day near the amount that they wanted to receive. After the animated example they would be given a chance to test it out themselves on an interactive example before moving on to the real survey so that

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they could become familiar with the clicking selection mechanism.

4. MEL Questions

Once they proceeded, the participant would be given a series of eight MEL questions with different dates and amounts for them to choose between. The questions would be presented in the particular condition that the participant was randomly assigned, either all eight were in word format, or all eight were in calendar format. Each MEL question was the same order for each participant.

5. Attention Check

After they completed the MEL questions, we would ask them a simple attention check question which would prompt them to select a specific answer. This was done to weed out participants that were blindly choosing answers in the hopes of still getting paid at the end of the survey.

6. Three Post Surveys

After the attention check they would be taken to a set of three post-surveys. The first would ask them several questions about their experience through the survey, such as if they enjoyed it. The second post-survey would ask financial questions to try to assess their financial literacy. The last post-survey asked about different aspects of their sense of purpose.

7., 8., and 9. Demographics, Debrief, and Thank You

Lastly, we asked for some general demographic information from them, debriefed them about the entire experiment and what we were trying to study. We then

thanked them, asked for general feedback, and reminded them about the instructions on how to get paid for completing the survey.

4.3.6 Implementation

We implemented the survey framework and tool in React. This allowed us to quickly build out the survey by: easily being able to reuse components, integrating with third-party modules, hosting and storing of the webpage and the participant data on an online platform, and finally, efficiently testing the application continuously during the development.

Reuse of Components

For each basic page in the survey we created a single React component. These basic pages consisted of the consent page, the instructions page, the demographics page, and the debriefing page. More advanced pages in the survey would be their own components as well, but also incorporate sub-components to simplify the code and allow for easy reuse across other pages. The best example of these sub-components we built were for the visualizations. Each visualization was its own component so that it could be used in the actual MEL question survey, but also reused for the interactive example in the condition-specific instructions page. The calendar visualization in particular was broken up into smaller sub-components so that a single-year calendar would call a single-month sub-component twelve times in order to generate the entire year. Similarly, the post survey components shared similar code since each page would complete the same steps of pulling the questions and options from a separate file in order to generate the same layout and interaction style across the post survey pages.

Third-Party Module Integration

Another benefit of using React was the ease of integration with third-party modules. Modules such as Material UI, D3, and Redux were used to make the clean and professional looking UI, have the data drive the calendar visualizations, and to easily iterate over the MEL question sequence, respectively. Material UI comes with a default styling for certain components that makes it look professional without having to create our own Cascading Styling Sheet (CSS) library. Material UI also helped with the color changes in the hover and selection interaction on the condition MEL questions by allowing us to edit JavaScript Object Notation (JSON) data objects instead of manipulating CSS, which would be more cumbersome. D3 was used to drive the updates to the structure and appearance of the calendar visualization. D3 was able to quickly build out a single-month calendar sub-component from a a 2d array that was generated for a particular month consisting of the weekdays and weeks in that month. A step higher, D3 then took a 2d array, representing a four month by three month single-year calendar format, and generated the single-year view using the single-month D3 sub-component. Lastly, Redux was used to load the MEL question sequence from a file into an iterator. The Redux iterator would populate the condition-specific view with the current MEL question being asked to the participant. When the next question was to be viewed, we alerted the iterator and it incremented to the next MEL question and automatically updated the condition-specific view with the new amounts and dates.

Online Hosting and Storage of the Survey and its Data

To serve the React application as a public webpage we used Amazon Web Services (AWS) Amplify. AWS Amplify allows out-of-the-box integration to a GitHub repos-

itory for simple deployment of React applications. Since we were already developing our survey in a GitHub repository, we simply created a new AWS Amplify project and inserted the repository link to deploy the webpage. We also edited the settings of the AWS Amplify project to redeploy the application on every new commit that was submitted into the release branch. This made keeping the public webpage up-to-date, with the latest code, automatic without needing any more intervention from us, other than making the actual code changes we wanted applied.

In order to save participant data, we set up an Amazon Simple Storage Service (S3) bucket. During the survey we collect participant data in a JSON object. When the participant closes the survey page, since that JSON object is stored in the browser, the participant data we collected is lost. An S3 bucket allowed us to convert the volatile data in the browser that we collected from participants and write it to a file in the online S3 folder to save it for later data collection and analysis. The React application was set up to only have write permissions so that participants would not be able to inspect the React code, for the S3 bucket details, and read the data of other participants. This file writing behavior was implemented by using the AWS software development kit which was available as a third-party module.

Continuous Testing

Lastly, during the implementation, we used Cypress to continually develop UI-driven tests to ensure that the code changes we made matched with the actual visual changes and back-end data collection we intended to see. Cypress is another online, readily-available, third-party module that can be used to visit webpages, interact with components, and validate any changes or interactions with those components. We created a test for each condition, word and calendar. In this test, it would visit the first page of the survey and click through, as if it was an actual participant.

Several interactions and states of components and buttons were validated during the test to flag abnormal or unintended behavior. When the test finished the survey, we used a simple local mock S3 bucket file server to reroute the data from the survey to, and validate the selections made during the test. By developing these Cypress tests, we were able to continually make changes to the code and quickly detect regressions or validate that our changes actually appeared in the survey without having to manually go through the survey each time.

4.4 Data Collection and Analysis

4.4.1 Participant Assignment to Conditions

We decided to conduct this as a between-subjects design. This would make the survey shorter, and not have previous condition choices affect the decisions of the later condition (Budiu, 2018). In this experiment we would present MEL questions in the word form and the calendar visualization form to see if the results differed between the conditions. One half of the participants were randomly assigned the word form (Figure. 3), while the other half would get the same questions visualized in the form of a single-year calendar (Figure. 4).

4.4.2 Experimentation Procedure

We recruited 64 participants from Prolific on April 5th, 2023, sent them to the AWS Amplify React application link and waited for the data to be written to the S3 bucket. After the data was written we would quickly check which participants finished the survey, correctly answered the attention check question, and would pay them. We found that two people consented, read the instructions, but never

continued past the instructions since we did not get MEL question or post survey responses from them. Also, we had two participants incorrectly answer the attention check question so we excluded them from the analysis as well. This means that we analyzed the data from the rest of the 60 participants we gathered, after excluding two for not starting the MEL questions, and another two for insufficient attention.

