Using Framing Effects to Inform More Sustainable Infrastructure Design Decisions

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Abstract: Decision aids, ranging from rating systems to design software to regulatory standards, guide the design and evaluation of infrastructure projects. To present the information in these decision aids, there must first be some options such as, attributes are or are not presented, and, just as in other domains, these factors are likely to influence decisions in infrastructure development. The authors of this paper seek to better understand how choice structures influence engineering decisions. Prospect theory, which is well established in the behavioral sciences, asserts that people tend to think of possible outcomes relative to their starting point, not the resulting end point. For instance, framing a decision outcome as a loss in value (rather than a gain) can reduce the decision makers' acceptance of risk and, in turn, lead to more conservative outcomes. To measure framing effects in engineering decisions, this paper uses the Envision rating system for sustainable infrastructure, which aims to help civil engineers achieve the highest feasible sustainability performance in their projects. The hypothesis is that Envision's framework inadvertently limits the likelihood that engineers will set the highest achievable goals for sustainability. In the current framework, engineers start with zero points and achieve points when design considerations move beyond conventional construction standards. In this modified experimental version, a higher benchmark is set. Engineers are endowed points and can lose them for not maintaining high goals for sustainability. Engineering professionals ($n = 65$) used Envision to make tradeoffs about site programming and functionality for a rural redevelopment project. Participants were randomly assigned the standard version ($n = 33$) or the experimental version ($n = 32$). The experimental group achieved 66% of points compared with the standard group's 51% ($p < 0.01$). These results indicate that a choice posed as a loss rather than a gain significantly improved engineers' consideration for sustainability achievement. The findings suggest the need for more thoughtfully designed decision aids, with guidance from established behavioral science. This type of interdisciplinary research holds the potential to yield relatively low-cost solutions that support greater sustainability in infrastructure development. **DOI: 10.1061/(ASCE)CO.1943-7862.0001152.** *© 2016 American Society of Civil Engineers.*

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Introduction

Infrastructure development creates path dependence, determining energy, water use, and climate change emissions for the life cycle of the project. In addition, engineering decisions about infrastructure broadly define how the public will use infrastructure services, affecting mobility, public health, and economic development. For instance, the Woodlands Township in Houston, Texas, commissioned an engineering study to either widen Interstate 45 or expand bus and trolley services. This decision will directly influence how residents commute to work, where to build future retail businesses, and the construction of new residential communities. In a similar way, material choices shape sustainability outcomes. For example, while recycled materials may reduce embodied energy, if the use of these materials means a road's life span is reduced, overall energy performance can be lower as well. In response to such considerations, this research aims to help those in the early phases of infrastructure development make more informed decisions that will lead to more sustainable infrastructure outcomes.

Decision aids, ranging from rating systems to design software to regulatory standards, are often used to design and evaluate infrastructure projects. The rating system called *Leadership in Energy and Environmental Design (LEED)*, for example, can guide project teams in site programming, building layout, and identifying energy efficiency goals (Bayraktar and Owens 2010). LEED provides metrics for decision makers to compare alternative options and justify decisions. Buildings labeled with LEED command higher occupancy rates (Fuerst and McAllister 2009) and higher lease prices in commercial buildings (Eichholtz et al. 2010). These higher prices suggest that commercial clients and the public value such rating systems, which substantiates the value of metrics in construction decision processes (Dermisi 2009).

Envision is a leading U.S. rating system for sustainable infrastructure. While LEED has been used mostly for buildings, Envision is meant for a range of infrastructure projects (i.e., roads, bridges, pipelines, railways, airports, dams, levees, landfills, and water treatment systems). Envision is similar to LEED because both are appropriate for project planning to inform goal setting and early design considerations. Envision, like LEED, is also used voluntarily by construction and design firms, but it can also be mandated by local governments and municipalities. Engineering

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companies such as HDR, CDM Smith, and Skanska have quickly acknowledged the benefits of Envision by each pledging to train more than 100 employees to use the rating system. The city of Berkeley, California, employs Envision to prioritize backlogged projects (City of Berkeley Process for Prioritizing Street and Watershed Improvements 2013), and Dallas, Texas, requires an Envision-certified member of the design team before submitting a proposal.

Envision broadly applies to all types of infrastructure, excluding single buildings. Current projects with Envision certifications include a fish hatchery, an underground pipeline, and several creek and wetland restoration sites. Additional projects that integrate Envision into project evaluations include the Port of Long Beach and the Los Angeles–San Diego–San Luis Obispo (LOSSAN) Rail Corridor. The Port of Long Beach is measuring success of a brownfield remediation project with Envision (Sheesley et al. 2014) and the LOSSAN project will use Envision to set a baseline for sustainability, which future rail development within the corridor will aim to meet (Dial et al. 2014).

