Utilizing Episodic Thinking and Temporal Framing to Enhance Future-Oriented Decision-Making in Social and Design Contexts

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Table of Contents

Chapter 1. Overview. **6**

1. Executive Summary. *6*

2. Chapters. *6*

2.1. Temporal Framing. 6

2.2. Episodic Thinking. 6

References. *7*

Chapter 2. Framing to reduce present bias in infrastructure design intentions. **8**

Original citation. *8*

Summary. *8*

1. Introduction. *8*

2. Methods. *9*

2.1. Data and code availability. 9

2.2. Preregistration. 10

2.3. Experimental model and subject details. 10

2.4. Project background. 11

2.5. Comprehension checks. 11

2.6. Experimental intervention. 12

2.7. Envision framework. 13

Table 1: Descriptions of the credits from the Envision Framework used within the study. 13

2.8. Quantification and statistical analysis. 14

3. Results. *14*

Table 2: Data Analysis Results. 15

Figure 1: A future orientation led to a statistically significant increase in useful life to community, design life, and return on investment. Error bars represent ± 1 SE. 16

4. Limitations. *16*

5. Discussion. *16*

Acknowledgments. *17*

Author contributions. *17*

Inclusion and diversity statement. *18*

References. *19*

Chapter 3. Episodic Thinking and Its Impact on Social-Relevant Delay Discounting. **22**

1. Introduction. *22*

2. Methods. *25*

2.1. Study design. 25

Figure 1: The study consisted of two experimental groups, with the temporal orientation, present or future, of the episodic thinking exercise being randomly assigned. 26

2.2. Episodic thinking exercise. 26

Figure 2: Participants in the future group were asked the questions shown above to measure the vividness to which they imagined the future action they would take to help their community. 27

2.3. Social monetary delay discounting scenario. 27

2.4. Data collection. 29
2.5. Data analysis. 30
Figure 3: Shows the breakdown of the raw data, completed responses and final sample. The majority of excluded data (61%) was due to participants who completed less than 15% of the survey. 30
2.6. Data cleaning. 30
2.7. Demographic breakdown. 31
Table 1: Demographic breakdown of the survey sample compared to the 2020 U.S. Census. 32
2.8. Delay discount calculation. 32
2.9. Qualitative data. 33

3. Results. *33*
3.1. Vividness. 33
Table 2: Mann Whitney U test comparing vividness between the future and past groups. 34
3.2. Time perspective. 34
Figure 4: Time perspective questions asked to participants in the future group. 34
Table 3: Mann Whitney U test comparing Time Perspective between the future and past groups. 35
3.3. Emotional intensity. 35
Table 4: Mann Whitney U test comparing Emotional Intensity between the future and past groups. 35
3.4. Urgency. 35
Figure 5: After the intervention, participants were asked to indicate the urgency of need they felt for themselves and others for enhanced stormwater infrastructure. 35
Table 5: Mann Whitney U test comparing Urgency, others and self, for enhanced stormwater infrastructure between the future and past group. 36
3.5. Delay discount rate – AUC_{ord}. 36
Table 6: Mann Whitney U test comparing AUCord between the future and past groups. 36
3.6. GRiPS. 36
Table 7: Mann Whitney U test comparing GRiPS between the future and past groups. 36
3.7. Judged Procedural Fairness, Trust, and Cooperation. 37
Table 8: Mann Whitney U test comparing the judged procedural fairness, trust, and cooperation around the proposed infrastructure between the future and past groups. 37
3.8. Social justice. 37
Table 9: Mann Whitney U test results comparing SJPBC between the future and past groups. 37
3.9. Qualitative findings. 37
Table 10: Participant's top five most frequently used words when describing actions to benefit their community. 38
Table 11: Participant's top five most frequently used words when describing their flood infrastructure funding choices. 39
Figure 6: Shows the count of positive and negative sentiment words used by participants in their descriptions of actions that would benefit their community, as well as when describing their flood infrastructure funding choices. 40

4. Discussion. *40*
4.1. Research question one: significantly lower the discount rate used in a social decision. 41
4.2. Research question two: significantly impact perceptions of social justice. 42
4.3. Future work. 43

5. Conclusion. *43*

References. *45*

Appendix A. *Memory Experiences Questionnaire.* *49*

Appendix B. *Urgency.* *51*

Appendix C. *GRiPS Risk Scale (Zhang et al., 2019).* *52*

Appendix D. *Judged Procedural Fairness, Trust and Cooperation (Earle & Siegrist, 2008).* *53*

Appendix E. *Social Justice Scale (Torres-Harding et al., 2012).* *54*

Chapter 4. Implications. **55**

1. Temporal Framing. *55*
1.1. Intellectual Merit. 55
1.2. Broader Impacts. 55

2. Episodic Thinking. *56*
2.1. Intellectual Merit. 56
2.2. Broader Impacts. 56

3. Future work. *56*

Chapter 1. Overview.

1. Executive Summary.

This dissertation explores two behaviorally-informed methods for improving decision-making in sustainable engineering: temporal framing and episodic thinking. The first chapter focuses on the use of future framing to reduce present bias and improve sustainability in decision-making. The study found that framing a decision scenario in terms of the future resulted in participants proposing significantly longer preliminary design concepts in terms of infrastructure design life, useful life to the community, and acceptable return on financial investment. The second chapter examines the effects of episodic future thinking or past thinking on social decision-making, in the context of delay discounting. The study found that while there were no significant differences in social delay discounting, episodic future thinking enhanced emotional intensity towards the community-benefitting action, while past thinking improved temporal placement and the vividness of the recalled action. These findings suggest that both temporal framing and episodic thinking have the potential to improve sustainable decision-making and inform future research.

2. Chapters.

2.1. Temporal Framing.

Present bias is the tendency to prefer a smaller reward now versus a larger payoff in the future[1]. Reducing present bias can result in improved sustainable decision-making in individuals[2]. Research has shown that one way to reduce present bias is through future framing – in which individuals are primed by a future orientation before a task[3]. Thus, in an online experimental survey (N = 261) with engineering professionals, a decision scenario was temporal framed in terms of the present or the future. Participants designed elements of a city's wastewater treatment plan that would impact the project's sustainability. Framing the task in terms of the future resulted in participants proposing significantly longer preliminary design concepts for infrastructure design life, useful life to the community, and acceptable return on financial investment[4].

2.2. Episodic Thinking.

In social contexts, the impact of delay discounting (the tendency to devalue temporally delayed rewards) on decision-making may be less pronounced than in individual decision-making[5]. However, it can still lead to suboptimal outcomes[6]. Episodic thinking refers to an individual's ability to vividly recall past experiences or imagine future possibilities[7], yet its effects on social decision-making are unclear. In the conducted experiment (N = 481) participants engaged in either future or past episodic thinking before a socially-relevant decision (funding levels for storm water infrastructure in their community). While no significant differences in social delay discounting were found, other effects emerged. Future episodic thinking enhanced emotional intensity, while past episodic thinking improved temporal placement and vividness of community-benefitting actions. These findings inform tools for socially relevant decision making and further research on episodic future thinking.

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Hancock, P., Klotz, L., Shealy, T., Johnson, E., Weber, E., Stenger, K., & Vuppuluri, R. (2021). Future tense can reduce present bias in infrastructure design. iScience 25, 103954 March 18, 2022 © 2022 The Authors. https://doi.org/10.1016/ j.isci.2022.103954

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Chapter 2. Framing to reduce present bias in infrastructure design intentions.

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Summary.

Infrastructure professionals (N = 261) were randomly assigned to either a future or present-framed project description and asked to recommend design attributes for an infrastructure project. The future-framed condition led professionals to propose a significantly longer infrastructure design life, useful life to the community, and acceptable return on financial investment. The findings suggest a straightforward and inexpensive way to lessen present bias in various design contexts.

1. Introduction.

Infrastructure systems provide essential water, shelter, mobility and other services. There is a global need to update these systems and to expand and adapt them to serve the billions who do not currently have access (DESA, 2016). At the same time, existing infrastructure accounts for around one fifth of climate changing emissions (Creutzig et al., 2016), and new infrastructure development that is more of the same would independently exceed the carbon budget needed to avoid the worst effects of climate change (Müller et al., 2013). Present-day choices about infrastructure will impact how effectively the water, shelter, and mobility needs of current and future generations are met, and present-day decisions about infrastructure will impact whether we maintain a set of safe conditions for life on earth.

Decisions made by a variety of project stakeholders long before construction begins play an outsized role in determining the costs and benefits of an infrastructure project (Sen, 2001). Previous work has discovered that, as in other domains (Johnson et al., 2012), the context in which such decisions about infrastructure are made can impact the outcome (Harris et al., 2016; Shealy et al., 2018, 2016). For example, compared to a control group, professional infrastructure engineers made aware of high achieving "role-model" projects set 34% more ambitious goals for sustainability (Harris et al., 2016). Consequently, one important path to more sustainable infrastructure is to identify the specific decision contexts that motivate designers (e.g., engineers, urban planners, and architects) to create more sustainable outcomes.

People's construal of time can lead to more or less sustainable outcomes (Trope and Liberman, 2010). One barrier to more sustainable choices is present bias: individuals' tendency to irrationally prefer options with more immediate benefits over options with delayed benefits. Present bias can be overcome by priming future considerations so that they are considered first or more extensively. One way in which this is done is through structured use of Construal Level Theory (CLT), which

describes the malleability of psychological distance, to alter an individual's construal of the decision context (Pronin et al., 2008; Trope and Liberman, 2010; Weber et al., 2007). For example, close psychological distance to the effects of climate change is correlated with increased concern for climate change impacts (Maiella et al., 2020; Spence et al., 2012). Similarly, a closer perceived distance to the future might elicit long-term sustainable outcomes by reducing present bias.

In CLT, temporal orientation refers to how people perceive and value time, in terms of past, present or future. Research has shown that eliciting a future orientation can lessen present bias in a variety of decision contexts. For example, having people contemplate future outcomes before current alternatives can lessen present bias in a variety of decision contexts (e.g. organ donation (Johnson and Goldstein, 2003) and retirement planning (Earl et al., 2015; Thaler and Shlomo, 2004)) and increase patience more generally (Weber and Johnson, 2015). This research explores whether eliciting a future-orientation towards a design task, to lessen present bias, generates more sustainable concepts for infrastructure design.

In practice, infrastructure design often begins with a request for proposals, which is a document outlining the initial requirements for design firms that wish to bid on a project. It communicates to designers the project intent of whoever is paying, often a government or municipality on behalf of taxpayers. The request for proposals is therefore an influential avenue for CLT interventions that might make individual designers more likely to generate sustainable design concepts during the preliminary phases of an infrastructure design project.

Here we examined whether a future orientation, delivered via an online survey and introduced via randomly assigned changes to the word tense in a request for proposals document (see Star Methods), would elicit professional infrastructure designers to take a longer-term view in their preliminary design concepts for an infrastructure project. The study population was comprised of certified Envision professionals. Envision is a sustainable design framework supported by the Institute of Sustainable Infrastructure. The Envision population was chosen because it is comprised of professionals with experience in infrastructure design who, by earning Envision certification, have demonstrated a commitment to enhancing infrastructure sustainability. Because our intervention targets the construal level we expect, but cannot be sure, that results from this group would extend to professionals lacking a similar commitment to sustainability.

2. Methods.

This paper presents the data of an online experimental survey that explored the impact of temporal framing on the sustainability of infrastructure designer's preliminary project concepts.

2.1. Data and code availability.

- The participant data reported in this study cannot be deposited in a public repository because of a non-disclosure agreement. To request access, contact the Institute of Sustainable Infrastructure and reference this study.