4.4.3   Measures and Data Conversion

MEL Questions

Each earlier response was transformed into a zero, while each later response was transformed into a one. Then we calculated the proportion of later responses by taking the average. This average would be calculated per condition and per question to be able to compare between the conditions. To analyze if the visualization affected the discount rate, we used the Chi-square test for independence on the average proportion of later responses to see if there was a significant difference between the conditions. If we found a significant difference between the proportions, we concluded that the visualization influenced decision making.

Timings

The timestamp for each page and MEL question was recorded. By calculating the difference in timestamps we measured and compared the time it took for participants to complete the entire survey, just the MEL question portion, and the time a participant took on each MEL question individually, across the two conditions. We used a two-tailed, homoscedastic t-test to determine if the results were significant. A t-test is appropriate in this scenario since we are comparing the means of a continuous variable between two groups.

Post Surveys

Each of the post surveys were comprised of questions with multiple choice answers. The answers were mapped to numbers, and the average across the question per condition was taken. A two-tailed, homoscedastic t-test determined if there was as statistical significance in any of the results. A t-test is an appropriate measure here since we are comparing the means of a scale or continuous variable between two groups.

Experience

In each experience post survey question the five options participants were allowed to select from to indicate their agreement or disagreement with the question were: "not at all or very slightly", "a little", "moderately", "quite a bit", or "extremely". Each of these was mapped to a number: 0, 0.25, 0.5, 0.75, or 1, respectively. The average was then calculated for each question across the conditions to compare if there was a statistical difference using a two-tailed, homoscedastic t-test.

Financial Literacy

For the financial literacy the participants were given a set of options for each question where one option was the correct answer. If the participant answered the question correctly, they scored a one for that question. An incorrect answer would be scored as zero. The average score was calculated per participant per condition to compare between the conditions. A two-tailed, homoscedastic t-test was used to determine if the results were statistically significant.

Sense of Purpose

In each sense of purpose post survey question the five options participants were

allowed to select from to indicate their agreement or disagreement with the question were: "strongly disagree", "disagree", "neutral", "agree", or "strongly agree". Each of these was mapped to a number: 0, 0.25, 0.5, 0.75, or 1, respectively. The average was then calculated for each question across the conditions to compare if there was a statistical difference using a two-tailed, homoscedastic t-test.

Chapter 5

Results

5.1 Discounting

Overall, we did not see a significant difference of discounting between the word and calendar conditions. Figure 7 shows the proportion of later responses on average between the conditions and per MEL question. Looking at each MEL question individually, we see that all of the proportion of later choices are not statistically significant. However, the first MEL question had the most significance with a p-value of 0.0631 between the word and calendar conditions. The rest of the questions had a p-value of 0.3472 or higher.
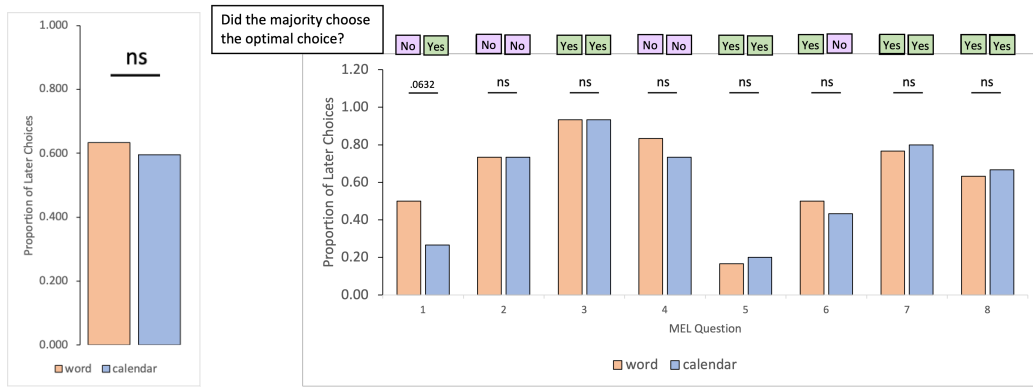
Figure 7: Overall proportion of later choices throughout the MEL questions (left) and a breakdown of the proportion of later choices per MEL question (right). Above the breakdown is a row indicating if the participants, for that condition, on average picked the optimal choice. The average is rounded to the nearest integer to determine the choice. n.s. (no significance) by the Chi-square test of independence.

5.2   Time

The time taken to complete the whole survey, shown in Figure 8, shows that there is no significant difference in the average and spread between the two conditions overall. Additionally, there is no significant difference in time spent on just the MEL questions between conditions.
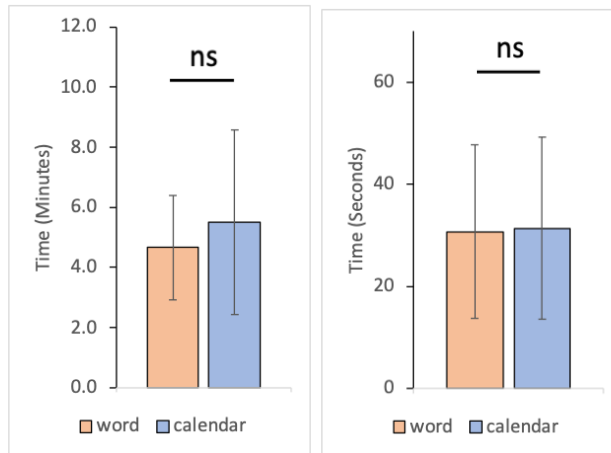
Figure 8: The overall average and standard deviation that it took participants to complete the whole survey (left) and just the MEL questions portion of the survey (right).

In terms of individual MEL questions, Figure 9 shows that the first MEL question takes more time to answer compared to subsequent MEL questions. This could be because, even with the initial example, participants are still learning how to make a quick decision based on the condition they are in. The difference in choice times in the third MEL question is significantly different between the two conditions. The word condition participants took significantly longer to answer the question compared to the calendar condition participants.
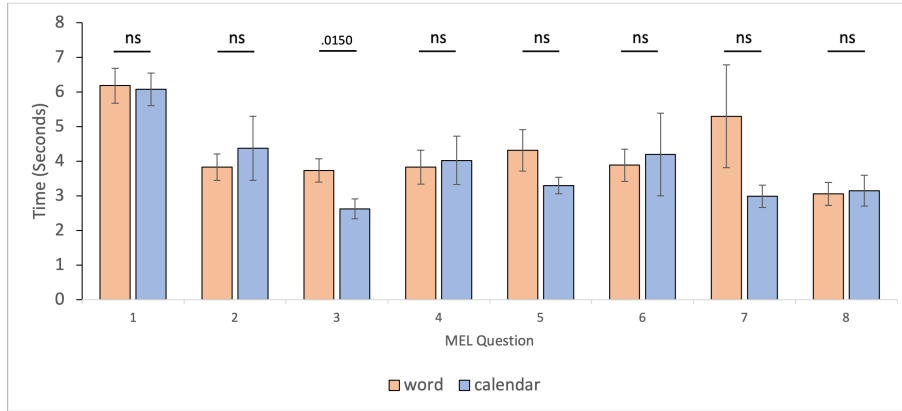
Figure 9: The average and standard error mean of the time taken for each MEL question between the word and calendar conditions.