The scale of adoption by municipalities and engineering firms indicates that metrics like Envision provide quantifiable justifications for project decisions. Labeling a project as sustainable can also be beneficial for both indirect stakeholders in the community and direct stakeholders, such as as project owners or city officials.

Understanding how these metrics influence engineers' decision making is critical to ensure nontechnical barriers do not limit consideration for sustainability. Behavioral science suggests that the framework or choice structure of options can influence the decision maker's choice. A body of research in behavioral science allows researchers to make accurate predictions about decision making based on framing effects (Levin et al. 1998) and loss aversion (Benartzi and Thaler 1993), among many other cognitive biases (Edwards 1996) and social heuristics (Beamish and Biggart 2012).

Human rationality is bounded by time and cognitive limitations (Gigerenzer 2006; Kahneman 2013). Modifications to decision-based processes to incorporate bounded rationality are improving fields from medicine (Johnson and Goldstein 2003) to law (Johnson 1993) to finance (Thaler and Benartzi 2004). Consider, for example, the difference in tort law for consumer car insurance in Pennsylvania and New Jersey. In Pennsylvania, the law sets "Full Right" to sue as the default auto insurance for customers. To change the default, policyholders must ask for "Limited Right" to receive a discount. In New Jersey, "Limited Right" is the default and policyholders must actively ask for "Full Right." The reluctance to break the default means that 75% of Pennsylvania motorists obtained "Full Right," and only 20% did so in neighboring New Jersey (Johnson 1993). The small change in choice structure translates to economic and political impact; more lawsuits are filed in Pennsylvania compared with New Jersey (Fischhoff and Kadvany 2011).

The tort law example demonstrates how small changes in decision frameworks can influence the decision process for consumers. This paper applies a similar technique to better understand how engineers make decisions. While the focus in this study is the Envision rating system for sustainable infrastructure, the findings can translate to other areas of infrastructure decision-based design and project delivery and management.

The engineering decision process being described here takes place early in project planning and is closely associated with goal setting. Decision makers are considering high-level decisions about site programming and functionality. The objective is to examine how engineering professionals interface with tools like Envision and to measure the effect on decisions about sustainability due to changes in choice structures.

Objective

This research examines how engineers make tradeoffs between design options. The paper empirically measures the effects of changes in choice structures of the Envision rating system. How information is presented or framed within Envision may inadvertently limit engineers' consideration for the highest achievable levels of sustainability. In this study, all other project constraints (i.e., time and budget) are equal.

More sustainable design is often no more expensive and only requires additional time and consideration during the design process. For example, findings from the LOSSAN rail corridor suggest that greater project sustainability could have been achieved at no additional cost had Envision been adopted earlier in the design process (Dial et al. 2014). The authors of this paper have developed a similar upfront planning scenario to test empirically if changes in the Envision framework create a shift in project goal setting to achieve higher points in Envision. By isolating this decision point, the impact of the intervention can be measured more effectively.

Background

This paper builds on previous research in construction engineering management suggesting that judgment and decision making, cognitive biases, and social heuristics distort managerial decisions in complex infrastructure governance, planning, and delivery (van Buiten and Hartmann 2013; Beamish and Biggart 2012; Klotz et al. 2010; Klotz 2010). Understanding how engineers make decisions can help reduce these biases (Shealy and Klotz 2014).

It also draws on previous research in psychology and economics (Hardman 2009). A concept called Prospect theory, developed by Daniel Kahneman and Amos Tversky (1979), is now widely accepted after three decades of confirming research. Results from these studies indicate external validity from multiple domains with a similar overall conclusion: decision makers are influenced by the presentation of options.

Prospect theory makes logical assumptions of economic rationality to account for behavioral biases. The main assertion of the theory is that people tend to think of possible outcomes relative to their starting point rather than the resulting end point (Kahneman and Tversky 1979). For instance, factory workers given a preliminary bonus met a higher productivity level than workers promised a bonus when they finished (Hossain and List 2009). The first group had something to lose compared with the second group that only had something to gain. The potential loss is more discomforting than a gain of equal value. Prospect theory is used in a similar way to predict how home sellers will behave in a down market (Genesove and Mayer 2001) or fund managers sell stocks (Abdellaoui et al. 2013). A potential loss reduces the decision makers' acceptance of risk to achieve an outcome. It also applies to issues in politics (Patty 2006) and international relations (Berejikian 2002). Yet, there is inadequate understanding of how these factors influence the crucial early-phase decisions in infrastructure project development, which this study addresses.