- All original code has been deposited at Zenodo and is publicly available as of the date of publication. DOIs are listed in the key resources table.
- Any additional information required to reanalyze the data reported in this paper is available upon request.

2.2. Preregistration.

Before the data collection took place for this study, after a pilot data collection for testing the decision scenario's functioning, the study was preregistered. The preregistration and any other supporting materials can be found on the projects Open Science Foundation page at https://osf.io/z89ve/. To create the preregistration the Aspredicted.org template was used and it listed our hypotheses, intentions for data collection, and data analysis. It should be noted that the original preregistered study design did not include some of the hypotheses from this paper, but all the dependent variables were included in the preregistration. This oversight was left as is in order to not create confusion from a second preregistration.

2.3. Experimental model and subject details.

Six-hundred and seventy-nine Infrastructure Design Professionals participated in this study. The participants recruited for this study were all Certified Envision Professionals who have experience in and are motivated to create sustainable infrastructure.

Written informed consent was obtained from each participant in accordance with the University of Virginia Institutional Review Board. Participants were excluded they failed any of the attention checks or left unanswered any of the questions pertaining to the studies primary DV's. This resulted in a usable sample size of two-hundred and sixty-one participants.

The study took the form of an online experimental decision scenario deployed through the Institute for Sustainable Infrastructure Envision professionals' email listserv. This amounted to a total population of 5,872 individuals. For completion of the experiment, participants received one credit hour towards the Envision certification continuing education requirement.

Professional infrastructure designers with training and experience with the Envision rating system served as the study population, due to their interest and expertise in creating more sustainable infrastructure. The Envision rating system is the leading sustainability rating system for infrastructure in the United States and is managed by the Institute for Sustainable Infrastructure.

Focusing on this specific set of designers served two purposes. First, if the intervention is successful it shows that sustainability focused behavioral interventions can elicit decision-making improvements for designers already committed to sustainably. Second, by indirectly generating improved sustainable decision-making, by priming the future, the impact of the intervention might be generalizable to non-Envision engineers, because a belief in sustainable actions might not be required for the intervention to be effective. In other words, these findings would add further

evidence to present needs being privileged, in the minds of designers, over future needs in a way that hinders improved sustainable decision-making.

A two-group experimental design was created for this study. Since, to the knowledge of the authors, this is the first study that explores the impact of temporal orientation on designer decision-making, estimations were used to select the experimental parameters. The resulting experiment was designed to measure a medium effect size, d = 0.5, at an alpha of 0.05 with a power of 80%. As such a sample size of N = 250 was targeted, or n = 125 for each of the present and future groups.

The experimental manipulation was delivered via modified request for proposal document outlining a fictional infrastructure design decision scenario. This scenario casted participants as the lead engineer in charge of decision-making regarding a Water System Master Plan for the District of Sparwood in British Columbia, Canada ("Water and Wastewater Infrastructure Plans RFP #: 2017-PW-001," 2017). According, participants were tasked with answering questions regarding the design decisions they would make if they were to be tasked with completing the project. The experimental manipulation sought to prime participants with either a future or present orientation while they completed the design questions pertaining to the decision scenario.

2.4. Project background.

The District's vision statement introduced the participants the design decision scenario. Participants were instructed that the District of Sparwood is looking to provide and manage infrastructure and services—including potable water, sewage, storm water, and roads—cost-effectively and sustainably. The RFP explained to participants how the Water System Integrated Master Plan fit with the broader District vision. As such, the Master Plan focuses on the District's need for water distribution, wastewater treatment and collection, and storm water conveyance systems.

The participants were told that the creation of Water System Master Plan served "to provide strategic direction, support asset management initiatives, and assist the District in short- and long-term decision making". This includes financial, operational, and strategic considerations for how and when decisions should be made according to the plan. Participants were assigned the role of lead engineer for the District of Sparwood. Accordingly, this meant that the participant would oversee the creation of the Water System Master Plan. Additionally, as the lead engineer, their decision-making responsibility was to do what was best for the District by ensuring the project benefits outweigh its costs.

2.5. Comprehension checks.

At this point, the participants were primed on the Envision framework requirements and the wastewater master plan project. The primes were broken up into multiple components to ensure prime strength and comprehension checks were used to ensure participants' understanding. For example, each participant was presented with a comprehension checks, form of a multiple-choice

questions, after the project master plan details and the Envision written response instructions. By ensuring the manipulation was primed in the participants as intended, we would have confidence the results were pertinent to the questions we are looking to ask.

A total of 679 participants opened the decision scenario and consented to the experiment. Only a small portion of these participants completed the decision scenario. If the participants failed any of the comprehension checks or did not answer the three design characteristic questions, they were excluded from the study. Accordingly, we excluded 418 participants from the study analysis for a total sample size of 261 and the completion rate was 38%. As the study population were working professionals, the long completion time, of around 45-minutes, likely resulted in a large number of the dropouts.

2.6. Experimental intervention.

The participants received a manipulation in the form of the RFP project description. As mentioned above, the participants read information detailing Sparwood as it is now or what Sparwood envisions for the future. The descriptions only varied in temporal framing across the two experimental groups.

Below, the manipulation is listed in full. The future statement appears in brackets, and the present statement appears in parentheses. The manipulation is designed influence the individual's perception of the temporal proximity of the design task. Therefore, we primed participants with a project description framed in terms of the present or the distant future. Research has shown it is possible to elicit temporal perceptions of the near-term future that are imperceivably from the present (Jones et al., 2017). However, as the timepoint becomes into the distant future, or over ten years, it less likely for individuals perceive the event as they would the present (Gifford, 2011; Soliman et al., 2018). As such, by framing the future condition in distant future, participants were more likely to perceive the design task as significantly different from the present.

"[In 2035,] Sparwood [will be] (is) a caring, neighborly, and sustainable community with pride in its natural environment. A world-class multi-purpose network of trails, parks, and recreational areas [will] support an active, healthy, and highly livable community. A unique and vibrant downtown [will be] (is) the social, cultural, and economic heart of Sparwood. Opportunities to live, work, learn, shop, and play [will be] (are) in close proximity. A diverse economy [will provide] (provides) a range of jobs and services to supplement the mining industry, which [will be] (is) the economic lifeblood. A variety of housing options [will allow] (allows) residents of all income levels and lifestyles to live comfortably in Sparwood [throughout all stages of their lives]."

After the manipulation, participants provided a written description of their conceptual designs for the scenario and also set targets, in years, for the outcome variables of interest: design life, useful life to the community, and maximum acceptable return on investment. By having the three outcome variables of interest relate to different aspects of the wastewater treatment plant's design

lifespan the participant's design intentions on projects goals relating to sustainability were measured.

2.7. Envision framework.

After completing the questions on the primary dependent variables, the participants moved on to the experiment section, which dealt with the Envision framework and the secondary dependent variables. Here, the participants provided their targets for ten Envision credits, which pertained to the wastewater facility's sustainable achievement. Participants had to select the level of sustainable achievement for each credit and write a prompt explaining how they would do so. The prompt increased in length if participants set their achievement at higher-levels to simulate the real-world mental effort required for a more sustainable project (Harris et al., 2016). The decision scenario finished with necessary demographic information along with questions on the participant's work history.

As mentioned above, Envision is a sustainable design framework facilitated by the Institute of Sustainable Infrastructure. The framework comprises 60 credits across five different areas: quality of life, leadership, resource allocation, the natural world, climate and resilience, and sustainable design. The achievement levels, for each credit, can range from improved (the lowest level), enhance, superior, conserving, and restorative (the highest level). Depending on a project's achievement for each of these individual applicable credits, and their achievement levels, the Institute of Sustainable Infrastructure will grant an overall project sustainability score. These sustainability certifications include: verified (the lowest level), silver, gold, and platinum (the highest).

Table 1: **Descriptions of the credits from the Envision Framework used within the study.**

Envision Credit	Description
Quality of Life 3.1	Advance Equity & Social Justice
Leadership 1.3	Provide for Stakeholder Involvement
Leadership 2.2	Plan for Sustainable Communities
Leadership 2.3	Plan for Long-Term Monitoring & Maintenance
Leadership 2.4	Plan for End-of-Life
Leadership 3.3	Conduct a Life-Cycle Economic Evaluation
Resource Allocation 2.1	Reduce Operational Energy Consumption
Resource Allocation 3.2	Reduce Operational Water Consumption
Climate and Resilience 1.2	Reduce Greenhouse Gas Emissions
Climate and Resilience 2.1	Avoid Unsuitable Development

After answering the questions to the main dependent variables, they provided their sustainability targets, for the project, via a series of Envision credits. The participants did so by responding to ten credits, presented in random order, from the existing Envision framework. The credits drew from a few different Envision categories, namely: quality of life, leadership, resource allocation, and climate and resilience – see Table 1 for more information. After selecting a

sustainability target the participant described, via a written statement, how they would accomplish this sustainability level, without technical specifications. The length of the response increased with each higher sustainability target in order to simulated the cognitive burden of greater achievement.

2.8. Quantification and statistical analysis.

Before significance testing the raw data was cleaned, which involved removing any of the participants that failed to pass the attention checks within the survey, and was then tested for normality. Then the data was analyzed using a Welch two sample t-test, due to unequal samples sizes and variance, for each of the three DVs (Useful life to the community, Design life and Longest acceptable return on investment) across experimentally manipulated future and present orientations.

The individual Envision credit scores were analyzed using a multi-level model due to the ten individual credits' repeated measures. The Envision scores were also examined to see if they would predict any of the design metrics.

3. Results.

The experimental deployment was able to collect N = 261 participants with n = 147 in the present group and n = 114 in the future group. While the group assignment was random and evenly assigned, the future group had a higher dropout rate than the present group for reasons that are unknown. The data was then analyzed across the participants' responses for the design task via the three dependent variables of design life, useful life to the community and maximum acceptable return on investment. For each dependent variable, the null hypothesis was that no significant difference exists between participants in the future-framed or present-framed group. A detailed breakdown of the statistics can be found in Table 2. Visual display of the main findings is in Figure 1. Findings related to each hypothesis are as follows:

- The participants who received the future-oriented request for proposal set a **significantly longer targeted useful life to the community (t = 2.26, df = 229.09, MD = 7.80, p = .02)** compared to those in the present group. Useful life to the community is an essential measure of a comprehensive sustainable infrastructure design (Valdes-Vasquez and Klotz, 2013). This measure influences how limited available capital benefits society now and into future (Sierra et al., 2017). All else being equal, a longer useful life is more sustainable.
- The participants who received the future-oriented request for proposal also construed a **significantly longer design life (t = 2.39, df = 228.96, MD = 8.12, p = .02)** compared to those in the present group. Targeting a longer design life obligates designers to mitigate a wider array of uncertain future risks, such as climate change, through their design decisions (Hallegatte, 2009). Increases to the design life of roadway infrastructure, for example, have been shown to contribute to improvements in the sustainability of the project's life-cycle (Al-Qadi et al., 2015).
- Finally, the participants in the future-orientated group were willing to accept **a significantly higher number of years for the return on investment (t = 2.14, df =**

227.67, MD = 2.93, p = .03) than those in the present group. This suggests that the future framing might be one way to mitigate time-inconsistency in designers decision-making (e.g., present bias—where small payoffs now are preferred over larger payoffs in the future) to allow for sustainable infrastructure across a wider temporal frame (Henderson and Bateman, 1995).