5.3 Descriptive Statistics

We wanted to make sure that we understood our sample population of participants. We also checked for any differences between the conditions and found some slightly but not significant differences in a few areas. Since these differences are not significant, this means that any effect we find in our results is more meaningful since it was not caused by any substantial difference between the condition populations.

5.3.1 Post Survey Responses

There was no significance or general trend between the experience of the participants across the two conditions which can be seen in Figure 10. The most interesting piece of data here is that the fourth question, that asks, "Were the questions presented clearly?" for the word condition had a mean of 0.98 with an extremely small standard deviation of 0.063.
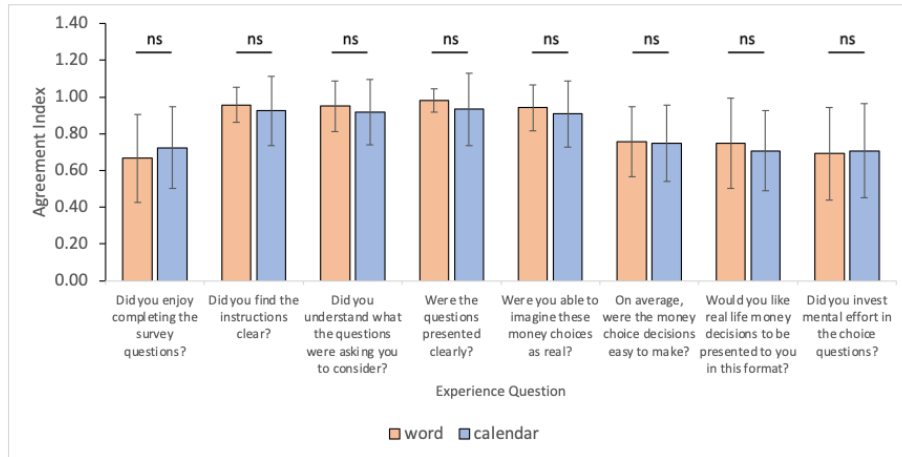
Figure 10: The average and standard deviation of the agreement index for each experience question between the two conditions. A higher agreement index corresponds to a higher percent of people agreeing with the survey question. Section 4.4.3 explains how the agreement index was calculated.

Likewise, the sense of purpose of the participants was similar across the two conditions as well. The most significant, but still not statistically significant difference, was question four with a t-test score of 0.22. As stated in Figure 11 this question asked if participants agreed with the following statement, "I have started thinking about what I truly want to achieve.". In this question the calendar participants responded with a higher average of 0.77 compared to the average of the word participants at 0.69.
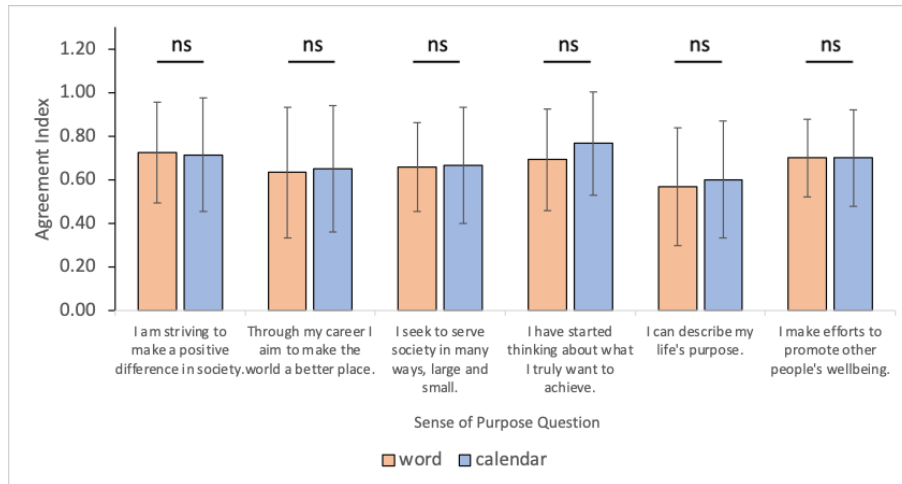
Figure 11: The average and standard deviation of the agreement index for each sense of purpose question between the two conditions. A higher agreement index corresponds to a higher percent of people agreeing with the survey question. Section 4.4.3 explains how the agreement index was calculated.

When looking at the financial literacy score between the conditions in Figure 12, we see that the participants in the word condition performed slightly better. This difference is not statistically significant, but it does get the best significance value out of all the post survey questions in a t-test with a value of 0.155.
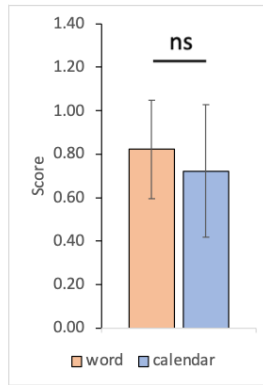
Figure 12: The average and standard deviation of the financial literacy score for the participants between the two conditions. A higher score corresponds to a higher percent of questions being answered correctly. Section 4.4.3 explains how the financial literacy score was calculated.

5.3.2 Familiarity with Visualizations

The participant's familiarity with visualizations did not have much of a difference between the two conditions which can be seen in Figure 13
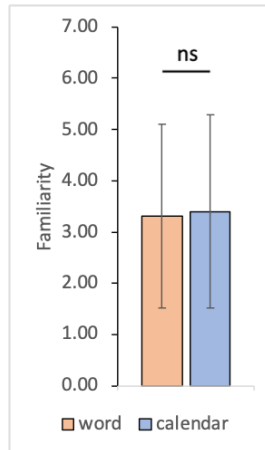
Figure 13: The average and standard deviation of participant's familiarity with visualizations between the two conditions. Seven is the highest familiarity, meaning that the participant uses charts and data visualization every day, while one is the lowest, meaning that they do not interact with charts of data visualizations at all.