To overcome the risk of losing requires the potential gain to be roughly twice as great (Benartzi and Thaler 1993). This is modeled as the value function within Prospect theory. A loss is more sharply felt compared to a gain of equal value. The effect of a marginal change in value decreases from the distance of the reference point. This means a gain from $100 to $200 is subjectively greater than a gain from $1,100 to $1,200. The distance from the starting point changes the perceived value, and therefore the acceptance of risk. More risk is often accepted when it is further from the decision makers' perspective of the starting point.

Decisions framed as positive or negative can have a similar effect as a loss or gain. Patients are more likely to choose a medical procedure when presented as a probability of survival (positive frame) compared with a probability of death (negative frame) (McNeil et al. 1982). Similarly, political affiliations changed preferences when a carbon dioxide surcharge was labeled a "tax" or "offset" (Hardisty et al. 2010).

These differences are also measurable in brain scans. Losses are associated with emotional pain in a way that gains are not (Rick 2011; Sokol-Hessner et al. 2013). Endowment effect can change the reference point, or frame, to induce a risky choice. By endowing someone with an object, or giving ownership, that person's willingness to accept a sale or trade decreases. In other words, people expect to earn more money when selling an item and expect to pay less when buying the same item. In some instances, the endowment effect increases the perceived value of an item by as much as 14 times (Carmon and Ariely 2000). The increase in valuated price is a reflection of the discomfort of the potential loss. Compellingly, experts appear just as susceptible as laypeople to framing effects and loss aversion (Duchon et al. 1989; Marteau 1989).

Such findings motivate the need for research to understand how framing effects influence not just relatively simple consumer decisions, but also upstream decisions about infrastructure that require active tradeoffs with multiple variables and uncertain consequences. To summarize, decisions are made by constructing preferences about options (Ariely and Norton 2008; Johnson et al. 2007; Slovic 1995) and Prospect theory provides the model for predicting which option likely fit a person's preferences. Applying this theoretical perspective to engineering decision making may aid in the decision processes. Whether intentionally designed or not, there is no neutral framework to present information. Some options must be first, attributes are or are not presented, and, just as in other domains, these factors are likely to influence decisions in infrastructure development. Across fields, modifications to choice structures are viewed as a method to improve the decision process (Thaler and Sunstein 2008). The methods can be controversial (Bovens 2009), but better understanding how choice structures influence engineering decisions can provide insight into designing more thoughtful decision aids, and ultimately leads to more sustainable infrastructure outcomes.

Envision Framework

The Envision rating system is composed of 60 questions divided into five categories: Quality of Life, Leadership, Resource Allocation, Natural World, and Climate and Risk. Each question, or credit, is associated with a series of points. Engineers use Envision's guidance manual to decide the amount of points achievable for their project. Levels of achievement are ranked from lowest to highest: improved, enhanced, superior, conserving, and restorative. The scale of points varies for each credit but all points accumulate moving from the improved through restorative levels. For example, Quality of Life question 1.3 asks: "How will the project team develop local skills and capabilities?" The improved level (1 point) is achieved by hiring a local workforce and conserving (12 points) is achieved through a training program for minorities and disadvantaged groups. The training program must also leave a competitive local workforce in place for future projects. To meet conserving and restorative levels means that the project provides sustained benefits to the community, economy, and local environment after the construction phase is complete (i.e., a trained, diverse workforce is more competitive for future projects in the community).

Table 1. Modifications to Envision Rating Scale

Level of achievement	Current scale	Endowed scale
Industry convention	0[a]	(−12)
Improved	1	(−11)
Enhanced	2	(−10)
Superior	5	(−7)
Conserving	12	12[a]
Restorative	15	(+3)

[a]Number of starting points.

The goal of Envision is to move project teams from the conventional construction standards (zero points) to the highest possible levels of sustainability (defined by Envision as conserving and restorative). To more effectively motivate Envision users to consider the highest achievement, the authors suggest starting users at the conserving level of achievement and endowing them with the points for that level. The modified scale in Table 1 shows the endowed scale, which starts users with 12 points. Additional points are still possible by achieving the highest level, restorative. Achievement below the new reference point results in a loss of points. Now, rather than adding 1 to zero, 11 is subtracted from 12. The final amount of points for each level of achievement remains the same in both versions. The only change is the process that achieved them. The shift from starting at the conventional standard to conserving restructures the frame of reference from a gain option to a gain/loss decision. The conserving level of achievement was chosen as the frame of reference because it represents the environmental neutral defined by the Envision rating system.