Table 2: **Data Analysis Results.**

Variable	n	Mean (SD)	95% CI	t	df	p	d	r
Design life			[1.41, 14.83]	2.26	229.09	.02	0.31	0.16
Present	147	49.75 (25.58)						
Future	114	57.88 (28.53)						
Community			[0.99, 14.62]	2.39	228.96	.02	0.30	0.15
Present	147	55.09 (28.99)						
Future	114	62.89 (26.01)						
ROI			[0.24, 5.63]	2.14	227.67	.03	0.28	0.14
Present	147	17.95 (10.23)						
Future	114	20.89 (11.51)						

While our findings suggest a way to lessen present bias, they did not confirm that doing so would translate to higher levels of achievement through the Envision rating system. No significant differences in Envision credits were found from the participant's temporal orientation. Perhaps participants found the Envision credits used unrelated to the temporal construal of the project. Or perhaps the participants future orientation had "worn off" by the time they engaged with Envision credits later in the study. Future research could examine whether stronger future-framing (i.e., through pictures or immersive virtual reality) directly introduced into Envision credits could lead to significant differences in sustainable achievement. Even absent other data, this research suggests that priming designers to have future orientation could elicit individual designers to generate more sustainable infrastructure design concepts, thus potentially opening the door for more sustainable design outcomes.

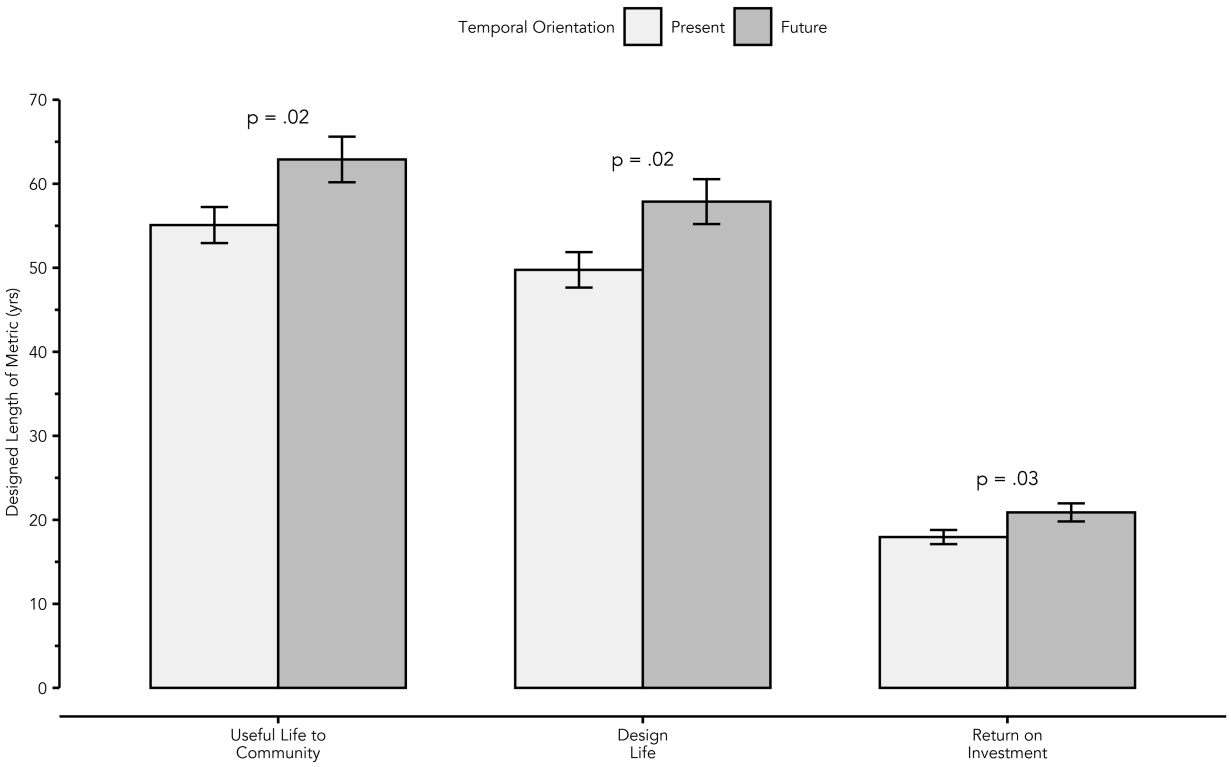

Figure 1: **A future orientation led to a statistically significant increase in useful life to community, design life, and return on investment. Error bars represent ± 1 SE.**

4. Limitations.

It is important to note a few limitations of the findings presented here. First, while significant results were found for the three dependent variables, the confidence intervals for them are large. This suggests that the sample for this study was undersized. An effect size of d = 0.30 was observed. This was smaller than the expected effect size of 0.5 (see Methods for more details). As such, extensions of this research could use studies powered to measure effect sizes that range from d = 0.2 – 0.5, thus allowing for the study of manipulation strength as well as less effective interventions. A larger sample population would be required to accomplish this.

Second, the study population of Envision professionals may already have a relatively strong future orientation; they have made a commitment to more sustainable infrastructure by joining the organization. Since the request for proposal interventions significantly impacted the decisions of this uniquely motivated group, we expect, but are not certain, that the interventions would similarly impact the decisions of designers who are less likely to be thinking of sustainability from the outset.

5. Discussion.

The future orientation, elicited through changes to word tense in a request for proposal, generated a longer-term perspective among designers who make decisions about sustainable

infrastructure. Not all requests for proposals are present framed, but many are (e.g., the Gordie Howe International Bridge that connects Detroit, Michigan and Windsor, Ontario ("Request for Proposals for Gordie Howe International Bridge," 2016), the Kosciuszko Bridge in New York City ("Kosciuszko Bridge Project - Phase 1 - Request for Proposals," 2013) and the Los Angeles World Airports Automated People Mover ("Request for Proposals for the Automated People Mover Landside Access Modernization Program at Los Angeles International Airport," 2016)). Considering that major requests for proposals are often written in the present tense greater attention to temporal framing in such requests could help designers ensure that the design concepts they come up with are more sustainable. Accordingly, priming a future orientation could provide a relatively straightforward and inexpensive way to reduce present bias.

These findings add to the growing evidence that construal-level interventions can elicit differences in designer decision-making. These research findings are relevant for practice in infrastructure and beyond. For example:

- Legislators could require the use of future framing for infrastructure design projects;
- Public agencies that issue request for proposals could modify their templates to be future oriented;
- Future orientation could be strengthened in the wording of sustainability and climate action plans which are documents that, like requests for proposals, have long-term consequences; and
- Future orientation could be strengthened with more explicit changes than word tense, such as explicit mentions of the future, visioning exercises (Dassen et al., 2016; Stein et al., 2016) and images of projected futures (Biliciler et al., 2021; Hershfield et al., 2011).

While this work suggests practical changes, the data only allows for limited speculation on the underlying psychological mechanisms driving the significant difference between the experimental groups. Future research could therefore examine whether heightened positive or negative emotion pathways mediate the observed effect (Van Boven and Ashworth, 2007), and whether episodic future thinking would enhance the presented effect, demonstrable, perhaps, via heightened Prefrontal-Mediotemporal Interactions (Benoit et al., 2011). A deeper understanding of the underlying psychology could allow for more effective interventions and provide insights for how to apply these findings in other contexts.

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Author contributions.

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Inclusion and diversity statement.

We worked to ensure that the study questionnaires were prepared in an inclusive way. While citing references scientifically relevant for this work, we also actively worked to promote gender balance in our reference list.

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Chapter 3. Episodic Thinking and Its Impact on Social-Relevant Delay Discounting.

Summary.

Delay discount rate is the degree to which an individual reduces the value of a reward as a function of the time from the reward receipt. Holding a high discount rate can result in large future benefits having little value in the present, if they are received too far in the future. Therefore, understanding how to reduce the delay discounting implicit in an individual's decision-making could open up decision-making pathways to solutions to problems with longer time horizons. For example, research has shown, in the context of domestic water consumption, energy use, and charitable donations, that both monetary and non-monetary incentives can enhance pro-environmental behavior. Yet, in these cases, the impact of human behavior on decision-making is often overlooked, even though insights from behavioral science demonstrate how our cognitive processes are impacted by the situation in which we make decisions. One method that has been shown to reduce an individual's delay discount rate for decisions that directly impacted them is episodic thinking. Episodic thinking refers to the practice of and degree to which an individual vividly recalls previous experiences, past thinking, or imagining 'yet to be' possibilities, future thinking. Many decisions we make individually have impacts that reach beyond ourselves and contribute to socially relevant problems like climate change, social inequality, and other forms of injustice. Yet, to date, the literature on the impact of episodic thinking on social decision-making is sparse. Therefore, using an online experimental survey (n = 481), this study explored how an individual's delay discount rate is impacted after engaging in either episodic future or past thinking before a social decision-making scenario. Our results did not find the intervention of engaging in future episodic thinking to be significantly more effective than past thinking in lowering an individual's social delay discount rate. However, our results demonstrate that **(1)** participants in the future group found reflecting on their future plans to be significantly more emotional than the past group did (**Emotional Intensity**); **(2)** participants in the past group were significantly more likely than the future group to be able to precisely place themselves in the memory/vision they explored by episodic thinking on an action that would benefit their community (**Time Perspective**); **(3)** participants in the future group rated the vividness of their envisioning at a significantly lower value compared to the participant's in the past group (**Vividness**). These findings contribute to our understanding of whether and how episodic thinking can be used to reduce present bias in individuals making socially relevant decisions.

1. Introduction.

Episodic thinking refers to the capacity for an individual to vividly recall previous experiences, known as past thinking, or imagine 'yet to be' possibilities, known as future thinking (De Brigard et al., 2017). Engaging in episodic thinking in terms of the past or future is a common practice in everyday life. This might look like taking the time to vividly engage with the details of a past or planned future vacation to place yourself there and relive or experience it. A growing body of research has documented the impact that engaging in episodic thinking can have on decision-

making outcomes. The literature has shown that episodic thinking engages different neurological pathways than other forms of thinking. Engaging in future episodic thinking has been shown to reduce an individual's present bias, or preference for a smaller reward now over a larger reward in the future for themselves (Benoit et al., 2011; Peters & Büchel, 2010; Schacter et al., 2015, 2015). For example, an increased present bias has been shown to reduce the ability for *individuals* to effectively make decisions on issues with long time horizons, like for their own retirement planning (Brown & Previtero, 2014; Xiao & Porto, 2019). In this paper, rather than focusing on a *personal reward*, we explored if engaging in future or past episodic thinking, before *socially* relevant decision making (i.e., local stormwater infrastructure) impacts an individual's present bias by measuring their delay discounting behavior of the funding of the hypothetical stormwater infrastructure improvements.

A core assumption to numerous decision-making tools, from retirement planning to cost-benefit analysis, are built from a neoclassical model of economics, where people are modeled as rational actors that will always choose the most economically cost effective and efficient option for themselves regardless of the context (Thaler, 2016). However, the extensive and growing research on human behavior shows that human decision-making outcomes are impacted by, amongst other factors, individual biases (see Hardisty et al., 2013 for the impact of present bias), the context in which options are selected (see Milgram, 1963, 1965 for the impact of power dynamics), and how decisions are framed (see Hancock et al., 2021 for the impact of temporal framing). For example, present bias has been shown to clash with the long-term decision-making required to effectively act on social issues such as climate change (Zhao & Luo, 2021). In these cases, individuals and groups can find it difficult to choose long-term benefits (e.g. mitigated climate change impacts by reducing greenhouse gas emissions) over short-term gains (e.g. reduced business costs due to limited emission regulations). Yet, promisingly, research has shown that present bias is not static, but rather dynamic across individuals and influenced by context. For example, individuals that exhibit less present bias and are more patient have been found to be more likely to purchase energy efficient appliances (Fuerst & Singh, 2018). Also, designing "smart defaults" for decision-making contexts has been shown to effectively reduce present bias (Sunstein & Reisch, 2014; Weber, 2017). For example, research has shown that people are significantly more likely to choose an energy efficient light bulb over a less efficient alternative when the efficient option is framed as the default choice, compared to if the less efficient option is the default (Dinner et al., 2011). Thus, because decision-making is not purely in the realm of rationality, as neo-classical economics would suggest, it is important to take steps to update and transform existing decision-making tools to incorporate the behavioral elements of choice making.