5.3.3 Age

The calendar condition seemed to have a slightly lower average age of participants, while the word condition had a higher average, but with a higher spread which can be seen in Figure 14. The bigger spread in the word condition means that there were more participants on both the younger and older side, while the calendar condition consisted of participant mostly around the age of thirty.
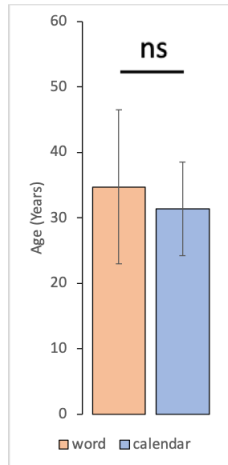
Figure 14: The average and standard deviation of the age of participants in years across the two conditions.

Another view of this spread can be seen in the histograms of the participant ages in Figure 15 This histogram has a bin size of 5 years.
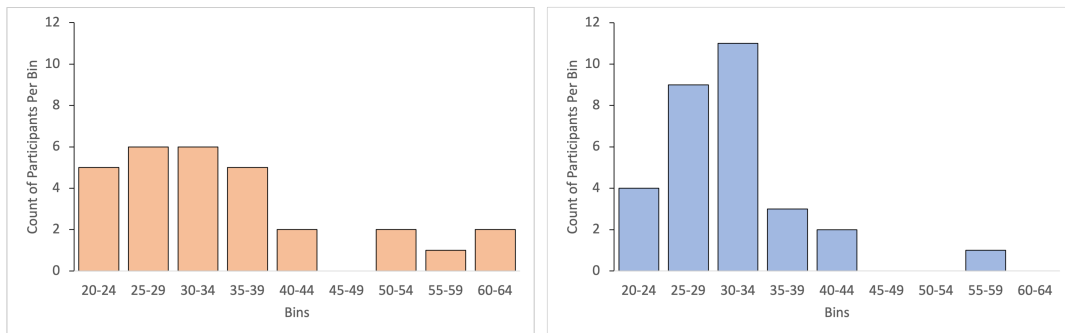

Figure 15: Histogram plots of the age of participants between the word (left) and the calendar (right) conditions. The bin sizes are 5 years.

5.3.4 Gender

The gender ratio can be seen in Figure 16, which was almost evenly split in the word condition. The calendar condition, on the other hand, had slightly more males and substantially less females.
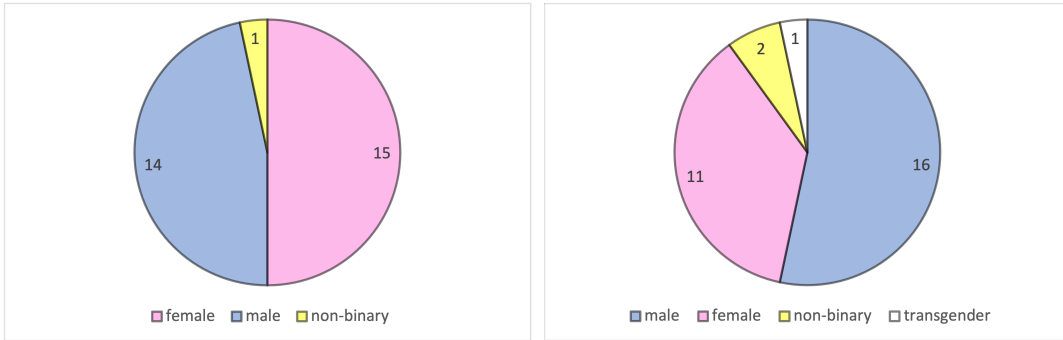
Figure 16: The difference in the count of participant's genders between the word (left) and calendar (right) conditions.

5.3.5 Employment

The most major difference between the conditions can be seen in the employment pie charts in Figure 17. The word condition had seven unemployed participants and a single retired participant, while the calendar condition did not have any unemployed or retired participants. This correlates with the age data in Figure 15, since the word had a handful more of younger participants, some of which might be unemployed students, while the retired participant would more likely be on the older side.
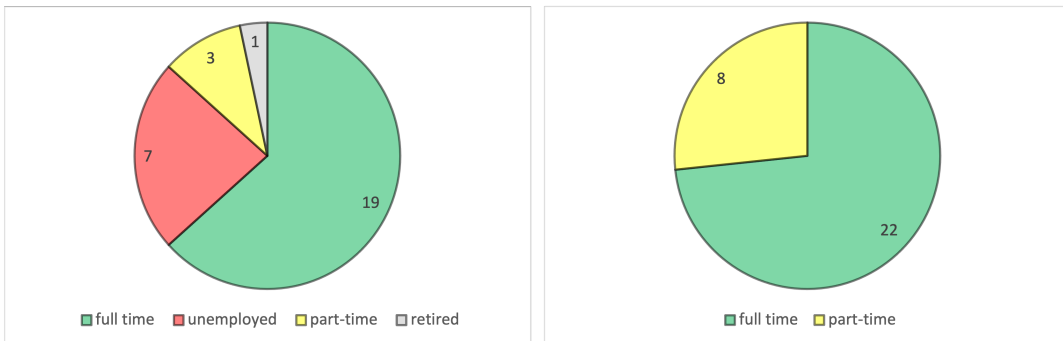

Figure 17: Pie charts showing the difference in employment between the word (left) and calendar (right) conditions.

Chapter 6

Discussion

6.1 General

The biggest finding of this study was that, surprisingly, there was no difference, in general, between the word and calendar conditions. This is different from what previous research has suggested. Visualizations usually have a strong impact on the speed and quality of decisions (Eberhard, 2021), leading us to believe that a calendar would also improve the speed and quality of decisions.

Initially, we thought that the widespread use of calendars would aid in helping participants make good financial decisions because the participants are able to easily understand the calendar. However, upon further thought, it is possible that an over-familiarity with the calendar format may have contributed to calendar visualizations being ineffective at changing participants' choices. In other words, because calendars are common, the participants were not receiving any new mental framework for viewing the question.

Conversely, if the participants were shown a more stunning visualization that emphasized their savings, maybe it would have had the desired effect. The emphasis

in the calendar visualization we created was more on the difference in time, instead of the difference in amounts. If the amounts were presented more visually, such as an icon array, maybe this would give participants a greater sense of how much money they were losing out on by picking the earlier option.

6.2   Discounting

We found almost a significant difference of discounting between the word and calendar conditions for the first MEL question, but not the others, which can be seen in Figure 18. At first, this finding was surprising because it was the only question where there was some possible effect. After more consideration, we think that this effect could be due to the date that the experiment was performed on. The experiment was conducted on April 5th. This question asked participants to choose between money on April 10th and September 8th. It is possible that the suggestion of receiving money at a date on a calendar so close to the actual calendar day, may have influenced more people to choose the earlier money option.