Prospect theory states that decisions are made in reference to other options. The farther the change is from the reference point, the less significant it appears. In the standard version of Envision, users may see 0 to 5 as a bigger gain than, say, 10 to 15 because the starting reference is zero. Endowing users with points may shift the value function of the reference to a higher level of points. In essence, starting more closely to the center of the metric may frame the decision, either loss or gain, as more equal.

Hypothesis

This paper hypothesizes that engineers make decisions in reference to alternative options and the beginning number of points will frame how participating engineers construct preferences about subsequent choices in Envision. Currently, engineers using Envision begin at the lowest possible level, with zero points. Much cognitive effort is required to move up five levels of achievement to meet the restorative option. By changing the reference point to conserving, users will consider, and achieve, a higher level of sustainability. This null hypothesis is that the change in reference will result in no significant point difference between groups. The term *significant* is defined as meeting at least a 95% confidence interval. This hypothesis follows Kahneman and Tversky's Prospect theory (1979). A more ambitious starting position, endowing users with points, will motivate them not to lose points, as opposed to gaining the same number of points.

Consumer studies report participants are often not aware of these types of framing effects (Duchon et al. 1989; Levin et al. 1998). Similarly, this paper hypothesizes that engineers will not be aware of the framing effects. Users will construct preferences about options differently, but this will not change their general perspective of sustainability or the Envision rating system.

Methods and Procedure

The authors created a replica of the Envision software to capture participant responses. The replica software was pilot-tested with a student group. Small changes were made based on student responses and retested with another student group. Engineering professionals were then recruited to participate in the study. After completing the Envision rating system, the participating professionals completed a posttask survey to explain their decision making.

The replica software is identical to the original version of Envision. The engineering professionals log in to see their initial score, the total possible points, and scroll down the page to view each credit. Just as in the original version, a link directs users to Envision's detailed explanations of how to meet achievement levels. Once the professionals review a credit, they select the level of achievement that they believe is possible and provide a detailed explanation of how the project team can meet these points.

One version of the replica software presents the standard rating scale, starting engineers with zero points, and another the endowed scale, starting with 150 out of a possible 181 points. Engineering professionals with the endowed version see the drop-down menu for levels of achievement preset to conserving. Expanding this menu shows a negative value instead of positive for improved through superior levels. The negative values in points are the points lost from the endowed starting point. Lesser achievement still results in a final positive score. The negative value is subtracted from the endowed score.

Both versions require users to explain how a team could meet the level of achievement specified. Similarly, if an infrastructure project is submitted to the Institute for Sustainable Infrastructure (ISI) for verification, an independent reviewer must authenticate the documents that support the project team's claims. A project team selecting conserving must also explain how they plan to meet improved through superior levels. Achieving a greater number of points requires a longer explanation. In the replica software used in this paper, a written explanation of at least 100 characters in length is required for improved and 300 characters for restorative. Intermediate levels are spaced by 50-character minimums. This text character minimum was included to reduce the likelihood that participants would maximize points by thoughtlessly selecting the highest levels of achievement for every credit. The character minimum performs as a sort of cost, in terms of the time and thought required to justify the achievement.

The authors considered introducing a monetary cost for each decision; however, points in Envision do not correlate with an increase in cost. In fact, meeting a higher level of achievement may actually cost less. For example, identifying a construction method to reduce excavated materials can be cost-beneficial and earn a project team six points. The objective of this study is to understand how engineers make these types of tradeoffs and if losing versus gaining points in sustainability deviates project considerations. To include additional time or cost variables in this study may create biases that are not controlled. This study underpins future research measuring the effects of framing with multiple variables. The Envision system is kept exactly the same, except for the preset number of points endowed and the required length of explanation.

The replica software was pilot-tested with two student groups. The first group was told to review a redevelopment case study using the Envision software and explain how the case study project team could achieve Envision credits. The students used the text box within each credit to fill in their responses. These responses guided the setting of the required length of explanation for levels of achievement. Students preferred a character minimum to a word minimum. The students also identified a potential flaw in this system. In the first version, an explanation was not required when participants selected a credit as not applicable to the project. Selecting "not applicable" would decrease the total possible points and increase the total percent achieved. The authors changed this for the second student group and industry group. Participants now must also explain why the credit is not applicable.

The software was tested again with a larger student group of upper-level and graduate engineering students ($n = 41$) who are close to making these types of decisions in their careers. Student participants were given class credit for completing the rating system. However, their grades were not based on their achievement score, which was made clear when introducing the assignment. Two of the five Envision categories, Quality of Life and Natural World (26 of the 60 available credits), were included in the pilot study. These categories ask participants how to improve community mobility, preserve cultural resources and greenfields, and manage storm water runoff. Other Envision categories were not included to reduce the time and the cognitive load required to complete the assignment. The authors wanted to encourage students to spend time thinking about the design choices rather than rushing to complete all 60 of the credits.