Behaviorally-informed decision-making tools can help individuals better align their choices to specific objectives they have previously committed to. Within examining decision-making related to environmental sustainability, there are numerous actor types, such as individuals and their consumption patterns compared to engineers and their design practices. Each, in their own way, has an impact on environmental sustainability; yet, depending on the decision-making context and

domain, the scale of impact a specific actor group might have on society's environmental sustainability widely differ. Some research has already taken such an approach showing that the targeted use of behavioral interventions on infrastructure designers like descriptive norms (Shealy et al., 2018) and choice architecture (Shealy et al., 2016) can help increase the likelihood for environmentally informed and sustainable decision-making outcomes. Critically, in both cases, the infrastructure designers themselves had already signaled their commitment to sustainability through the design tools they had previously adopted. Therefore, by considering some of the behavioral aspects of decision-making and assisting infrastructure designers in creating outcomes that aligned with their values, the researchers were able to enhance the quality and consistency of the designer's decision-making based on the designer's own values – or at the very least the values of their clients. Thus, the further creation of behaviorally informed decision-making tools for strategically identified actors and contexts to maximize a targeted impact could increase the likelihood, like in the aforementioned studies, of meeting individual and societal objectives on issues such as climate change, inequality, and justice.

Identifying some of the driving and restraining behavioral forces that hinder or promote the resolution of society issues could be a first step in developing behaviorally informed decision-making supports for social decisions (e.g., climate change, inequality, and justice). Using such insights would allow for the creation of behaviorally informed decision-making contexts that would increase the likelihood that individual decision-making outcomes would align with personal values and achieve broader societal goals. For example, a recent study indicates that priming infrastructure designers with a future orientation, through a project description framed in terms of the future, led the designers to generate significantly more sustainable preliminary design concepts compared to the designers given a present-framed project description (Hancock et al., 2021). This research suggests that creating more behaviorally informed decision-making contexts, like with future framing to reduce present bias, can enhance the quality of an individual's long-term social decision-making. Thus, identifying contextually relevant and behaviorally informed decision-making supports is important to effectively aid specific actors to be more likely to opt for value-aligned actions on societal problems.

However, there may be more effective temporal interventions than framing alone. For instance, studies have shown that episodic future thinking, in which one imagines a potential future while still in the present, can minimize the influence of present bias on individual decision-making for individuals (Daniel et al., 2015; Dassen et al., 2016; Lee et al., 2020). Yet, to date, the volume of literature on the impact of episodic thinking on social decision-making is sparse. While it should be noted that several studies have explored and shown evidence of the impact that social distance can have on an individual's delay discount rate - where greater social distance leads to hyperbolically greater discounting (Rachlin & Jones, 2008). However, in this study, the impact of social distance on delay discount rates was not examined, therefore, the social distance the participants had to the decision scenarios was held constant. Instead, this study measured if engaging in either episodic future or past thinking before a social decision-making scenario is

effective in reducing present bias. In this case, a decrease in the monetary delay discounting, the degree to which an individual devalues a reward over time, was used to gauge a participant's reduction in present bias due to the intervention. Therefore, this research investigated whether thinking about episodic past or future events before participants made a hypothetical funding decision regarding their local flood infrastructure (i.e., a socially-relevant decision) would: **(1) significantly lower participant's delay discounting of the local flood infrastructure funding**; and (**2) impact on the participant's perceptions of social justice in relation to their decision-making**. We hypothesized: **(1) the delay discounting will be significantly lower if participants engage in episodic future thinking before making their funding decision as opposed to episodic past thinking**; and (**2) people's desire to act for social justice will significantly rise if they think about the future episodically as opposed to the past episodically**.

2. Methods.

This paper presents the data of an online experimental survey that explored the impact of episodic thinking on an individual's monetary delay discounting for decisions affecting others.

2.1. Study design.

The study was a between-subjects design where participants were randomly assigned to either an episodic future thinking or episodic past thinking experimental condition. The sample size of the study was calculated using the free to use software tool G*Power (Faul et al., 2007). To detect a difference in participant's delay discount rate across the experimental groups with an effect size of d = 0.35 with a statistical power of 0.95 (alpha = 0.01, two-tailed t-test), the study required a sample size target of 586 participants (293 participants per group). The area under the discount curve (AUC) was used to estimate participant's discount rate (Myerson et al., 2001). If participant's discounting responses were not normally distributed, it is often expected for delay discounting to be highly skewed; therefore, for non-parametric distributions, a Mann Whitney U test was used when testing for significant differences in AUC between the experimental groups at the different temporal delays and entirely. The parameters were selected in accordance with existing research on the impact that episodic future thinking has on an individual's delay discount rate (see Kovacs & Larson, 2008 for an in-depth overview).

Unlike the aforementioned work on individual delay discount rate, this research explored how episodic thinking impacts an individual's delay discount rate for a hypothetical decision scenario. This study design allows for the experimental measure of the participant's discount rate of socially relevant decisions. It is for this reason, and the fact that an individual's experience interacts with the intervention's impact that this study has more measurement sensitivity in comparison to tangential work in the literature where, in many cases, Cohen's d was found to be greater than 0.4 (see Daniel et al., 2015 for regulating children's dietary intake; O'Donnell et al., 2017 for goal orientated delay discounting; Stein et al., 2016 for reducing cigarette smoking). The primary dependent variable for this study is the social delay discount rate of the participants, which will be assessed based on their responses to an intertemporal choice task (where participants choose

between a smaller sooner and a series of larger later rewards). Figure 1 shows the experimental design of this presented work, with the hypothesized impact of the episodic thinking intervention overlayed.

	Episodic Thinking	
	Present	Future
Delay Discounting	+	-

Figure 1: **The study consisted of two experimental groups, with the temporal orientation, present or future, of the episodic thinking exercise being randomly assigned.**

2.2. Episodic thinking exercise.

If the participant consented to the study, they immediately began the survey starting with the episodic thinking exercise. The exercise was adapted from Dassen & Jansen's 2016 study on episodic thinking's impact on appetite (Dassen et al., 2016), but here the participant engaged in a socially-relevant future or past episodic thinking task rather than a food orientated task. The episodic future thinking prompt read as follows:

> Take a few moments to imagine an action that you want to do or conceivably could do within the **next six months**, however big or small, that would improve the lives of people in your community.
>
> Once you have clearly imagined this action in your mind, describe the action you plan to take in as many details as possible. Be sure to include what you would do, why would you do it, who would it help in your community and how they would benefit.

Participants in the episodic past thinking group followed a similar procedure. After consenting, they were first asked to recall a design relevant task they accomplished in the past month. To maintain consistency between groups, the prompt, which is shown in its entirety below, was kept as similar to the episodic future thinking prompt as possible through word-tense changes. The episodic past thinking prompt read as follows:

> Take a few moments to recall an action you took within the **last six months**, however big or small, that improved the lives of people in your community.
> Once you have clearly recalled this action in your mind, describe the action you took in as many details as possible. Such as: what you did, why you did it, who it helped in your community and how they benefited.

Several measurements pertaining to the episodic thinking exercise were also collected to see whether the intervention was effective. This included qualitative data gleaned from each participant's descriptions of the actions they have taken, past group, or would take, future group, to assist their community. It was expected that the description in the future group will occur in the future, while the description in the past group will have occurred in the past. The participants' temporal alignment with their assigned intervention was evaluated using a variety of quantitative measures, including the vividness of the action they either recalled or imagined during the episodic thinking exercise, the time perspective they adopted, and the emotional intensity of the memory or imagined action. Each of the nine items asked to participants were adapted from the Memory Experiences Questionnaire (MEQ) (Sutin & Robins, 2007) in a similar manner as the temporal future extension of the MEQ scale created by Grysman (Grysman et al., 2013). For each item, participants answered using a five-point Likert-type linear numeric response format that ranged from strongly disagree (1) to strongly agree (5). An example of what these questions looked like to the participant can be found in Figure 2 below and a full list of the questions can be found in Appendix A. For all the linear numeric response format scales, the participants selected values through a draggable slider, at increments of 0.1, that showed the participant their currently selected value. For each participant, the sum of each of these scales was taken, some were reverse scored, and used to create a composite score for vividness, time perspective and emotional intensity in relation to action created from the episodic thinking exercise. For the questions with linear numeric response format data, Mann Whitney U tests used to test for significant differences for these measures between the two experimental groups.

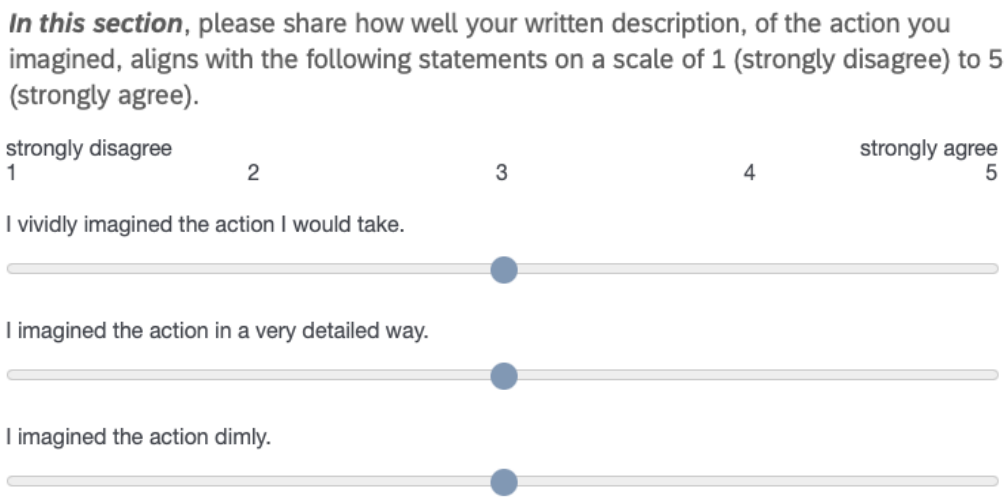

Figure 2: **Participants in the future group were asked the questions shown above to measure the vividness to which they imagined the future action they would take to help their community.**

2.3. Social monetary delay discounting scenario.

After the participant performed the episodic thinking exercise and self-assessed the attributes of actions they wrote about, participants were presented with a social decision scenario. The decision scenario provided participants with a shared context that allowed for the impact of the

episodic thinking exercise to be measured. The study materials provided the details of the decision scenario and were the same across study groups. This included the specifics of the role the participant would assume during the decision scenario. The prompt seen by participants was as follows:

> "**Instructions:** Imagine this scenario is taking place in the city that you currently live.
>
> Your city has received $500,000 to address existing flood vulnerabilities in the city through enhancements to stormwater infrastructure.
>
> One option is for the city to immediately spend the $500,000 on stormwater infrastructure.
>
> Alternatively, the city could invest the $500,000 and spend the available balance on stormwater infrastructure at some point in the future.
>
> The city will use flood vulnerability data to determine specific stormwater enhancements. This data driven approach will reduce the flood vulnerability for the city as a whole, but there is no guarantee that every citizen will see a reduction to their personal flood vulnerability.
>
> Since some of the options would occur in the future, while casting your vote for the following questions, please assume that you will not move away from your current city, even if that is unlikely to be true in reality."