Alternatively, this difference could be due to the format. When more closely reviewing the calendar visualization, it seems apparent that it gives a greater sense of distance between the two choices. This visual distance can be seen in Figure 20. The earlier and later choices on the calendar visualization span from the top right corner to the bottom left corner which is the farthest month-to-month screen distance that is possible on this visualization. When thinking about the word condition, instead of spacial distance, the participants had to rely on the numerical difference. The word version of the first MEL question can be seen in Figure 19. It's possible that this five-month span sounded shorter without seeing the whole distance of the screen between the two labeled dates.
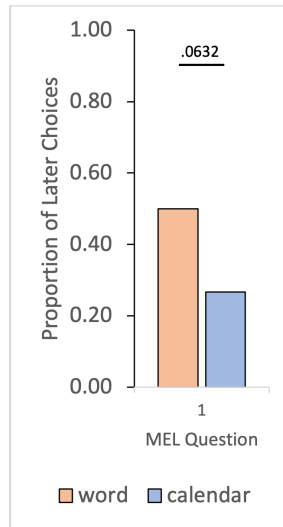
Figure 18: The average proportion of later choices across the two conditions for the first MEL question.

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

Figure 19: First MEL question in the survey presented in textual form

Figure 20: First MEL question in the survey visualized as a calendar.

When comparing this back to the table that showed optimal discounting behavior, we see that the calendar condition did nudge the participants into the correct choice, the earlier amount, more often.

6.3 Time

The calendar response times were significantly lower than the word response times in the third MEL question. This difference can be seen in Figure 21. The same figure, Figure 21, also shows that both of the conditions received the same average proportion of the later choice.

Revisiting the word and calendar presentation of the third MEL question can be seen in Figures 22 and 23. The amounts for this question are large given the two month difference between the earlier and later date. In the span of those two months, a participant would be able to almost double the amount they received. The choice the participant should make is obvious: they should choose the later amount.

Consistent with the easy choice, this question had among the shortest response times. With more difficult financial questions, time spent answering questions is likely allotted to choosing the best answer. On this question, because the answer was obvious, as soon as the participant understood the question they were able to answer. Their understanding of the question was likely aided by the calendar, thus allowing them a quicker response time.
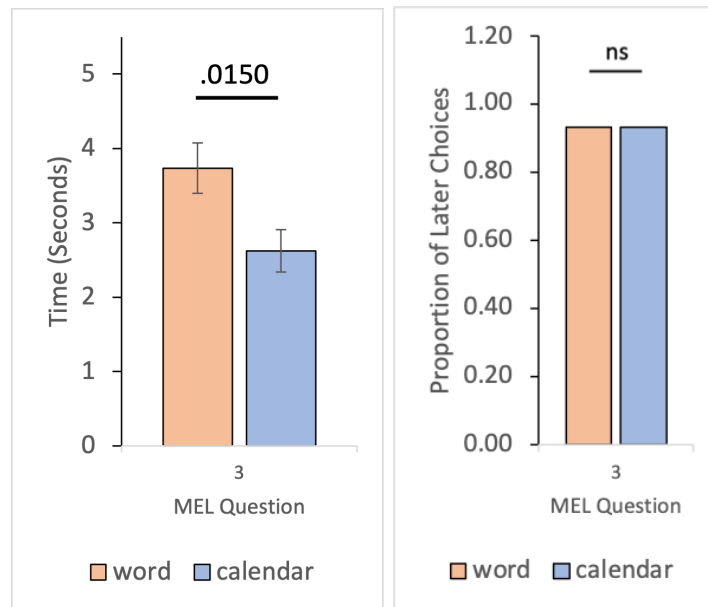

Figure 21: Average and standard error mean time (left) and the average proportion of later choices across the two conditions (right) for the third MEL question.

Figure 22: Third MEL question in the survey presented in textual form
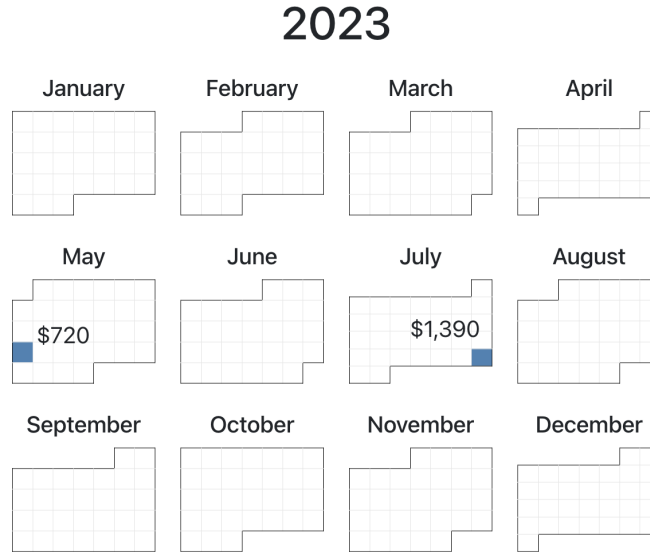
Figure 23: Third MEL question in the survey visualized as a calendar.

6.4 Future Work

6.4.1 General Effect

In general we did not find an effect when using the calendar visualization we created. Since visualizations should have an effect on the choices that people make, we still think there is a version of this calendar visualization that would nudge people to pick the later option more than the textual version.

One possibility we indicated was the familiarity of the calendar style we used. Instead, maybe a more non-traditional layout could be used such as the GitHub contribution calendar. This calendar has a single row of months, where the weeks axis and weekday axis is flipped from the traditional two-dimensional array of months. Other calendar designs that could be researched are circular or spiral designs where the days and weeks go in a circle or spiral into the center.

Another possibility for not finding a general effect that we identified could be due to the emphasis on the distance between days instead of emphasising the amounts. If, instead, the amount was emphasized through an icon array, the participant might see more clearly how much they were losing out on by picking the earlier date.