Students were instructed to review a case study and use the Envision rating system to identify credits and possible level of sustainability the project team could meet. They were randomly assigned the standard or endowed version of Envision. Instructions for the endowed version read, "Decisions made below the *conserving* level will lose you points. Decisions made above the *conserving* level will earn you points." Instructions on the standard version read, "You are starting at the industry norm benchmark with 0 points. Every decision you make above the industry norm will earn you points."

For the pilot study, the participants endowed with points scored significantly higher design achievement for sustainability than the standard group. The endowed group ($n = 16$) averaged 63% ($SD = 19.2$) of applicable points; the standard group ($n = 25$) averaged 44% ($SD = 19.8$). Scores were evenly distributed on a normal curve and a t-test identified that the difference was significant ($p < 0.01$). A power analysis ($p < 0.05$, power level $= 0.80$) using results from this pilot study suggested that a sample size of 70 professionals would be roughly twice the number needed to yield significant findings.

Procedure for Industry Group

Engineering professionals volunteered to participate in a training seminar about the Envision rating system. All participants were unfamiliar with the Envision rating system prior to the training. Six training sessions were organized and group sizes ranged from 8 to 25 people. The sessions averaged 90 min. in length. Participants were given a presentation about the purpose of Envision and how to navigate the guidance manual and the online rating tool. A case study was presented about a redevelopment project in a rural Alabama town. Background information about the project's intended goals, local governance, community, and site programming were also included in the presentation. Participants were instructed to act as the consulting engineer and make recommendations to the owner about site use, layout, accessibility, public space, and alternative modes of transportation. Details such as how to integrate alternative transportation were intentionally left open-ended to encourage engineers to develop their own ideas. Each participant was instructed to use the online Envision rating system to help guide their decision making. Their job was to identify and explain how their designs could meet Envision credits. Only Quality of Life credits were given to the participants (12 credits out of a possible 60) because of the limited time for participation. Similar to the student group, the objective was to aid the decision-making process for the professional group. By reducing the number of credits that participants needed to consider, they could spend more time consciously reviewing each credit and option. Still, some credits are more difficult or easy to achieve within the context of this case study. Restorative is likely not obtainable across all credits and categories. A total of 12 credits were determined to be sufficient because the results of the pilot study with students were statistically significant with this number of responses.

The online software used in this study randomly assigned participants to the standard or endowed version of Envision. Once logged in, participants could see their score and total possible score. Participants could scroll down the page to credit QL1.1 through QL3.3. Quality of Life credits were used because the case study has close links to the health and well-being of the local community and environment. For example, participants had to explain how their ideas align with the community goals and define the long-term community benefit. Physical safety of the construction workers and community were also addressed. Participants were asked to develop methods to reduce noise, vibration, and construction odors. As mentioned previously, financial considerations were not included because a cost-benefit analysis was not available this early in project planning, and a correlation between infrastructure cost and greater achievement in sustainability is misleading. For instance, several of the student participants from the pilot study suggested reducing the number of lanes and the width of the roadway, which would lower repaving costs and help achieve Quality of Life Credit 2.5. At this point, requiring participants to include detailed financial considerations for these types of decisions during upfront planning would be misaligned with the objective of the study, which was to understand framing effects of the rating system.

After participants finished the rating process, the online software directed them to an online survey. The survey asked whether the framing effects changed their motivation or confidence in their score. Eight survey questions were adapted from previous posttask motivation surveys (Fernet 2011; Thelk et al. 2009; Watson et al. 1988; Wolf and Smith 1995). The survey measured a difference in motivation and confidence by the average scores of the standard and endowed groups. Responses were given on a 5-point anchored scale ranging from "1—Strongly Disagree" to "5—Strongly Agree." If survey results indicated that the loss frame decreases participant motivation or confidence, then the higher reference point may not be a preferred starting point.

In addition, participants were asked, in several arrangements, if the framing influenced their decision. The survey asked if their strategy was to begin with improved and then move to enhance, superior, and conserving (in that order), and if they were aware how many points they started with before reviewing the credits. Furthermore, the survey probed for their perception of achievement by asking if they believed meeting improvedis a big accomplishment and later asking if conservingis a big accomplishment.