Following instructions, the participants engaged in the Intertemporal Choice Task. In the task participants choose, over the course of ten questions between $500,000 today and ten alternatives ($495,000; $502,500; $521,000; $568,000; $686,000; $982,000; $1,720,000; $3,580,000; $8,260,000; $20,000,000) a set point in the future (1-day, 1 week, 1 month, 6 months, 1 year or 5 years). All participants answered each of the six matching lists, one for each of the six time points, and they were randomly presented based on the time points. Additionally, as done in Hardisty et al. 2013, the potential for ordering effects was reduced by randomly assigning participants in both the future and past groups into either a low to high or high to low sub-group for the matching Intertemporal Choice Task. Those participants in the low to high group would have their matching lists begin with $495,000 for all six time points. An example of the matching list (low to high order at the 1-month time point) can be found below:

> Imagine the stormwater infrastructure funding is available either **today** or in **one month**. With this in mind, for each of the following pairs, please select the option that you would vote for.
>
> ○ $500,000 or ○ $495,000 in one month

○ $500,000	or	○ $502,500 in one month
○ $500,000	or	○ $521,000 in one month
○ $500,000	or	○ $568,000 in one month
○ $500,000	or	○ $686,000 in one month
○ $500,000	or	○ $982,000 in one month
○ $500,000	or	○ $1,720,000 in one month
○ $500,000	or	○ $3,580,000 in one month
○ $500,000	or	○ $8,260,000 in one month
○ $500,000	or	○ $20,000,000 in one month

Several decision-making scenario measures will be collected to examine the scenario's potential impact on the outcome. First, the participant's sense of urgency, see Appendix B for more details, around the need for flood protections for themselves and others was measured. Next, the General Risk Propensity Scale (GRiPS), see Appendix C, was used to measure the individual risk tolerance of each participant to determine if risk tolerance influences the discount rate for social delay between the two groups (Zhang et al., 2019). Other measures, such as the participant's Judged Procedural Fairness, Trust, and Cooperation, see Appendix D, that corresponded to the scenario or its actors were collected (Earle & Siegrist, 2008). Lastly, the impact of episodic past and future thinking on individuals' conceptions of social justice, see Appendix E, was investigated using the Social Perceived Behavioral Control subscale of the Social Justice Scale (Torres-Harding et al., 2012). As with the Likert-type data from the episodic thinking exercise, Mann Whitney U tests used to test for significant differences for these measures between the two experimental groups.

2.4. Data collection.

Participants were recruited through the online survey pool Prolific. The Prolific platform provides a few benefits over other tools. Palan & Schitter observe that the Prolific platform provides a more transparent process for both researchers and participants regarding rules and expectations and has been shown to provide higher quality responses for online research when compared to the commonly used MTurk platform (Palan & Schitter, 2018).

The study listing provided the potential participant with background information on the study along with a link to the online study. Upon clicking the link, the potential participant was presented with the experiment consent form. If the participant consented, they were randomly assigned to one of the two experimental groups and immediately began the survey. After completing the full survey, participants were asked to confirm they consented to the use of their data in the study. Upon completion of the study the participants were paid $2.78. All payments were handled by

Prolific through their payment platform. As the median completion time of the study was 14 minutes at 58 seconds, the average rate per hour paid to participants was $11.14.

2.5. Data analysis.

A total of 802 participants started the study. Of that number, 219 participants dropped out before finishing the survey, and 8 participants did not consent to have their data included in that analysis sample. All the data from these participants were excluded from the analysis, leaving 575 participants' data utilized for analysis. Thus, in relation to the total number of participants that started the survey, the completion percentage for this study was 72%.

Some of the incomplete responses (n = 11) were due to the participant's "timing-out". Prolific sets a maximum time for participants based on the estimated study completion time that is entered by the researcher. In this study an estimated study completion time of 13 minutes was provided to Prolific and, as such, participants were given a maximum of 52 minutes to complete their survey response.

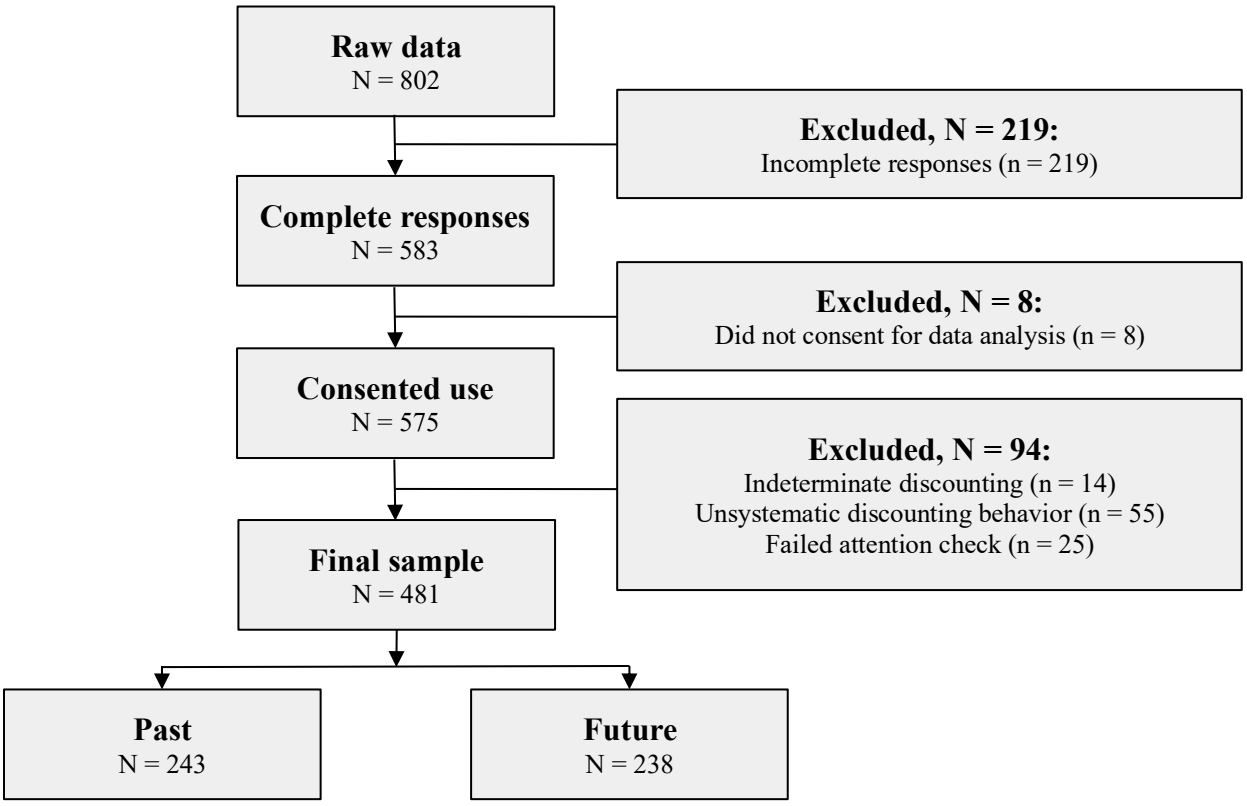

Figure 3: **Shows the breakdown of the raw data, completed responses and final sample. The majority of excluded data (61%) was due to participants who completed less than 15% of the survey.**

2.6. Data cleaning.

The discounting data of the 575 remaining participants was cleaned by: removing indeterminate discounting, failed attention checks and testing for systematicity (Johnson & Bickel, 2008). The Johnson & Bickel algorithm found that 75% of participants, or 398 out of 530,

exhibited discounting behaviors that were systematic. With that said, utilizing the Johnson & Bickel algorithm excluded 7 participants for exhibiting a preference reversal to the smaller immediate reward from the larger later reward at longer delays. Preference reversals were included into the sample, because, at the longer time delays, factoring in the size of the reward, it is not unreasonable for some participants to decide it is no longer worth waiting in the context of the presented infrastructure decision scenario. For this reason, a modified nonsystematic checking algorithm was used with variable inclusion criteria for the needs of this study (Green & Lawyer, 2014; Stoltman et al., 2015). Yet, unlike Stoltman, a mean value of the two adjacent indifference points was not used to replace participants, that had a single criterion 1 violation (n = 88). Instead, that datum was used without modification. As such the nonsystematic discounting criterion used within this study was as follows:

- Criterion 1: No indifference point should be 20% greater, in terms of the relative present value of the immediate reward, than the preceding indifference point
- Criterion 2: The last indifference point should be at least 10% greater than the relative present value of the immediate reward

Thus, the modifications to the Johnson & Bickel algorithm resulted in a reduced exclusion of participants, to where only fifty-five participants were excluded for exhibiting unsystematic discounting behaviors throughout the decision scenario.

Lastly, an attention check was included in the delay discounting exercise, as seen in other research (Hardisty et al., 2013), to verify the participant was actively engaged in the discounting task. The attention check took the form of a smaller later value of $495,000 that was present in each of the temporal delays. If a participant selected this value, thereby indicating they would prefer less money in the future rather than more money now, they were excluded from the analysis. Twenty-five participants were excluded for failing this attention check by picking the smaller later value of $495,000. Thus, 481 out of 575 participants (84%) were included in the final sample, of this number, 243 participants were in the past group and 238 participants were in the future group. A breakdown of the complete data cleaning process can be found in Figure 3 above.

2.7. Demographic breakdown.

This research seeks to understand how, in general, the public is impacted by engaging in various types of episodic thinking before making socially relevant decisions; thus, a representative sample of the USA was chosen. To meet the representative sample target, options within the Prolific platform were enabled that ensured that a representative sample was collected (see Table 1 below that compares the collected percentages during the Prolific sampling to the U.S. demographic makeup as measured by the 20202 U.S. Census). It should be noted that some of the Prolific categories did not match up one-to-one with the U.S. Census categories, but once a comparable set of categories was found, see the notes below Table 1 for more specifics, Prolific provided a close match to the U.S. Census categories, aside from the oversampling: of the 55-64 age cohort, white participants and under sampling of the 65+ age cohort.

Table 1: **Demographic breakdown of the survey sample compared to the 2020 U.S. Census.**

Variable	Item	Frequency	Percentage	2020 U.S. Census
Gender[1]	Female	248	51.6%	50.5%
	Male	233	48.4%	49.5%
Age[2]	18-24	57	8.9%	9.3%
	25-34	101	15.8%	13.9%
	35-44	70	10.9%	12.6%
	45-54	80	12.5%	12.3%
	55-64	108	16.9%	12.7%
	65+	65	10.2%	16.0%
Ethnicity	Asian	25	5.2%	6.1%
	Black	55	11.4%	13.6%
	Mixed[3]	10	2.1%	2.9%
	Other[4]	6	1.2%	1.6%
	White	385	80.0%	75.8%

Note:

[1]Prolific and the US Census did not include questions about gender, sexual orientation, or sex at birth.

[2]Prolific age percentages were adjusted by the proportion, 77.6% from US Census data, 18 years of age and older.

[3]The Census category of Two or More Races was compared to the Prolific category of Mixed.

[4]The Census categories of American Indian and Alaska Native and Native Hawaiian alone and Other Pacific Islander alone were compared to the Prolific category of Other.