6.4.2 Day Selection

In this paper, we researched the effects that a calendar visualization had on randomly selected choice dates. It would be interesting to see if there was an effect on discounting when picking specific days in order to make them seem visually closer to one another. With the calendar layout a small adjustment of a few days can have a significant effect on the visual distance between the options, moving the later date from August 31st, 2023 to September 3rd, 2023 brings the later choice much closer to the earlier date of May 28th, 2023 as seen in Figure 24. We would suspect that bringing the later date visually closer, by pushing the actual date a few days into the future, would have participants choose the later date more often since it seems like a closer option to the earlier date, just by changing visual proximity.
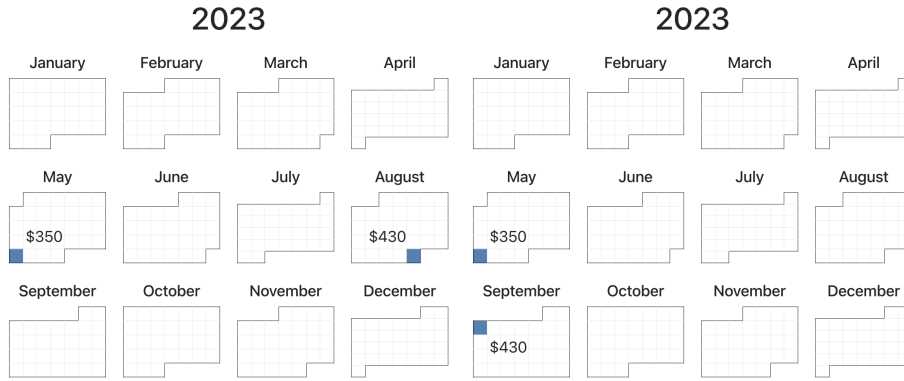
Figure 24: Two calendars showing a within week row choice (left) and an across week column choice (right). The same earlier date and amount are used for both, May 28$^{\text{th}}$, 2023 and \$350 respectively. The within week row choice date (left) is August 31$^{\text{st}}$, 2023, while the across week column choice date (right) is September 3$^{\text{rd}}$, 2023. Both of the later amounts are \$430.

Chapter 7

Conclusion

In conclusion, we have presented a React framework where we conducted a between-subjects design experiment. In our experiment we did not find a significant difference between the sample populations between the word and calendar conditions. The only significant differences we found in discounting and response times were in the first and third MEL question, respectively. We believe that the difference in discounting between the conditions in the first MEL question is attributed to the far screen space between the choices that is shown in the calendar visualization, making the earlier option more attractive due to the relative closeness of the earlier amount. Additionally, we believe that the difference in response times in the third MEL question can be attributed to the visual guidance of the calendar condition as opposed to the more internal numerical calculation that needs to be conducted for the word condition. Overall, if the goal is to nudge people in the right direction, a traditional calendar visualization which does not emphasize the amounts does not seem to produce a significant general effect.
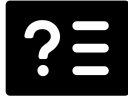
Appendix A

GitHub Repository

All of the code for this thesis can be found in the GitHub repo branch release-calendar on the repo vizsurvey owned by The-Discounters organization. https://github.com/The-Discounters/vizsurvey/tree/release-calendar

Appendix B

Screenshots of General Survey

Pre-Survey

Screenshots of all the survey pages before the condition-specific pages which include the consent page and the general instructions page.

Figure 25: First page of the survey is the consent page. On this page, participants are given brief details about the experiment, the data we collect, the risk (minimal to none), and the payment of $3 for completion of the survey.

General Instructions

In the first set of questions, you will be asked to make money choices as instructed in the next screen. You will need to answer all these questions in order to remain in the study.

Then, you will be presented with three short sets of questions about your experience answering the survey, as well as about you in general.

Finally, you will then be presented with a more detailed explanation of the goals behind this research along with an opportunity to submit feedback and a **code you must enter into Prolific to get paid.**

The entire survey will take about 10 minutes to complete.

Click the Next button to start.

NEXT

Figure 26: The second page is general instructions about the survey and how it will proceed. Details here include the telling participants that they will answer some questions about money choices, then they will complete a few post surveys, and lastly, they will be given a fuller explanation about the study and get paid $3 for their completion.

Appendix C

Screenshots of Condition-Specific Instructions

Screenshots of the condition-specific instructions that occurs after the general instruction, but before the actual MEL survey questions.

Money Choice Instructions

You will be presented with a series of hypothetical choices of receiving two different amounts of money on two different dates. Both amounts are in United States Dollars (USD). **All amounts and dates in the questions are hypothetical. We do ask that you imagine to the best of your ability that you are in this situation and need to make a choice between the two payments. These are very realistic choices that can present themselves to anyone, so for each question, please think which option you would choose if you were truly in this situation.**

The amount and date for each option will be represented as a radio button. You will make your choice by clicking on one of the buttons.

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

Try it out below: In the example below, the button with the earlier day represents the choice of receiving $300 on May 7th, 2023 and the button with the later day represents receiving $700 on October 2nd, 2023. Select one of the options by clicking the button for your choice.

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

START

Figure 27: This set of instructions are specific to the word condition. Most of the text is similar except for the wording that deals with describing the selection items, which are radio buttons in this case. The visual differences here comprise of a word specific animated GIF example and a word specific interactive example.

Money Choice Instructions

You will be presented with a series of hypothetical choices of receiving two different amounts of money on two different dates. Both amounts are in United States Dollars (USD). **All amounts and dates in the questions are hypothetical. We do ask that you imagine to the best of your ability that you are in this situation and need to make a choice between the two payments. These are very realistic choices that can present themselves to anyone, so for each question, please think which option you would choose if you were truly in this situation.**

The amount and date for each option will be represented as a calendar space. You will make your choice by clicking on one of the spaces.

2023

| January | February | March | April |
| May | June | July | August |
$300 (May)

| September | October | November | December |
$700 (October)

Try it out below: In the example below, the space on the earlier day represents the choice of receiving $300 on May 7th, 2023 and the space on the later day represents receiving $700 on October 2nd, 2023. Select one of the options by clicking the day for your choice.

2023

| January | February | March | April |
| May | June | July | August |
$300 (May)

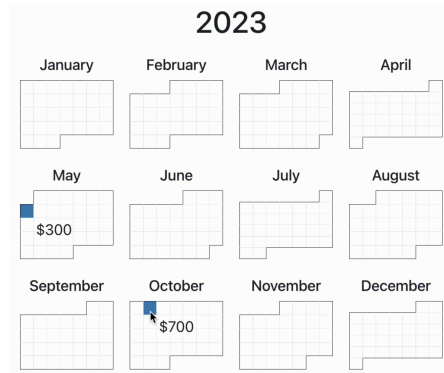| September | October | November | December |
$700 (October)
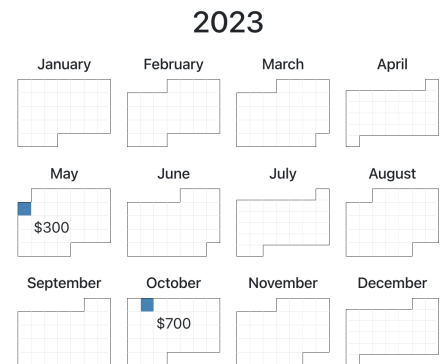
START

Figure 28: This set of instructions are specific to the calendar condition. Most of the text is similar except for the wording that deals with describing the selection items, which are blue boxes that represent the selection day in this case. The visual differences here comprise of a calendar specific animated GIF example and a calendar specific interactive example.