The training session ended with a group discussion about Envision, and the need for tools like Envision, in the decision-making process for infrastructure. The overwhelming sentiment was that Envision is a valuable tool. The majority of design engineers who participated said that the greatest benefit to Envision is the ability to provide an extra deliverable to the owner; each credit is categorized and provides supporting justification and reasoning for the designer. Participants who function professionally as an owner's representative or city engineer viewed Envision as a stakeholder-engagement tool where the credits prompt discussions about project outcomes that sometimes are not discussed. Construction engineers who attended the training seminars said that Envision is a service they can facilitate and seemed excited to use the software during project planning.

Results

The current Envision framework starts users at zero points, while the modified framework endows users with points at the conservinglevel. The findings suggest that engineers with the endowed version strive for higher achievement. The endowed group scored an average of 31 more points than the standard group. In total, the endowed group averaged 112 points compared with the standard group's 81 points. They achieved ($n = 32$) 66% of the total possible points compared with the standard group's ($n = 33$) 51%. The authors were able to reject the null hypothesis. A t-test indicates that the endowed group score, compared with the standard group, is statistically significant ($p < 0.01$).

Outliers were considered and defined as a total score outside two standard deviations from the mean. However, the results listed in Table 2 include the four outliers (one outlier from the standard group; three outliers from the endowed group) because removing them makes the results even more significant.

Both groups achieved equal numbers of points for credit QL 1.1, but in the following 11 credits, the endowed group averaged more points than the standard group. The average difference per credit is 2.27 points, and the greatest difference of any credit is 4.6 points. Fig. 1 shows the points possible for each credit, the average endowed score, and the average standard score.

Participants had to decide which credits were applicable to the project. A credit that was not applicable would reduce the total points possible and increase the total percent achieved. Both groups, on average, chose an equal number of credits as applicable. The total possible applicable points were 181. The endowed group

Table 2. Engineers Achieve More Points When Given the Endowed Version of Envision

Statistic	Standard	Endowed
Mean	81	112
SD	40.1	42.6
Percent achieved	51	66
p-value	<0.01	<0.01

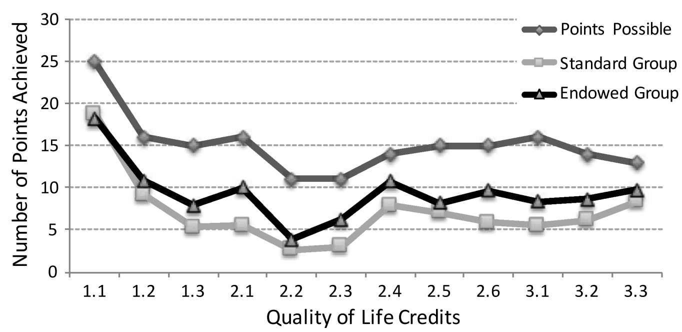

Fig. 1. Endowed group achieved more points in credits 1.2–3.3

designated 170 points as applicable and the standard group designated 167. These findings indicate both groups believed a relative number of credits, and points, are applicable to the project. The endowed group deemed that they could achieve slightly more of these points than the standard group.

The distribution of participants selecting levels of achievement (i.e., improvedthrough restorative) varies with each credit. Yet, in all credits, more participants from the endowed group chose conserving or restorative compared with the standard group. This suggests that participants given the endowed version were more likely to reach the conserving and restorative levels than participants given the standard version.

The variance between participants selecting levels of achievement is greater in the standard group compared with the endowed group. In all 12 credits, the endowed group is more closely clustered around one level of achievement. The standard group is more varied and evenly distributed across levels of achievement.

To summarize the results, anchoring to a higher reference point influences the decision process. Engineers given the endowed version achieve more points per credit and as a group, they come closer to consensus about what is possible to achieve. More engineering professionals agree that high levels of sustainability achievement are possible with the endowed version of Envision, and the variance between levels of achievement is less in the endowed group.

In the posttask survey, participants were asked to recall how many points they started with before using the rating system and if they believed that this influenced their decision making. A total of 11 participants of the 33 in the endowed group believed that the starting number of points influenced their decisions. Yet, only 3 of the 11 could recall the starting point as 150. The remaining 8 either said they could not remember, or they remembered incorrect numbers between 20 and 181.

Several questions asked how the framing effect influenced their decision process. The Mann-Whitney U-test was used to compare survey responses between groups. Participants in the standard group ($n = 32$) strongly agreed ($x = 16$) or agreed ($x = 9$) with the statement, "My strategy was to begin with *improved* and then move to *enhance, superior*, and *conserving*, in that order ($p < 0.001$)." More participants in the endowed group strongly agreed ($x = 11$) or agreed ($x = 12$) with the statement, "My strategy was to avoid losing points ($p = 0.02$)." The standard group also strongly agreed ($x = 8$) or agreed ($x = 12$) with the statement, "My strategy was to achieve as many points as possible ($p = 0.01$)."

