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A story induces greater environmental contributions than scientific information among liberals but not conservatives

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Summary

Scientific evidence that links human activities to environmental damage frequently fails to motivate people to act. Meanwhile, research on emotion, imagery and identifiable victims has found these factors to influence behavior, and scientists and environmentalists are increasingly advocating for the use of narratives depicting personal stories of loss. We tested the behavioral effects of a narrative compared to scientific facts in a randomized field experiment with over 1,200 adults in a polluted urban watershed. Prior to making real purchase decisions about landscaping products that reduce nutrient runoff, consumers saw either scientific information about runoff's impacts or a narrative with tenuous scientific foundations. When exposed to the narrative rather than scientific information, consumers were willing to pay 11% more (CI 95%[4%, 18%]). This average effect, however, masks heterogeneity by political affiliation. While Democrats paid more after reading the narrative, Republicans paid less by roughly the same amount.

Keywords: environmental decisions, field experiment, behavioral science, nutrient pollution, science communication, water quality

Introduction

The contributions of human activities to environmental change, and the subsequent consequences for human well-being, have been well-documented by international scientific panels and assessments (e.g., MEA[1], IPBES[2], and IPCC[3]). In their reports, and in the articles that comprise their sources, information is provided in statistical and quantitative terms, describing impacts over large spatial and temporal scales and in probabilistic language.

Some of the most iconic shifts in environmental stewardship, however, have occurred not in response to novel scientific findings but to media stories that engender concern and compassion. The publication of *Silent Spring* has been directly linked to stronger controls on the use of agricultural pesticides, despite awareness of the ecological impacts of pesticides within the scientific community for decades[4]. "Frightening" media coverage of stories on health risks from Love Canal, New York sparked public outcry and government intervention in spite of contrary scientific evidence[5]. The death of the African lion, Cecil, rallied millions to advocate for species conservation, even though the effects of poaching on African wildlife had been widely published for years[6]. Scientists are now advocating for greater use of emotion and narrative to improve science communication[7,8].

Behavioral science offers insights into why such narratives may attract attention in ways that statistical information does not. Humans make decisions as if guided by two systems: one fast, emotional and intuitive; the other slow, rational and cognitive[9]. People's motivation and ability to process the information provided can determine which of the two systems dominates[10]. When factors like personal relevance, focus, and message comprehensibility are low, people tend to be more sensitive to peripheral cues and rely on their fast, automatic system. For example, perceptions of climate change are influenced by local weather, which is easily available in the mind, rather than data on global climate patterns, which is complex and abstract[11]. These intuitive responses can be elicited by framing information in ways that make certain aspects salient[12].

Narratives, which describe a cause-and-effect sequence of events involving characters over time, tend to be rich in imagery and emotionally engaging[13]. The identification of characters in narratives also points to a potential mechanism behind their effects: a large body of research on charitable giving shows a modest but consistent behavioral effect from describing a single, identified victim rather than a larger number of statistical victims, known as the 'identifiable victim effect'[14]. Imagery and emotion are similarly well established as influencers in decision making[15–17]. The use of identified characters, imagery and emotion make narratives persuasive communication tools, a benefit recognized and advocated for by some scientists[18].

Despite these characteristics, it is unclear how much narratives can change individual behaviors that contribute to global environmental challenges in comparison to scientific information typically used by practitioners to frame environmental problems. To our knowledge, research on the identifiable victim effect has not addressed its impact on environmental behaviors. Studies of climate change communication report that emotions, especially negative affect, are associated with risk perceptions, policy support, and adaptation behavior[19–21], but this research is largely observational and cannot establish a causal link without strong assumptions[22] (for exception, see Schwartz and Loewenstein[23]). One study tests the effect of a narrative on climate change beliefs[24], but its outcome measure (beliefs), study population (from Amazon Mechanical Turk) and comparison condition (a word-sorting activity) do not capture the real-world contrast between using narrative or scientific information to frame environmental problems and influence behavior.

The reliance on observational studies and self-reported measures of attitudes, values and intentions makes it difficult to quantify the relationship between efforts to change behavior and the environmental outcomes that matter. While there is some experimental evidence of framing effects on pro-environmental behaviors, there is a paucity of studies with large samples[25,26]. Underpowered empirical designs and publication biases against null effects have led to a proliferation of scientific publications with exaggerated claims about the magnitudes of causal relationships[27]. Given repeated calls by experts to use narratives in science communication, it is important to build a body of research with precise estimates of framing effects and construct validity for how narratives affect behavior compared to the status quo and for whom.

