

# Future tense can reduce present bias in infrastructure design

**Patrick Hancock**

University of Virginia

**Leidy Klotz** (✉ [lk6me@virginia.edu](mailto:lk6me@virginia.edu))

University of Virginia <https://orcid.org/0000-0002-4656-0463>

**Tripp Shealy**

Virginia Tech

**Eric Johnson**

Columbia University

**Elke Weber**

Princeton University

**Katelyn Stenger**

University of Virginia

**Richa Vuppuluri**

University of Virginia

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## Brief Communication

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# Abstract

Design professionals (N = 261) were randomly assigned to either a future or present-framed project description before recommending design attributes for an infrastructure project. The future condition led designers to propose a significantly longer infrastructure design life, useful life to the community, and acceptable return on financial investment. The findings suggest that using future framing when soliciting sustainable design expertise can be a straightforward and inexpensive way to lessen present bias.

## Introduction

Infrastructure systems provide essential water, shelter, mobility and other services. There is a global need to update these systems and to expand them to serve the billions who do not currently have access<sup>1</sup>. At the same time, existing infrastructure accounts for around one fifth of climate changing emissions<sup>2</sup>, and if new infrastructure development follows a similar path it will independently exceed the carbon budget needed to avoid the worst effects of climate change<sup>3</sup>. Present-day choices about infrastructure impact how effectively the water, shelter, and mobility needs of current and future generations are met, and present-day decisions about infrastructure impact whether or not we maintain safe conditions for life on earth.

Decisions made by a variety of stakeholders long before construction begins play an outsized role in determining the costs and benefits of an infrastructure project<sup>4</sup>. As in other domains<sup>5</sup>, the context in which decisions about infrastructure are made can impact the outcome<sup>6-8</sup>. For example, compared to a control group, infrastructure designers made aware of high achieving "role-model" projects set 34% more ambitious goals for sustainability<sup>6</sup>. Consequently, one important path to more sustainable infrastructure is to identify the specific decision contexts that motivate designers to create more sustainable outcomes.

Due to the long-term nature of sustainability goals, people's construal of time can lead to more or less sustainable outcomes<sup>9</sup>. One harmful tendency is to irrationally prefer options with more immediate benefits—present bias—over options with delayed but greater benefits. Present bias can in some cases be overcome by priming future considerations so that they are considered first or more extensively. In other words, psychological distance is malleable, and this, in turn, can alter an individual's construal of the decision context<sup>9-11</sup>. For example, closer psychological distance to climate change is correlated with increased concern for climate change impacts<sup>12</sup>. Reducing an individual's perceived distance to the future might therefore elicit long-term sustainable outcomes by reducing present bias.

Key to how individuals construe psychological distance is how they perceive and value time, whether 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. Having people contemplate future outcomes before current costs, for example, can lessen present bias and increase patience more generally<sup>13</sup>. Building from such findings, the present research explores whether eliciting a gain-framed future-orientation towards a design task lessens present bias, thus allowing improved long-term sustainable decision-making.

In practice, infrastructure design typically begins with a request for proposals, which is a document outlining the initial requirements for design firms that wish to bid on a project. This key document communicates to designers the goals of whoever is paying for the project, often a government or municipality on behalf of taxpayers. The ubiquitous and essential nature of the of request for proposals makes it well-suited for framing interventions that might lead to more sustainable outcomes in infrastructure design.

Here we examined whether a future orientation, introduced via relatively subtle changes to the wording of a request for proposals (see Methods), could cause designers to take a longer-term view of infrastructure. We hypothesized that the future framed request for proposals would cause a significant increase in the designers' goals for: useful life to the community; design life; and acceptable years for return on investment.

## Methods Summary

Due to their interest and expertise in creating more sustainable infrastructure, professional infrastructure designers who had been previously trained to use a sustainability rating system were selected as the study population. The Envision rating system is the most widely used sustainability rating system for infrastructure in the United States, and the rating system is managed by the Institute for Sustainable Infrastructure. Participants were recruited through the Institute of Sustainable Infrastructure's email listserv. The recruitment email provided the potential participants with background information on the study, along with a link to the experiment. Clicking the link brought the participant to the experiment consent form.

After consenting, participants were randomly assigned to either a future or present-framed request for proposal. Both groups received the same project information with the only difference being subtle differences in word tenses. For example, "Sparwood is a caring, neighborly, and sustainable community" or "In 2035, Sparwood will be a caring, neighborly, and sustainable community". Additionally, "A ... network of trails, parks, and recreational areas support an active ... and highly livable community" versus "A ... network of trails, parks, and recreational areas will support an active ...and highly livable community". For complete project descriptions, please see the extended methods section.

After reading the future or present-framed request for proposal, participants provided conceptual infrastructure designs, including setting targets, in years, for the outcome variables of interest: design life, useful life to the community, and maximum acceptable return on investment. Finally, participants answered demographic questions. The methods are described in further detail in the supplemental methods section, along with a link to the study's Open Science Foundation preregistration site.