An open-response question asked participants to think back to a memorable Envision credit and explain how they decided to meet a level of achievement. Some participants answered broadly, saying they used the guidance manual to identify which level was possible. Some responded with a specific credit, stating, for example, that they started with light pollution because this was a familiar area of work. Two respondents from the standard group stated they began with improved and moved up in levels until they did not think the project team could meet anything higher. Four participants from the endowed group indicated that they tried not to lose points or they began with what was given and tried not to move down in level.

In both the open-response question and scaled-anchor question, more participants from the standard group said that they started with the improved level and moved up in levels of achievement, while participants from the endowed group said that they began with the conserving level.

Participants appear to make realistic judgments and tradeoffs when selecting sustainability credits. A total of 62 of the 65 participants were neutral about, agreed with, or strongly agreed with the idea that a project team could achieve their score. Standard group participants were more likely to strongly agree ($x = 6$) or agree ($x = 17$) compared with the endowed group ($p = 0.04$). However, the endowed group more likely strongly agreed ($x = 7$) or agreed ($x = 9$) with the statement and they were eager to compare their scores with others ($p = 0.05$).

The survey also asked each participant to list the number of years of work experience directly related to civil engineering. Work experience ranged from 1 to 25 years. The standard group averaged 10 years of experience and the endowed group 8.6 years. All participants were new to the Envision rating system, were currently working as engineering professionals for design firms, were industrial contractors, or were employed by a city as civil engineers. Participants were randomly assigned the standard or endowed software version.

Discussion

The standard version of Envision may overemphasize conventional construction standards. Decision makers considering whether to break free from the status quo may perceive such choices as more risky and uncertain (Dinner et al. 2010; Fox and Langer 2005; Brown and Krishna 2004). In its current form, the Envision rating scale awards points to encourage decision makers to do better than the industry norm. However, the results of this study indicate that losing points for not meeting a high level of sustainability encourages engineers to consider even greater achievement. The endowed version sets a defined goal for users to achieve and shifts the decision process from a gain-only scenario to a gain/loss decision. The loss appears to provide greater incentive to obtain more points.

Previous research suggests setting a goal as a reference point can extend the motivation to achieve the highest-level outcomes (Heath et al. 1999). The group beginning with the conventional construction norm likely has less reference for which goals to set, whereas the endowed group begins with a goal to try to keep what its members have. The results indicate that the reference changed the decision-making process. In fact, the endowed group reached a consensus of what is achievable more often than the standard group. Thus, if the purpose of Envision is to guide infrastructure development to the highest levels of achievement possible, then the shift in frame from gain to possible loss appears to help users better attain this goal. Even if the highest goal is never met, raising the reference point is likely to lead to a greater outcome (Jacowitz and Kahneman 1995; Strack et al. 1988).

The upgrades in achievement may likewise change project procedures and management. In Leadership, credit 1.1, the project team is encouraged to move from talking about sustainability to making sustainability a core organizational value. A shift in framing may create a noticeable change in future project performance for the company.

If the intervention caused a negative perception of sustainability, or Envision, it is not recommended to shift the reference point to conserving. A negative association may create resentment for the rating system or reduce the chance of using the tool in the future. Instead, the endowed group indicated that they were eager to compare scores, and both groups believe that their score is attainable. The survey responses suggest that participants in both groups tried to make realistic mental tradeoffs and likely used previous work experience to guide their decisions. Unrelated to the version that participants used, the majority of participants believe meeting improved is still a significant achievement for a project.

In fact, more participants given the endowed version believed that the Envision rating system ensures that the design is successful. These same participants were unaware of the change in frame, yet the results indicate that the endowed frame did influence their decision making.

These findings follow the authors' hypothesis and the Prospect theory of Kahneman and Tversky (1979). Engineering professionals make decisions similar to consumers by comparing options in reference with other options. Knowing how to frame decision tools, like Envision, can help improve engineers' decision making. Anchoring engineers to a higher goal can also help (Chapman and Johnson 1999; Galinsky and Mussweiler 2001). Engineering professionals could benefit from the endowed version of Envision when working with cities like Berkeley, California, that use Envision to prioritize backlogged infrastructure projects.

In addtion, the higher goal in the endowed version may enable decision makers to more closely reach consensus. This could benefit infrastructure teams who are each using Envision separately and come to a project agreement more quickly. For example, the multicity infrastructure development project, LOSSAN Rail Corridor, set a higher baseline for future projects.