2.8. Delay discount calculation.

After the individual completed the exercise in episodic thinking, monetary choice matching was used to determine the social delay discounting. In the intertemporal choice task, participants choose between monetary values: a $500,000 today versus ten alternatives ($495,000; $502,500; $521,000; $568,000; $686,000; $982,000; $1,720,000; $3,580,000; $8,260,000; $20,000,000). Each of these ten monetary alternatives were tested against the present choice of $500,000 across six different future time intervals (i.e. 1 day, 1 week, 1 month, 6 months, 1 year or 5 years). At each temporal point, an interference point was calculated for each participant. The interference point is an estimate for the value in which the participant's preference shifted from the immediate to the delayed reward. Using the interference points, the participant's discount factor was estimated by calculating the area under an individual participant's discount curve. Thus, to find the total AUC (Myerson et al., 2001), the area of the trapezoid formed between each temporal delay was calculated using the following formula:

$$AUC_{delay_1} = (x_2 - x_1)\left(\frac{y_2 + y_1}{2}\right)$$

where x_1 is the delay (in days) at time one, x_2 is the delay (in days) at time two, y_1 is the subjective value of the reward at time one, and y_2 is the subjective value of the reward at time two. The summation of each AUC_{delay} value will produce a participant's total AUC. The higher their AUC, the less an individual discounts a reward over time. In addition, to account for the "pseudoexponential" increase between six successive temporal delays used in this study, an ordinal transformation was made to the delay values, allowing the different delays to contribute to the calculated delay discount rate more equally (Borges, A. M. et al., 2016). All delay discount calculations were performed in RStudio 2022.07.2 Build 576.

2.9. Qualitative data.

To better understand any decision-making differences between the experimental groups, participant's responses to episodic thinking exercise as well as their explanation of their discounting behavior were qualitatively analyzed. This was accomplished through two steps: 1) a word frequency analysis and 2) a word sentiment analysis. The word frequency analysis was accomplished using text mining using the tm_map function from the tm package in RStudio. The frequency analysis generated a list of the most used words, by each experimental group, for each of the qualitative questions, thus allowing for examination of differences between the groups. In addition, a sentiment analysis was performed using the get_sentiment function from the syuzhet package in RStudio 2022.07.2 (Build 576). Like the word frequency analysis the sentiment analysis allowed for differences in qualitative response sentiment to be quantified between the future and past experimental groups.

3. Results.

The results portray data collected: 1) before the participants interacted with the intervention and 2) after they interacted with the intervention. First, quantitative data is shared on any differences between the groups on *vividness*, *time perspective,* and *emotional intensity* (before the intervention); followed by *urgency for action* and *discount rate* (after the intervention). Next, the qualitative data is analyzed on participant's *episodic thinking responses* (the intervention) and *discounting rational* (after the intervention).

3.1. Vividness.

After completing the written description of their memory or imagined action for their community, participants were asked to rate how vivid their experience was. This was accomplished through a three-question scale on vividness that was adapted from the Memory Experiences Questionnaire (Grysman et al., 2013; Sutin & Robins, 2007). Analysis of the composite score of the scale (Table 2) yielded no significant difference between the future and past episodic thinking groups. With that said, a significant difference was measured between the groups when they were asked to respond (1 - strongly disagree to 5 - strongly agree) to: "I imagined the action dimly"

(future group) or "My memory for this action is dim" (past group). Here, where a higher score indicates a lower perceived vividness, participants in the future group rated the vividness of their envisioning (M = 1.87, SD = 1.02) at a significantly lower value compared to the past group's vividness (M = 1.56, SD = 0.8).

Table 2: **Mann Whitney U test comparing vividness between the future and past groups.**

Dependent Variable	*U*	*p*
Vividness Composite	26069	0.06
Vividness Question 3	34176	**< .001**

3.2. Time perspective.

Time perspective measures the degree to which a participant was orientated to either the future or the past. It was expected that participants would take on a time perspective aligned with the designated episodic thinking orientation given within their assigned experimental group (i.e., engaging in future episodic thinking would result in a future time perspective). The full list of the questions asked to participants regarding their Time Perspective can be found in Appendix A. The results show that both participants in the Future (M = 3.38) and Past (M = 3.85) groups were past the midpoint of the scale (see Figure 4 below) and thus somewhat agreed that they could imagine or recall the action temporally.

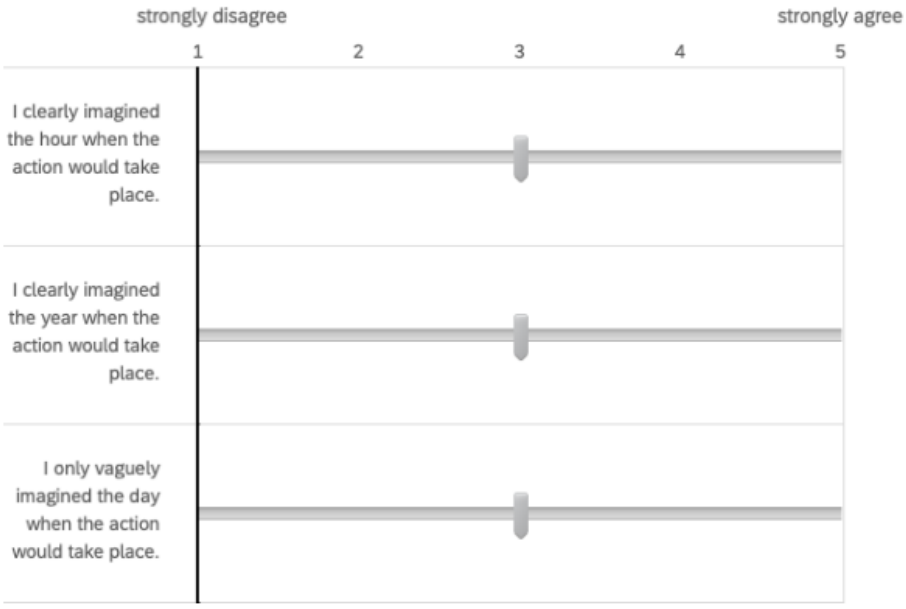

Figure 4: **Time perspective questions asked to participants in the future group.**

Yet, participants in the past group were significantly more likely to indicate they could clearly place themselves in their memory of their recalled action compared to those in the future group. As a result, the 243 participants in the past group (M = 3.85, SD = 0.79) compared to the 238 participants in the future group (M = 3.38, SD = 0.83) had a significantly higher time perspective

in relation to action they recalled during the episodic task, (U = 19513, p < .001). (See Table 3 below for further statistical data and Appendix A for the full list of questions answered by participants).

Table 3: **Mann Whitney U test comparing Time Perspective between the future and past groups.**

Dependent Variable	*U*	*p*
Time Perspective	19513	**< .001**

3.3. Emotional intensity.

The participants in the group assigned to think about their future plans reported experiencing significantly more emotions than the group assigned to recall their past actions. The full list of the questions that participants were asked regarding their Emotional Intensity can be found in Appendix A. The participants in the future group (M = 3.45, SD = 1.11) compared to the participants in the past group (M = 3.20, SD = 1.19) had a significantly higher emotional intensity in relation to an action they recalled or imagined during the episodic task, (U = 32382, p = .023). (See Table 4 below for further statistical data and Appendix A for the full list of questions answered by participants).

Table 4: **Mann Whitney U test comparing Emotional Intensity between the future and past groups.**

Dependent Variable	*U*	*p*
Emotional Intensity	32382	**0.023**

3.4. Urgency.

After the intervention, participants were asked to indicate the urgency of need they felt for themselves and others for enhanced stormwater infrastructure in their community (see Figure 5 below). This was indicated on a 5-point linear numeric response format that ranged from 1 - Not at all urgent to 5 - Very urgent.

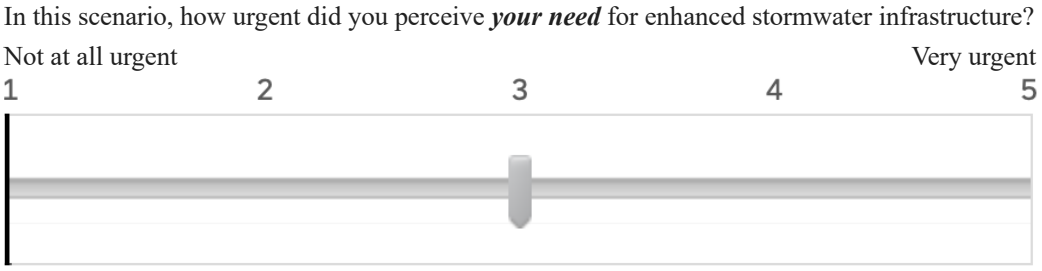

Figure 5: **After the intervention, participants were asked to indicate the urgency of need they felt for themselves and others for enhanced stormwater infrastructure.**

When it came to the urgency for self or others, there was no significant difference found between the past or future groups. See Table 5 below for statistical data and Appendix B for the full list of questions answered by participants.

Table 5: **Mann Whitney U test comparing Urgency, others and self, for enhanced stormwater infrastructure between the future and past group.**

Dependent Variable	*U*	*p*
Urgency for Others	28756	0.92
Urgency for Self	25954	0.051

3.5. Delay discount rate – AUC_{ord}.

The area under the discount curve (AUC) analysis was used to estimate each participant's delay discount rate in the investment decisions they made regarding the flood infrastructure under consideration in their community. A Mann Whitney U test was used to test for a significant difference at various delays and for AUC_{ord} values across the future and past episodic thinking groups, no significant difference in delay discount rate was found. Since multiple comparisons were made, the resultant p-values were adjusted using the p.adjust function in RStudio using the holm method (Holm, 1979). The results of this analysis can be found in Table 6 below.

Table 6: **Mann Whitney U test comparing AUCord between the future and past groups.**

Dependent Variable	*U*	*p (adjusted)*
AUC_{1d}	29060	1.00
AUC_{1w}	30450	1.00
AUC_{1m}	31493	0.61
AUC_{6m}	29178	1.00
AUC_{1y}	29738	1.00
AUC_{5y}	28658	1.00
AUC_{ord}	29412	1.00

3.6. GRiPS.

No significant difference was found between the future and past episodic thinking groups in terms of their risk tendencies (Table 7).

Table 7: **Mann Whitney U test comparing GRiPS between the future and past groups.**

Dependent Variable	*U*	*p*
GRiPS	41720	0.84

3.7. Judged Procedural Fairness, Trust, and Cooperation.

No significant difference was found between the future and past episodic thinking groups in terms of their perceived fairness of the funding process or their trust in or cooperation with those organizing it (Table 8).

Table 8: **Mann Whitney U test comparing the judged procedural fairness, trust, and cooperation around the proposed infrastructure between the future and past groups.**

Dependent Variable	*U*	*p*
Judged Procedural Fairness	41721	0.84
Trust	42269	0.64
Cooperation	38804	0.20

3.8. Social justice.

Participants answered the five-item, seven-point (1-disagree strongly to 7-strongly agree) Social Justice Perceived Behavioral Control (SJPBC) sub-scale of the larger Social Justice Scale (SJS). No significant difference in the SJPBC score was found between the future (M = 5.27, SD = 1.15) and past (M = 5.26, SD = 1.02) episodic thinking groups utilizing a Mann Whitney U test. The results of this analysis can be found in Table 9 below and the full list of questions can be found in Appendix E.

Table 9: **Mann Whitney U test results comparing SJPBC between the future and past groups.**

Dependent Variable	*U*	*p*
SJPBC	29518	0.69

3.9. Qualitative findings.

Two main streams of qualitative data were collected in this study: 1) participant descriptions of the actions that they either planned to take (future group) or had taken (past group) that would/had benefit their community; 2) participant explanations of their rationale behind the financial decisions they made regarding the flood infrastructure plan. In the first set of qualitative findings, participants' words formed the word corpus of the study (one for the future group and one for the past group). To perform text mining more easily on the data: special characters, chaptalization, numbers, stop words, punctuation and white spaces were all removed. At this point text stemming, which removes the suffixes of words to only have the root of the word remain, was performed on the future and past word corpora. A breakdown of word frequency in these responses can be found in Table 10 for future and past actions. For both groups, the top three most common words (help, comuniti, peopl) were the same with a different ordering. Words four and five on the list were different between the two lists, with participants in the future group using descriptive words (need and will) compared to the past group (food and donat) using action words. It should

be noted that a number of these words showed up in the instruction prompt given to the participants for the envisioning task (help, peopl, communiti) and the discounting task (will).