## Findings

For each dependent variable, the null hypothesis was that no significant difference exists between participants in the future-framed or present-framed group. Findings related to each hypothesis are as

follows:

The participants who received the future-oriented request for proposal construed a **significantly longer targeted useful life to the community (MD = 7.80, p = .02)** compared to those in the present group. Useful life to the community is an essential measure of sustainable infrastructure design<sup>15</sup>, influencing how present allocation of resources benefits society into the future<sup>14</sup>. 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 (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<sup>16</sup>. Increases to the design life of infrastructure will generally contribute to sustainability improvements over the project's life-cycle<sup>17</sup>.

Finally, the participants in the future-orientated group were willing to accept **a significantly higher number of years for the return on investment (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, such as when small immediate payoffs are preferred over much larger payoffs in the future<sup>18</sup>.

## Discussion

Subtle wording changes in a request for proposal elicited a longer-term perspective among those who make decisions about sustainable infrastructure. This specific change to induce a future orientation is a relatively straightforward and inexpensive way to reduce present bias. Beyond requests for proposals and beyond infrastructure, this work suggests that the contextual temporal understanding provided in sustainability plans and climate action plans, for example, is an opportunity to lessen present bias among those who will be acting on these plans.

While this work suggests practical changes to influence professional design, the data also raises questions about the underlying psychological mechanisms driving the significant difference between the experimental groups. Future research could examine, for example, whether heightened positive or negative emotion pathways mediate the observed effect<sup>19</sup>, and whether episodic future thinking can be demonstrated, perhaps via heightened Prefrontal-Mediotemporal Interactions<sup>20</sup>. A deeper understanding of the underlying psychology could allow for more powerful interventions and provide insights for how to apply these findings in other contexts.

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. 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.

## Methods

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. After consenting, participants were randomly assigned to either the future or the present framed experimental groups. The manipulation took the form of the project vision statement within the RFP for the District of Sparwood's Water System Integrated Master Plan in British Columbia, Canada.

Upon the completion of data collection, statistical analysis was performed on the collected responses. The analysis looked for significant differences in design metrics: design life, return on investment, useful life to the community, and the Envision credits. For the design metric, individual t-tests were performed between the present and future visioning groups. 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.

**Background information.** When introducing the project to the participants, the background was given in the District's vision. 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 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, the participant oversees 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.

**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.

**Experimental Manipulation.** At this point, 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 imperceivable from the present<sup>21</sup>. 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<sup>22,23</sup>. 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]."

The participant answered the three main DV questions after the manipulation. All three DV questions related to different aspects – design life, ROI, and useful life to the community – of the wastewater treatment plant's design lifespan allowed for assessing the participant's goals around project sustainability.

**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<sup>6</sup>. 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).

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 figure 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 simulate the cognitive burden of greater achievement.

## Declarations

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**Author contributions.** P.I.H. preregistered the research, collected and analyzed data, and drafted the manuscript; T.S. conceived and designed research, analyzed data, and edited manuscript; E.J.J. conceived and designed research, analyzed data, and edited manuscript; E.U.W. conceived and designed research, analyzed data, and edited manuscript; L.K. conceived and designed research, analyzed data, and drafted manuscript; K.S. edited manuscript; R.V. collected data.

**Materials and correspondence.** For questions or comments please email Patrick Hancock at [pih9nc@virginia.edu](mailto:pih9nc@virginia.edu).

**Competing interest declaration.** The authors declare no competing interests.

**Data and material availability.** Before the data collection took place for this study, after a pilot data collection for testing the decision scenario's functioning, the researchers preregistered the study with the Open Science Foundation. We followed the Aspredicted.org template to list 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.

All the code used for data analysis is available from the corresponding author upon request. Because of a non-disclosure agreement, sample data would require authorization by the company.