Those interpreting these results should keep in mind that participants were aware that this was a one-time assignment. They volunteered to learn about Envision and are likely already interested in sustainability topics. However, Envision is also a voluntary tool, and those using it will likely be interested in considering sustainability in their design. These results are also based on engineering professionals' individually using the Envision system, making tradeoffs between design options. The authors cannot claim that the endowed version will similarly influence a team of professionals working together, nor can they report the influence of framing effects had participants been told why the decision is framed as a loss *prior to* using Envision. Finally, future research should incorporate complex tradeoffs between design considerations on sustainability (including time and budget constraints), which affect later decisions in project planning and design phases.

Conclusion

Infrastructure development requires deliberate design in conjunction with key stakeholder input. Understanding how the presentation of options in relation to others informs the decision process and can assist those developing decision aids, metrics, or project simulations to better inform decision making. Three decades of research in behavior science now enable more accurate predictions of decision outcomes based on the presentation of choices, framing effects, and loss aversion (among many other cognitive biases). In the case of Envision, the objective is to help users meet the highest levels of sustainability. The shift from a positive frame (only point gain options) to a positive/negative choice (gain/loss point options) empowered engineers participating in the study to set a higher sustainability goal. The endowed group was more likely to initially consider a higher level of achievement and tried not to lose points, as opposed to the standard group, who tried to earn points. The intervention induced a loss-averse response from participants and resulted in an increase in achievement by roughly 15%.

If participants reviewed all five categories and their scores were reflective of the findings from Quality of Life credits, the difference in score projects to 125 points. Such an increase can drastically affect project goals and possible outcomes. Suppose that different defaults led to just 15% better performance in the Envision credit "Reduce Greenhouse Gas Emissions." Applied to all U.S. infrastructure, this represents a reduction of over 2 billion tons of CO_2 [an estimate based on a per-capita carbon footprint of infrastructure of 53 t (Muller et al. 2013) and a U.S. population of 316 million]. Of course, infrastructure is not updated all at once. However, considering the successful cash-for-clunkers program invested roughly $3 billion and saved an upward estimate of no more than 30 million tons of CO_2 (Li et al. 2013), tweaking defaults in an infrastructure rating system appears relatively promising. This is just for one of the 60 Envision credits. Intentionally designed defaults might promise similar gains in the 59 other sustainability outcomes.

Numerous project considerations, as well as project phases, could have been studied, but Envision was used in this study because it provides a defined metric for sustainability and the levels of achievement allowed for inference into how engineers make decisions in relation to other design options. These findings suggest that engineers make tradeoffs between design choices and the conserving reference point reframes subsequent decisions. The authors intentionally isolated project considerations about sustainability to measure the outcome of the framing effect on a single variable: the number of points towards a sustainability goal. Subsequent iterations could involve modifying the order of questions/points in Envision. Rather than progressing through the decision-making process based on topical ordering of points, as is currently the case in Envision, points could be rearranged within each of the five categories so that those requiring the largest tradeoffs were asked first. A similar approach has shown promise in consumer decisions for car configurations (Levav et al. 2010). Another area for future research is applying the assertion of value outcomes described in Prospect theory. Value outcome states that a gain in value closer to the starting point appears greater than a value further from the starting point. For instance, winning $200 rather than $100 has a greater impact that winning, say, $1,200 compared to $1,100. The difference is the same, but the $100 appears greater relative to the lesser winnings. Similarly, Envision rewards points from the reference point. Changing the scale of points between levels of achievement may influence motivation to achieve more, or less. A score further from the reference point should hold a greater relative difference than points closer to the reference in order to have the same cognitive effect. Future research with Envision could explore a change in the point scale that aligns with value-outcome models. The authors hope that such studies will motivate future research examining how similar interventions affect complex tradeoffs in later project phases.

Observing how tools like Envision influence decisions throughout a project could offer new insight into infrastructure delivery and decision making. In cities like Berkeley, California, the framing effect may change which projects are granted funding. Alternatively, a similar intervention may influence multicity projects like the LOSSAN rail corridor. By observing how a change in a rating system affects goal setting, and how these goals translate to project outcomes, it is possible to learn more about how relatively small interventions affect long-term sustainability outcomes.

Research in behavior science can support infrastructure researchers to better understand complex decisions, stakeholder tradeoffs, and the influence of cognitive biases on choice structures. Rating systems like Envision (and the EPA's EnergyStar and the U.S. Green Building Council's LEED) are filled with choice structures. Those framing these and other decisions within the infrastructure development process need to understand how decisions are made, and when appropriate, apply interventions to help guide users toward defined objectives. Choice structures influence how engineers interpret design options, and in turn, affect the design outcome. More interdisciplinary studies like this one are needed to describe how changes in choice structure can aid infrastructure delivery.

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