In order to address these gaps, we implemented a large-sample field experiment with real, costly actions for environmental protection. We measured the behavioral impacts of moving from a status quo framing, which emphasized scientific information, to a narrative framing, which emphasized an emotional story about an identifiable victim. We estimated the effect of this change in framing on people's actions to improve water quality in a polluted urban watershed, and how those effects vary for different groups (see registered pre-analysis plan here: https://osf.io/wj39f).

With a sample of 1,239 adults who maintain lawns or gardens, we elicited willingness-to-pay in a random-price auction for landscaping products that reduce nutrient pollution. Before expressing their values for these products, participants were randomly assigned to one of two framing treatments. To enhance the external validity of our results, we attempted to mimic framing constructs that are used by environmental advocates. In the “narrative” framing, participants saw a story about a man's death that had plausible, but tenuous, connections to nutrient pollution. In the “scientific information” framing, participants saw an evidence-based description of the impacts of nutrient pollution on ecosystems and surrounding communities.

We also explore whether the effect of the narrative on pro-environmental behavior is moderated by the participant's gender or political partisanship (both moderators were pre-registered). The influence of these two attributes is important given persistent claims of gender and partisan divides in attitudes towards environmental issues and how such issues are framed. Framing environmental impacts with scientific information is thought to dissuade conservatives[28], while liberals are perceived as more sensitive to human suffering[29]. Whether these attitudinal divides imply behavioral divides is unclear. For example, despite divergent partisan attitudes towards environmental problems[30,31] and contrasting moral foundations in shaping those attitudes[32], field experiments with large sample sizes have found little difference in the behavioral responses to norm-based environmental messages between Republicans and Democrats in the United States[33,34]. Similarly, gender differences in affective processing and orientation[35] and in pro-environmental values and attitudes[36] suggest certain narratives may influence environmental behavior differently among women than men, but we know of no test of this hypothesis.

Results

Participants were willing to pay an average of $7.10 for the landscaping products offered (Table 1). A total of 737 participants (59%) purchased a product, having expressed a willingness-to-pay that exceeded the randomly selected price.

For each product (Table 1, Figure 1), and for the products overall (Table 1, Figure 2), participants who read the narrative were willing to pay more, on average, than those who read the scientific information. The narrative induced participants to increase the amount they were willing to pay by $0.77, or 11% (95% CI [$0.27, $1.27], $p < 0.01$; Table 3); a standardized effect size of 0.17 standard deviations. The estimates are similar ($0.76-$0.86) if we use alternative estimators that make different assumptions about the data generating process (see Figure S1 and Table S1 in *Supplementary Information*).

The effect of the narrative is moderated by political partisanship (Figure 3). The narrative increased willingness-to-pay among liberals by $1.17 (95% CI [$0.41, $1.93]), but decreased willingness-to-pay among conservatives by $1.05 (95% CI [-$2.21, $0.11]), compared to the scientific information. The difference in the subgroup treatment effects is $2.22, or 31% of the overall mean (95% CI [-$3.54, -$0.90], $p < 0.001$; Table 2). This difference is statistically significant using the Benjamini-Hochberg procedure to control for multiple comparisons in our moderator analysis. We did not detect an effect of gender on response to the narrative. The point estimate is positive ($0.24), suggesting that willingness-to-pay is higher among women in the narrative framing compared to scientific information, but it is imprecisely estimated (95% CI [-$0.62, $1.10], $p = 0.58$) (Table 2).

Discussion

In comparison to scientific information about environmental damage, a narrative about a deceased individual caused people to bear additional private costs to reduce their impact on the environment. This effect of a simple change in framing adds to a growing body of research implying that insights from behavioral science may offer a new toolkit to help address environmental challenges[37,38].

Nevertheless, the narrative did not outperform scientific information among all people. Although we were unable to detect any moderating effect of gender, our results imply that narratives may be more effective than scientific information in generating pro-environmental behavior among liberals; among conservatives, however, the effect is reversed, by roughly the same amount.

This heterogeneity by party affiliation aligns with previous work that found liberals to associate emotion with “acting green”[39] and to express greater environmental concern as a result of moral foundations related to caring for and protection of others[32]. Considering the political polarization of environmental issues in the United States[40], narratives may ‘preach to the choir’ and fail to engage, or even repel, citizens who are less environmentally conscious. This result also highlights the importance of examining how behavioral effects vary by context and participant attributes. The average treatment effect we observed was driven largely by our predominantly Democratic sample. In a predominantly Republican population, the scientific information framing would be expected to do better, on average, than the narrative.