Appendix D

Screenshots of Word MEL Questions

Here are screenshots of the actual MEL questions used in the survey in word form. The amounts and dates are specified in the Table 1. These occur after the condition-specific instructions, and before the attention check pages.

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

Figure 29: A screenshot of the first MEL question in word form.

Make a choice to receive $490 on July 24rd, 2023 or $700 on December 6th, 2023.

◯ $490 on July 24rd, 2023   ◯ $700 on December 6th, 2023

Figure 30: A screenshot of the second MEL question in word form.

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

Figure 31: A screenshot of the third MEL question in word form.

Make a choice to receive $840 on June 15th, 2023 or $1,120 on September 26th, 2023.

◯ $840 on June 15th, 2023   ◯ $1,120 on September 26th, 2023

Figure 32: A screenshot of the fourth MEL question in word form.

Make a choice to receive $32 on August 6th, 2023 or $39 on November 14th, 2023.

◯ $32 on August 6th, 2023   ◯ $39 on November 14th, 2023

Figure 33: A screenshot of the fifth MEL question in word form.

Make a choice to receive $45 on May 29th, 2023 or $70 on September 17th, 2023.

◯ $45 on May 29th, 2023   ◯ $70 on September 17th, 2023

Figure 34: A screenshot of the sixth MEL question in word form.

Make a choice to receive $66 on September 12th, 2023 or $110 on November 8th, 2023.

◯ $66 on September 12th, 2023   ◯ $110 on November 8th, 2023

Figure 35: A screenshot of the seventh MEL question in word form.

Make a choice to receive $77 on July 30th, 2023 or $118 on October 15th, 2023.

◯ $77 on July 30th, 2023   ◯ $118 on October 15th, 2023

Figure 36: A screenshot of the eighth MEL question in word form.

Appendix E

Screenshots of Calendar MEL Questions

Here are screenshots of the actual MEL questions used in the survey in calendar form. The amounts and dates are specified in the Table 1. These occur after the condition-specific instructions, and before the attention check pages.

Figure 37: A screenshot of the first MEL question (left) and the second MEL question (right) in calendar form.
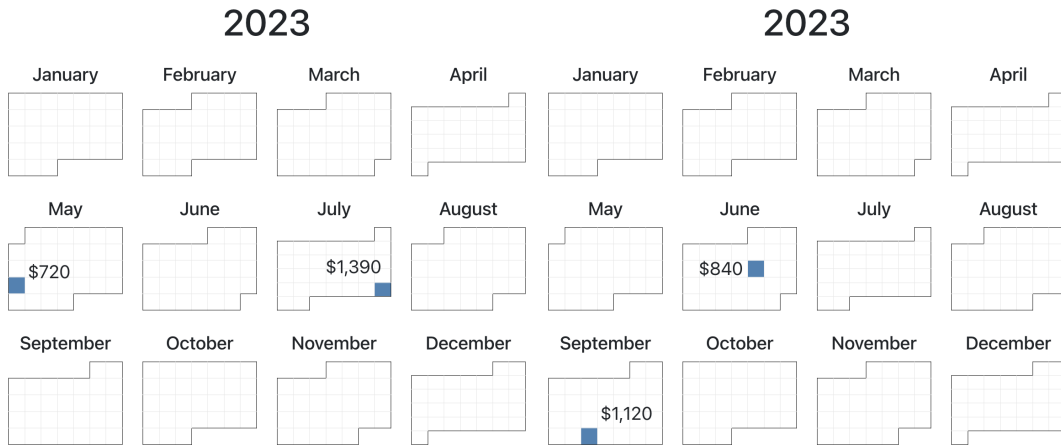
Figure 38: A screenshot of the third MEL question (left) and the fourth MEL question (right) in calendar form.
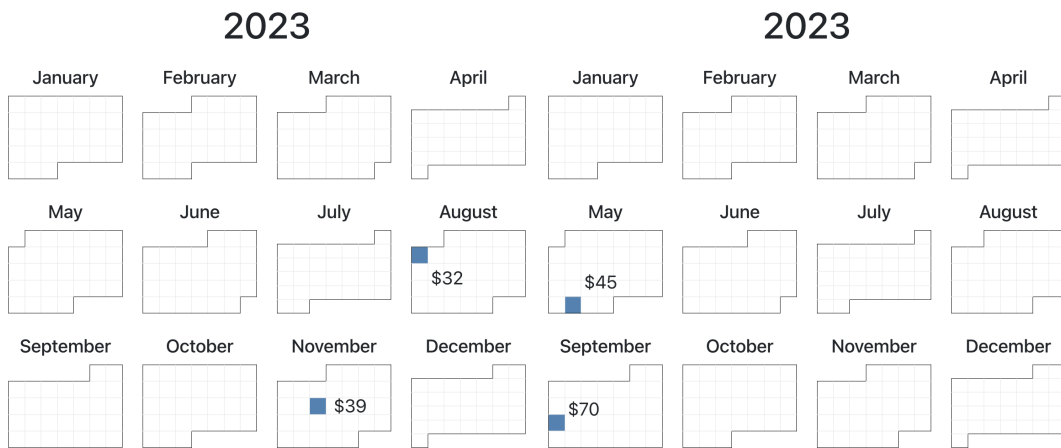
Figure 39: A screenshot of the fifth MEL question (left) and the sixth MEL question (right) in calendar form.
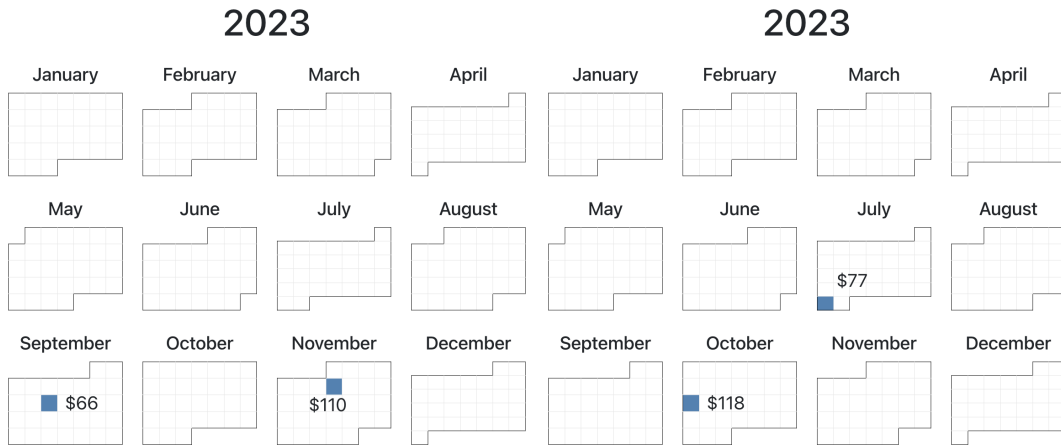
Figure 40: A screenshot of the seventh MEL question (left) and the eighth MEL question (right) in calendar form.