Table 10: **Participant's top five most frequently used words when describing actions to benefit their community.**

Dependent Variable	Temporal Frame	*word*	*freq*
Socially Beneficial Action	Future	help	251
		peopl	227
		communiti	212
		need	112
		will	107
	Past	help	249
		communiti	180
		peopl	131
		food	90
		donat	90

The next set of qualitative findings are from participant responses to how they decided on the funding choices they made regarding the flood infrastructure in their community. As with the past or future action responses, participant data was analyzed for word choice frequency. The results of that analysis can be found below in Table 11 for the future and past groups. The results show that the top five most common words were the same for both the future and past groups (wait, money, time, amount, fund). In addition, the frequency of their use was also consistent in each of the two experimental groups. It should be noted that one of the words (time) was used in the wording for one of the emotional intensity questions given to the participants.

Table 11: **Participant's top five most frequently used words when describing their flood infrastructure funding choices.**

Dependent Variable	Temporal Frame	*word*	*freq*
Funding Rational	Future	wait	210
		money	176
		time	172
		amount	152
		fund	106
	Past	wait	236
		time	184
		money	177
		amount	155
		fund	102

To gain a deeper understanding of the mindsets of the participants before and after the intervention, a sentiment analysis was performed on the same written responses that were analyzed through word choice frequency, as shown above Tables 10 and 11. The results of this analysis can be found in Figure 6 below. The Figure shows that a positive sentiment was expressed in the responses to the action (after intervention) and funding (after experimental measure) questions. With that said, the total number of instances of positive sentiment expressed was higher in the action statement than was observed in the funding statements.

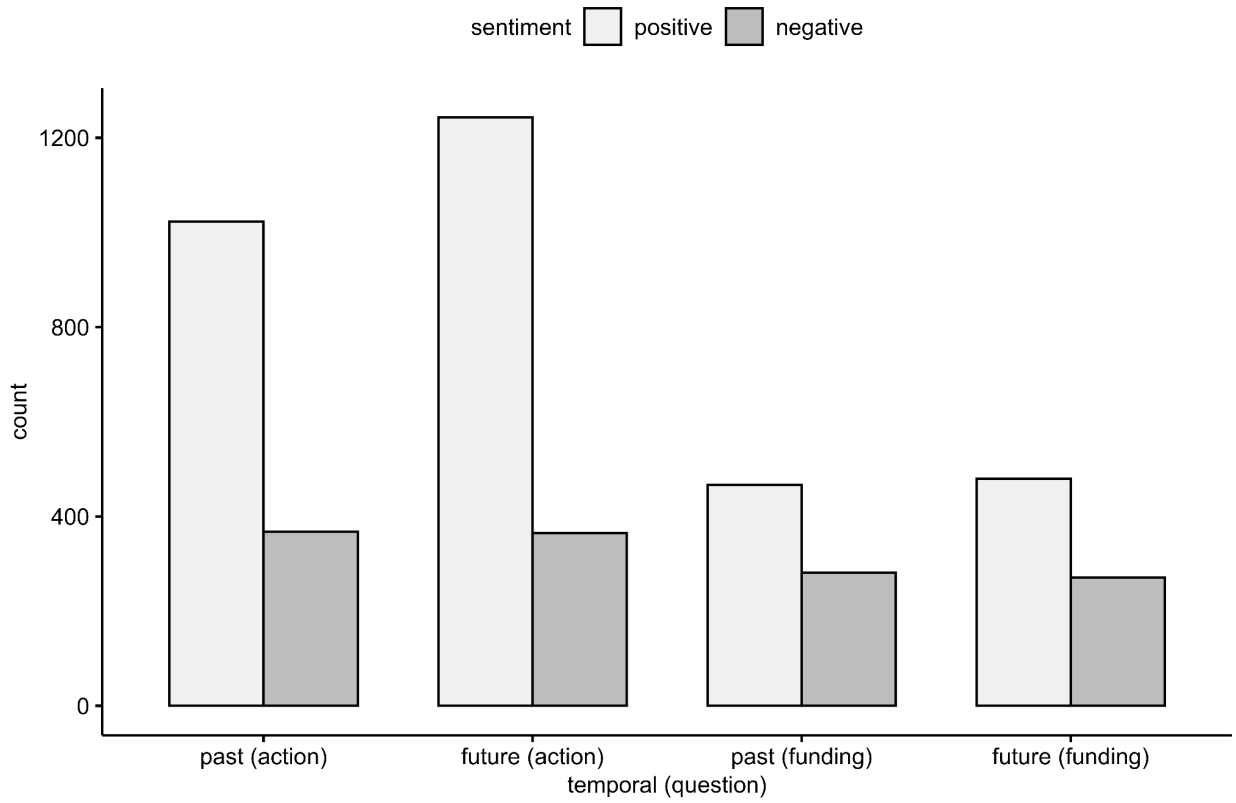

Figure 6: **Shows the count of positive and negative sentiment words used by participants in their descriptions of actions that would benefit their community, as well as when describing their flood infrastructure funding choices.**

4. Discussion.

Individuals are faced with decisions with outcomes that might not directly benefit them but, depending on their choices, could aid or harm others. In this paper, the impact of episodic future and past thinking on an individual's social delay discount rate was explored. The study sought to shed light on whether engaging in episodic future thinking, rather than past thinking, would significantly reduce an individual's delay discount rate when making socially relevant decisions. An example of a socially relevant decision could be, as was used in this study, funding for improvements to flood infrastructure in your community, which can be contrasted with a more individually relevant decision like setting personal investment amounts for retirement savings. In order to further explore the dynamics behind socially-relevant decision making, the study made use of an online experimental survey. In the survey, participants either engaged in episodic past thinking or a future thinking exercise. Then, participants were asked to choose how they would like their local flood infrastructure to be funded. The participants' social delay discount rate for the flood infrastructure funding was estimated based on the choices they made in the decision scenario. An analysis of this data was performed to see if engaging in episodic past or future thinking elicited significant differences in participants' delay discount rate. While we did not find an effect on delay discount rate, several other interesting and significant findings were observed. This section will

discuss these findings in relation to the corresponding research questions and hypotheses. The section will conclude with lessons learned and recommendations for future research.

4.1. Research question one: significantly lower the discount rate used in a social decision.

No evidence was found to support hypothesis one (see Table 5) that engaging in episodic future thinking, compared to past thinking, significantly lowers an individual's delay discount rate for socially relevant decision-making. With that said, there were a few significant differences between the future and past experimental groups that might provide some rationale for the null result. Significant differences were found between the two experimental groups in their self-ratings for the *vividness*, *emotional intensity* and *time perspective* experienced in the episodic thinking exercise. Participants in the future group imagined the action they would take during the episodic thinking exercise with a significantly greater emotional intensity, but with a significantly lower time perspective and vividness than the participants in the future group. In other words, the participants in the past group were able to more clearly experience (vividness) and temporally place (time perspective) themselves in the action they were recalling than those in the future group, yet the experience was less emotional (emotional intensity). This is important because some research suggests that there is a link between an increased future time perspective and emotional valence in reducing delay discounting (Lin & Epstein, 2014). In addition, sentiment analysis in participant responses show that the use of positive sentiment words decreased in both experimental groups from the episodic thinking to the delay discounting exercise, possibly indicating further questions about the impact of the intervention on participant's delay discount rate. As such, the secondary findings of this study, coupled with the existing literature on episodic thinking, suggest that the intervention from this study might not have provided a strong enough episodic thinking exercise to generate a significant difference between the past and future experimental groups.

The lack of a main effect conflicts with the literature on the demonstrated impact of episodic future thinking on reducing an individual's delay discount rate for personally relevant decisions. This has been shown in several different studies (Berry et al., 2017; Daniel et al., 2015; Green & Lawyer, 2014; Peters & Büchel, 2010) in a wide range of different contexts (i.e., climate action, finance, food consumption and addiction studies). Considering the literature on episodic future thinking on individual delay discounting, the results of this study on social delay discounting raises several questions. In particular, the challenge of how to ask individuals to think about and engage in socially relevant decisions might be more difficult than priming individual's to choose between options that solely benefitted them. Additionally, individuals are, at times, faced with socially relevant decisions in different or more complex contexts than alternative individually relevant decisions. As such, a few elements of the study presented in this paper might have contributed to the null result:

- The size of the monetary amount ($500,000) participants were deciding on
- The project (local flood infrastructure) that was the focus of the decision scenario
- A lack of perceived ramifications for a project delay by study participants (i.e., the required infrastructure changes will happen sooner or later)

- Current events taking place during data collection (i.e., global pandemic and rising inflation)

Future work that further isolates these complexities of social decision-making might provide clarity on if engaging episodic future thinking can reduce the monetary delay discounting individuals use in socially relevant decision-making.

4.2. Research question two: significantly impact perceptions of social justice.

The second research question from this study examined if engaging in episodic future thinking, versus past thinking, significantly increases people's desire to act for social justice. This question explored if having individuals imagine their possible future actions, versus their past actions, made individuals perceive they had more decision-making control to generate socially just outcomes. Participant's perceptions of social justice were measured using the perceived behavioral control subscale of the social justice scale (Torres-Harding et al., 2012). The results did not support the hypothesis that engaging in episodic future thinking before a socially relevant decision significantly impacted individual's perceptions of social justice. Since participants in both the future and past groups expressed the had a high level of perceived behavioral control surrounding social justice (see section 3.8.), further research is recommended to gain a more sophisticated understanding of the relationship, if it exists at all, between individual perceptions of social justice and discounting behavior. When creating space for people to think about the future and what benefits it could contain, a mixed methods approach that includes the use of interviews would help increase our understanding of social justice intertemporally (how lived experience changes people's past and future thinking).

Adding the lens of social justice to engineering decision making is critical to understanding the complex intersection of identity, power, and influence that is inherent to various contexts engineers design within. As such, engineering as social justice allows for engineers to seek out the requirements for designs that meet the specific needs of people within a particular domain. Take, for example, the flood infrastructure funding that was used in this study, where research has shown that flood risk can disproportionately impact socially-vulnerable groups both directly and indirectly (Collins et al., 2018). In this research, Collins shows that the risk dynamics around flood risk are different for socially-vulnerable groups in cities like Miami and Houston. In Houston, due to the presence of oil and gas infrastructure on the coast, socially-vulnerable groups are directly affected by coastal flood, whereas in Miami it is the socially-privileged that are directly affected by coastal flooding. Due to the differing histories of these cities, responses to their coastal flooding that are both effective and socially just are likely to require different interventions. Thus, work, like which was presented here, begins to scratch the surface on a new generation of engineering decision-making tools that support the effective creation of contextually tailored solutions to socially relevant problems by moving beyond traditional individual focused approaches.

4.3. Future work.

The significantly higher levels for emotional intensity (future group) as well as time perspective and vividness (past group) provide compelling insights into the limitations of the study presented here and potentially shed light on possible mechanisms for how future and past thinking influence the decision-making of individuals in different ways. Future work could explore how to change the episodic thinking intervention to reduce the gaps in emotional intensity, time perspective and vividness between the experimental groups. If a future study can eliminate these variations between the experimental groups or explain that these differences are due to engaging to the episodic thinking exercise, it will allow for greater insight into the impacts of future episodic thinking, compared to episodic past thinking, on an individual's social delay discount rate.