## References

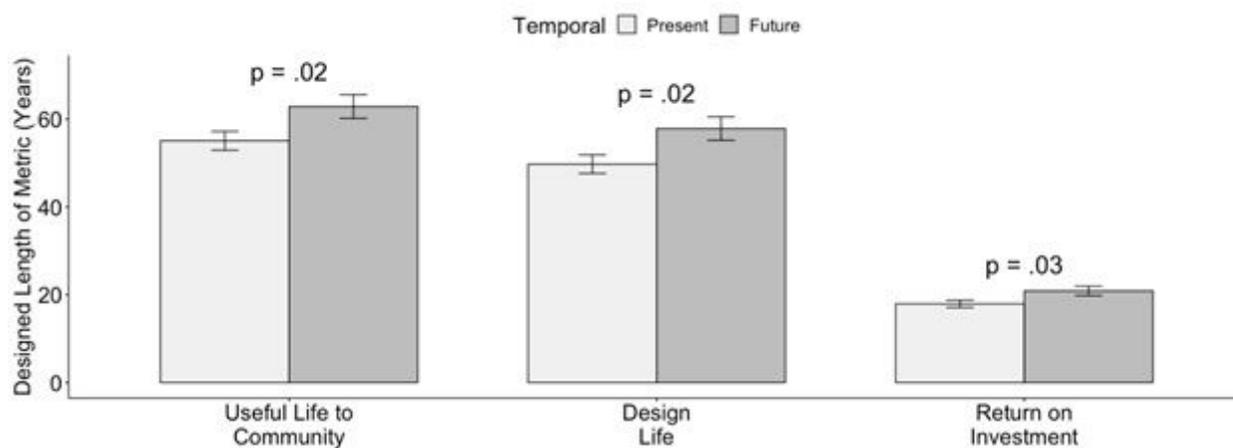
1. Transforming Our World: The 2030 Agenda for Sustainable Development. in *A New Era in Global Health* (ed. Rosa, W.) (Springer Publishing Company, 2017). doi:10.1891/9780826190123.ap02.
2. Creutzig, F. *et al.* Urban infrastructure choices structure climate solutions. *Nat. Clim. Change* **6**, 1054–1056 (2016).
3. Müller, D. B. *et al.* Carbon Emissions of Infrastructure Development. *Environ. Sci. Technol.* **47**, 11739–11746 (2013).
4. Sen, P. Communicating preferences in multiple-criteria decision-making: The role of the designer. *J. Eng. Des.* **12**, 15–24 (2001).
5. Johnson, E. J. *et al.* Beyond nudges: Tools of a choice architecture. *Mark. Lett.* **23**, 487–504 (2012).
6. Harris, N., Shealy, T. & Klotz, L. How Exposure to “Role Model” Projects Can Lead to Decisions for More Sustainable Infrastructure. *Sustainability* **8**, 130 (2016).
7. Shealy, T. *et al.* Providing descriptive norms during engineering design can encourage more sustainable infrastructure. *Sustain. Cities Soc.* **40**, 182–188 (2018).
8. Shealy, T., Klotz, L., Weber, E. U., Johnson, E. J. & Bell, R. G. Using Framing Effects to Inform More Sustainable Infrastructure Design Decisions. *J. Constr. Eng. Manag.* **142**, 04016037 (2016).
9. Trope, Y. & Liberman, N. Construal-level theory of psychological distance. *Psychol. Rev.* **117**, 440–463 (2010).
10. Pronin, E., Olivola, C. Y. & Kennedy, K. A. Doing unto future selves as you would do unto others: Psychological distance and decision making. *Pers. Soc. Psychol. Bull.* **34**, 224–236 (2008).
11. Weber, E. U. *et al.* Asymmetric Discounting in Intertemporal Choice: A Query-Theory Account. *Psychol. Sci.* **18**, 516–523 (2007).
12. Spence, A., Poortinga, W. & Pidgeon, N. The Psychological Distance of Climate Change. *Risk Anal.* **32**, 957–972 (2012).
13. Weber, E. U. & Johnson, E. J. Cognitive barriers to future-oriented decision making. in *Global Cooperation and the Human Factor in International Relations*. (Routledge, 2015). doi:10.4324/9781315691657.
14. Sierra, L. A., Pellicer, E. & Yepes, V. Method for estimating the social sustainability of infrastructure projects. *Environ. Impact Assess. Rev.* **65**, 41–53 (2017).
15. Valdes-vasquez, R. *et al.* E.Klotz, “ Social sustainability considerations during planning and design: Framework of processes for construction projects. *J. Constr. Eng. Manag.* ASCE 80–89.
16. Hallegatte, S. Strategies to adapt to an uncertain climate change. *Glob. Environ. Change* **19**, 240–247 (2009).

17. Al-Qadi, I. L. *et al.* Scenarios Developed for Improved Sustainability of Illinois Tollway: Life-Cycle Assessment Approach. *Transp. Res. Rec.* **2523**, 11–18 (2015).
18. Henderson, N. & Bateman, I. Empirical and public choice evidence for hyperbolic social discount rates and the implications for intergenerational discounting. *Environ. Resour. Econ.* **5**, 413–423 (1995).
19. Van Boven, L. & Ashworth, L. Looking forward, looking back: Anticipation is more evocative than retrospection. *J. Exp. Psychol. Gen.* **136**, 289–300 (2007).
20. Benoit, R. G., Gilbert, S. J. & Burgess, P. W. A Neural Mechanism Mediating the Impact of Episodic Propection on Farsighted Decisions. *J. Neurosci.* **31**, 6771–6779 (2011).

## Methods References

21. Jones, C., Hine, D. W. & Marks, A. D. G. The Future is Now: Reducing Psychological Distance to Increase Public Engagement with Climate Change. *Risk Anal.* **37**, 331–341 (2017).
22. Soliman, M., Alisat, S., Bashir, N. Y. & Wilson, A. E. Wrinkles in Time and Drops in the Bucket: Circumventing Temporal and Social Barriers to Pro-Environmental Behavior: *SAGE Open* (2018) doi:10.1177/2158244018774826.
23. Gifford, R. The dragons of inaction: Psychological barriers that limit climate change mitigation and adaptation. *Am. Psychol.* **66**, 290–302 (2011).

## Figures



**Figure 1**

Future orientation led to a statistically significant increase in useful life to community, design life, and return on investment. Error bars represent  $\pm 1$  S.E.

<b>Envision Credit</b>	<b>Description</b>
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

**Figure 2**

Envision credits used within the study, along with their description.