Appendix F

Screenshots of Post-MEL Questions

Screenshots of the pages after the actual MEL questions. These pages include: the attention check page, the three post survey pages (experience, financial literacy, and sense of purpose), the demographics page, and the combined page that debriefs participants, thanks them for participating, and reminds them about using the completion code to get paid for their participation.

Additional Question

Answer the question below.

1. Please select the 'stongly agree' option below. *

◯ strongly disagree ◯ disagree ◯ neutral ◯ agree ◯ strongly agree

NEXT

Figure 41: A screenshot of the attention check question that is used in the survey to tell if participants are blindly selecting answers without any thought.

Additional Questions 1 of 3

We would like to know what you thought of this survey. Please indicate your agreement or disagreement with the following statements.

Did you enjoy completing the survey questions?
○ not at all or very slightly
○ a little
○ moderately
○ quite a bit
○ extremely

Did you find the instructions clear?
○ not at all or very slightly
○ a little
○ moderately
○ quite a bit
○ extremely

Did you understand what the questions were asking you to consider?
○ not at all or very slightly
○ a little
○ moderately
○ quite a bit
○ extremely

Were the questions presented clearly?
○ not at all or very slightly
○ a little
○ moderately
○ quite a bit
○ extremely

Were you able to imagine these money choices as real?
○ not at all or very slightly
○ a little
○ moderately
○ quite a bit
○ extremely

On average, were the money choice decisions easy to make?
○ not at all or very slightly
○ a little
○ moderately
○ quite a bit
○ extremely

Would you like real life money decisions to be presented to you in this format?
○ not at all or very slightly
○ a little
○ moderately
○ quite a bit
○ extremely

Did you invest mental effort in the choice questions?
○ not at all or very slightly
○ a little
○ moderately
○ quite a bit
○ extremely

NEXT

Figure 42: A screenshot of the experience post survey questions and the possible answers participants can choose from.

Please answer these questions to the best of your ability.

Suppose you had $100 in a savings account and the interest rate was 2% per year. After 5 years, how much do you think you would have in the account if you left the money to grow? *

○ more than $102

○ exactly $102

○ less than $102

○ do not know

Imagine that the interest rate on your savings account was 1% per year and inflation was 2% per year. After 1 year, would you be able to buy more than, exactly the same as, or less than today with the money in this account? *

○ buy more today than a year ago

○ buy exactly the same today as a year ago

○ buy less today than a year ago

○ do not know

Do you think that the following statement is true or false? 'Buying a single company stock usually provides a safer return than a stock mutual fund.' *

○ true

○ false

○ do not know

NEXT

Figure 43: A screenshot of the financial literacy post survey questions and the possible answers participants can choose from. In each question only one answer is correct.

Additional Questions 3 of 3

The following questions ask you generally about your life. Please indicate your agreement or disagreement with the following statements.

I am striving to make a positive difference in society.
- ○ strongly disagree
- ○ disagree
- ○ neutral
- ○ agree
- ○ strongly agree

Through my career I aim to make the world a better place.
- ○ strongly disagree
- ○ disagree
- ○ neutral
- ○ agree
- ○ strongly agree

I seek to serve society in many ways, large and small.
- ○ strongly disagree
- ○ disagree
- ○ neutral
- ○ agree
- ○ strongly agree

I have started thinking about what I truly want to achieve.
- ○ strongly disagree
- ○ disagree
- ○ neutral
- ○ agree
- ○ strongly agree

I can describe my life's purpose.
- ○ strongly disagree
- ○ disagree
- ○ neutral
- ○ agree
- ○ strongly agree

I make efforts to promote other people's wellbeing.
- ○ strongly disagree
- ○ disagree
- ○ neutral
- ○ agree
- ○ strongly agree

NEXT

Figure 44: A screenshot of the sense of purpose post survey questions and the possible answers participants can choose from.

Demographic Questions

Please tell us about yourself by answering the questions below. All data collected will be analyzed in aggregate form only and will not be used to identify you.

Country of residence ▾   Dataviz experience ▾   Age   Current Profession

The country you are living in now   Your experience with data
                                      visualizations and charts

Gender ▾   Self Describe Gender   Current Employment ▾   Describe Employment

NEXT

Figure 45: A screenshot of the demographics page in the survey.

Study Explanation

Your answers have been recorded.

When it comes to decisions between payoffs sooner or later in time, people tend to place less value on the later reward and choose the sooner option even at the cost of larger later rewards. This is called discounting the later reward. Discounting can manifest itself in decisions regarding finance, health, and the environment. Life expectancy and quality of life can be negatively impacted, especially in later years as the negative consequence of choosing the shorter term option accumulate over time. Decisions like these are malleable and discounting can be counteracted by how attention is focused, how a reference point is framed, and how time is represented. Visualization offers a powerful tool that influences all three of these factors.

This experiment seeks to examine how visualization can be designed to influence people in making long term decisions differently. For this purpose, participants in this experiment are randomly assigned to be presented with word choices or different versions of graphical displays, such as a calendar. In particular, we examine how this familiar single-year calendar layout can be used to increase the likelihood of choosing the longer-term option.

For more information about this research or about the rights of research participants, or if you would like to get in touch with us for any other reason the contact information is below:

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Please remember to enter the code C1KQNGZK into Prolific so that you will be paid $3.

We hope you have enjoyed taking this survey and welcome any feedback or questions by filling out the text box below and clicking submit & exit.

Feedback

SUBMIT FEEDBACK & EXIT

Figure 46: A screenshot of the debrief page in the survey.

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