We recommend that the episodic thinking exercise be strengthened in intensity (i.e., longer prompt, pictures, videos or virtual reality) and duration (i.e. require participants to spend more time with the episodic thinking exercise). In addition, we recommend that future work test out smaller monetary scales in the decision scenario (i.e., $500,000 for flood infrastructure) in the case the large monetary size that was used in this study overwhelmed the potential impact to delay discounting from engaging in episodic future thinking.

It is recommended that follow-up work measures the social distance perceived by participants in the decision scenario, to better understand if perceived social distance impacts the effect of episodic thinking. Research shows that social distance can impact an individual's delay discount rate - where greater social distance leads to hyperbolically greater discounting (Rachlin & Jones, 2008). With that said, some research has shown evidence that episodic thinking can reduce social distance in psychological distance scenarios (Yi et al., 2016). Thus, measuring participants perceived social distance could provide valuable insights on how to improve outcomes for social decision-making.

It was felt that the survey instrument used to measure individual delay discount rate constricted the creation of decision-making scenarios that accurately depict social decision-making. It should be noted that while other tools were explored for use in this study, (see Stein et al., 2017; Yoon & Chapman, 2016) user testing raised concerns for participant confusion. So, we encourage future researchers to explore how to move beyond older tools for measuring delay discount rate towards more accurate and newer ways while still being accessible to the participant. In order to understand how people interact with the delay discount measurement tool and the decision scenario it will be necessary to collect more qualitative data. Such qualitative data would help validate that the data being measured is the data desired (i.e., ensuring participants are not confused by the intervention or experiment).

5. Conclusion.

Many decisions we make individually can contribute to socially relevant issues like climate change impacts, social inequality, and other forms of injustice. Nevertheless, much of the decision-

making literature to date has focused on the individual making decisions for themselves. For this reason, this study sought to explore ways to improve individual decision-making in socially impactful contexts. Episodic thinking, or the degree to which an individual vividly recalls previous experiences (past thinking) or imagines yet to be possibilities (future thinking) was used to reduce participants' delay discount rate before making a socially relevant decision regarding the funding of stormwater infrastructure in their community. While engaging in future episodic thinking was not found to be significantly more effective than past thinking in lowering an individual's social delay discount rate, secondary findings present a pathway to future work. In particular, our results demonstrate: **(1) Time Perspective**: While engaging in the episodic thinking exercise, participants in the past group were significantly more likely to precisely place themselves in the memory they shared than the future group was for their planned action to benefit their community; **(2) Emotional Intensity**: Participants in the future group found that reflecting on their future plans to be significantly more emotional than the past group did and **(3) Vividness:** participants in the future group rated the vividness of their envisioning at a significantly lower value compared to those in the past group. Moving forward, the insights generated from this research provide opportunities for future work to enhance existing tools and generate new ones to effectively inform socially relevant decision making. Such understandings will be vital to generating outcomes for present and future societal challenges in ways that justly fulfill the needs of all people.

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Appendix A. Memory Experiences Questionnaire.

9 items adapted from the Memory Experiences Questionnaire (Sutin & Robins, 2007) in a similar manner to (Grysman et al., 2013). Each of the items below were answered by participants using a five-point linear numeric response format that ranged from strongly disagree (1) to strongly agree (5).

(R = Reverse-scored item)

Vividness

Future

- I vividly imagined the action I would take.
- I imagined the action in a very detailed way.
- I imagined the action dimly. (R)

Past

- My memory for this action is very vivid.
- My memory for this action is very detailed.
- My memory for this action is dim. (R)

Emotional Intensity

Future

- Imagining taking this action invoked powerful emotions.
- My emotions are very intense concerning the possibility I would take this action.
- I do not expect I would have particularly strong emotions while performing this action. (R)

Past

- The memory of this action evokes powerful emotions.
- My emotions are very intense concerning this action.
- I do not remember having particularly strong emotions at the time of this action. (R)

Time Perspective

Future

- I clearly imagined the hour when the action would take place.
- I clearly imagined the year when the action would take place.
- I only vaguely imagined the day when the action would take place. (R)

Past

- My memory for the hour when the action took place is clear.
- My memory for the year when the action took place is clear.
- My memory for the day when the action took place is vague. (R)

Appendix B. Urgency.

Each of the items below were answered by participants using a five-point linear numeric response format that ranged from not at all urgent (1) to very urgent (5).

In this scenario, how urgent did you perceive **your need** for enhanced stormwater infrastructure?

In this scenario, how urgent did you perceive **other people's need** for enhanced stormwater infrastructure?

Appendix C. GRiPS Risk Scale (Zhang et al., 2019).

Each of the items below were answered by participants using a five-point linear numeric response format that ranged from not at all urgent (1) to very urgent (5).

GRiPS Risk Scale

- Taking risks makes life more fun.
- My friends would say that I'm a risk taker.
- I enjoy taking risks in most aspects of my life.
- I would take a risk even if it meant I might get hurt.
- Taking risks is an important part of my life.
- I commonly make risky decisions.
- I am a believer of taking chances.
- I am attracted, rather than scared, by risk.

Appendix D. Judged Procedural Fairness, Trust and Cooperation (Earle & Siegrist, 2008).

The following section covers the questions adapted from Earle & Siegrist. The questions for the three scales were slightly modified in order to be applicable to the decision scenario. Each of the items below were answered by participants using a five-point linear numeric response format that ranged from (1) to (5). (R = Reverse-scored item)

Judged Procedural Fairness

- Was the process used by the city to determine your preferences for stormwater infrastructure funding, unbiased or biased? (unbiased to biased)
- Was the process used by the city to determine your preferences for stormwater infrastructure funding, balanced or slanted? (balanced to slanted)
- Was the process used by the city to determine your preferences for stormwater infrastructure funding, even-handed or one-sided? (even-handed to one-sided)
- Was the process used by the city to determine your preferences for stormwater infrastructure funding, fair or unfair? (fair to unfair)

Trust (disagree entirely to agree entirely)

- My city's decision makers are too busy looking out for selfish interests to be helpful in dealing with local flooding issues. (R)
- I couldn't trust my city's decision makers to manage local flooding issues. (R)
- In working on the issue of local flooding, my city's decision makers can be counted on to do the right thing.
- In working on this issue of local flooding, my city's decision makers will make a good-faith effort to treat everyone even-handedly.

Cooperation (disagree entirely to agree entirely)

- I would support the efforts of my city's decision makers on local flooding issues in any way I can.
- If we are ever going to make progress in dealing with local flooding issues, it will be through the efforts of my city's decision makers and others like them. I support their efforts.
- It's about time that some people who know what they're doing—such as my city's decision makers and others like them—tried to do something constructive about local flooding issues. I'm with them all the way!

Appendix E. Social Justice Scale (Torres-Harding et al., 2012).

Each of the items below were answered by participants using a seven-point linear numeric response format that ranged from (1) disagree strongly to (7) strongly agree.

Social Justice Perceived Behavioral Control

- I am confident that I can have a positive impact on others' lives.
- I am certain that I possess an ability to work with individuals and groups in ways that are empowering.
- If I choose to do so, I am capable of influencing others to promote fairness and equality.
- I feel confident in my ability to talk to others about social injustices and the impact of social conditions on health and well-being.
- I am certain that if I try, I can have a positive impact on my community.

Chapter 4. Implications.

The aim of this dissertation was to investigate how different temporal perspectives could affect the quality of decisions made by individuals. This was explored in two distinct decision-scenario contexts: 1) examining the impact of temporal framing on the quality of sustainable design concepts generated by infrastructure designers and 2) assessing the impact of episodic future thinking on an individual's delay discount rate for a socially-relevant infrastructure project in their city. This section of the dissertation will discuss the implications of the research for each project in terms of their intellectual merit and broader impacts. The section will conclude with brief recommendations for future extensions of this work.

1. Temporal Framing.

1.1. Intellectual Merit.

The research presented in Chapter 2 on temporal framing, found that framing a design decision-scenario in terms of the future leads to significantly more sustainable infrastructure design concepts being generated by designers, compared to framing in the present. Designers in the future group aimed for significantly longer targets for the design life, useful life to the community, and maximum acceptable return on investment period compared to those in the past group. These findings support and expand upon existing research that highlights how the quality of designer decision-making can be improved through carefully considered and behaviorally-informed decision supports. As a result, this research offers an effective and cost-efficient intervention (through word tense changes to a Request for Proposals document) that can help designers generate more sustainable design choices.

1.2. Broader Impacts.

According to the broader impacts criteria set by NSF, this research project generated impacts through societal well-being (via the enhanced achievement of sustainability metrics), public engagement (via written reports and presentations) and partnerships (via the collaborative research relationship with the Institute for Sustainable Infrastructure). If the results of this study are found to be generalizable, enhancing project documents (using future framing) could motivate designers to generate more sustainable design concepts, leading to enhanced societal outcomes along various metrics of sustainability. Public engagement included the publication of a paper titled "Framing to reduce present bias in infrastructure design intentions" in the journal iScience, which is also Chapter 2 of this dissertation. The publication in iScience allowed for the wide dissemination of the findings to an interdisciplinary audience. Additionally, versions of this work were presented at several venues, including two events at the Behavior Energy and Climate Change (BECC) 2020 conference. In the first event, I was invited to participate as a panelist for a session titled "Future Framing: Considering the Future Today for Tomorrow." Alongside experts in the fields of

Behavioral Science and Architecture, we discussed potential positive societal outcomes using future framing. In the second event, I gave an oral presentation entitled "Effects of future-framing on design for more sustainable infrastructure," which provided an overview of the preliminary research findings.

2. Episodic Thinking.

2.1. Intellectual Merit.

This study did not find a significant difference in effectiveness between engaging in future episodic thinking and past thinking to lower an individual's social delay discount rate. However, we did find that participants in the future group experienced more *emotional intensity* when reflecting on their future plans than those in the past group. Additionally, participants in the past group were significantly better at *temporally* placing themselves in a recalled past action (that benefited their community) than those in the future group. Furthermore, participants in the future group rated the *vividness* of their envisioned action significantly lower than those in the past group. These results contribute to our understanding of how episodic future thinking can be utilized to reduce present bias in individuals making socially-relevant decisions.

2.2. Broader Impacts.

To meet the NSF's broader impacts criteria, this research project aimed to engage the public through various channels. The dissemination of this dissertation document marks the first step in sharing the research findings. Additionally, the work will be submitted to an academic journal and conference. By engaging with the public through these mediums, the goal is to encourage discussion, debate and further exploration into how episodic thinking can be used to enhance societal decision-making.

3. Future work.

The findings presented in this dissertation offer promising opportunities for further research. For example, the impact of the temporal framing intervention presented in Chapter 2 could be tested in various design contexts (e.g., product design, system engineering or architecture) to examine the extent to which it can influence design decision-making. Additionally, the effectiveness of the intervention itself could be further studied to identify ways to enhance its impact.

Furthermore, the episodic thinking research presented in Chapter 3 provides another avenue for future work. Specifically, research could focus on developing an episodic future thinking exercise that eliminates the significant differences (i.e., the vividness of imagined/recalled action between the past and future groups). These changes could result in an intervention capable of

generating a significant difference between the future and past groups in the delay discount rate participants use in the socially-relevant decision scenario.

Lastly, understanding effective ways to motivate decision-makers towards sustainable and socially beneficial outcomes will have broader impacts beyond the intellectual merit of the research findings. These impacts could include: 1) an increase in societal well-being by creating a more intergenerationally secure planet, 2) the development of behavioral-informed design tools that enhance outcomes and lead to a more effective STEM workforce, or 3) improved economic competitiveness resulting from timelier and successful action on climate change.