Although we labeled our treatment as a "narrative," we are not claiming to have isolated and quantified the mechanisms through which it operated. As in most field experiments, our treatment is an amalgam of information, messenger, and context. The treatment may have elicited emotional reactions, such as fear or sadness, that have shown to influence behavior[15]. The effect may have also stemmed from an intuitive response to the number of victims in the two treatments[41]. For those who read the scientific information, the scale of the problem was perhaps so large—with millions affected by poor water quality—that any one effort to reduce nutrient pollution appeared negligible. Whereas those who read the narrative, which described only a single victim, may have felt their actions could make a difference in preventing the death of another individual in the future. The damage described in the narrative and the accompanying photo may have also been easier to empathize with compared to statistical descriptions of damages[16]. Participants may have also reacted to the easy-to-understand terminology in the narrative. As an example, people reduced beef consumption following newspaper articles describing an outbreak of "Mad Cow" disease, but not after articles used the scientific label of the same disease[42]. Rather than employing multiple treatment arms across our sample to explore these plausible hypotheses about mechanisms, we prioritized statistical power and mimicking real-world communications strategies. Future research could investigate which aspects of this specific narrative and scientific information influenced behavior, as well as whether effects change with different products or environmental contexts.

Open questions

Our study offers causal evidence of how shifting from science-based framing to narrative framing can affect actual, rather than self-reported, behaviors that have private costs and private and public benefits (i.e., impure public goods), and how this framing effect can vary by partisan affiliation. Yet important questions remain about how reframing environmental challenges might matter in practice. For one, we do not know whether the observed effect will persist over time or if it is scalable. There is evidence that the behavior-change effects of emotional appeals can dissipate after immediate exposure[23]. Similarly, the attention and feelings that fuel the intuitive response to stories have been reported to be difficult to sustain over the long term and for large numbers of victims[43]. We also do not know how responses might differ in a more natural consumer environment, where people's attention is less guaranteed and sensitive to the observation of experimenters. Future experiments might replicate our design over longer time periods, with repeated exposure to the framing, or as a natural field experiment in which participants are unaware of their role in research.

Moreover, our results do not suggest that similar narratives would necessarily induce socially desirable behaviors. Memorable stories feed into heuristics and biases in evaluating probabilities[44]. If that information is not representative, people may under- or over-estimate the likelihood of some event. For example, a vivid story about an atypical individual who abused the social welfare system led to negative judgments of welfare recipients, while statistical information explaining average characteristics did not change opinions[45]. Leveraging emotionally charged frames could also lead to non-optimizing behavior if people react more strongly in the moment than they would after deliberation. Vivid and emotional framing of risk, such as protection from "terrorist attacks," induced people to pay more for hypothetical travel insurance than for protection against "all possible causes," which includes terrorism and other—more likely—travel risks[46].

People may also perceive narratives as manipulative, simplistic, misleading, or fatiguing[47]. Hitching complex problems to single stories makes them vulnerable to debunking or misuse, as has happened when attributing isolated weather events to climate change[48]. Given calls to "decode science to a narrative that generates feeling"[8], these potential side effects warrant more research.

Lastly, we should consider the cost-benefit of employing such strategies. At face value, achieving a nearly one-fifth of a standard deviation change in behavior at zero financial cost makes for an appealing policy tool. But there are nonmonetary costs to leveraging emotion and single stories. Certain narratives may create negative utility by making people sad or unsettling environmental practitioners and scientists who doubt their credibility[49]. These costs should be weighed against the benefits of the environmental action.

The complexity and psychological distance of global environmental challenges are at odds with the processes of everyday decision making. Reframing these problems using narratives can encourage some people to make choices that are better for the environment. Yet, the range of unknowns and potential for unintended consequences warrant caution. Future research may fill knowledge gaps, but there are also ethical questions. In the face of global environmental challenges that may threaten future prosperity, can harnessing people's humanity be justified if it aligns their individual actions with the interests of society, both current and future?

Experimental Procedures

Resource Availability

Lead Contact

Further information and requests for resources should be directed to and will be fulfilled by the Lead Contact, Paul Ferraro (pferraro@jhu.edu).

Materials Availability

This study did not generate new unique materials.

Data and Code Availability

The pre-analysis plan, experimental data and code that support the findings of this study are available on Open Science Framework on our project site: https://osf.io/wj39f

Study Design

Sample

We tested the effect of framing on willingness-to-pay for landscaping products that reduce nutrient runoff with a sample of adult residents in the Delaware River Basin who maintain lawns or gardens. The Delaware River Basin spans 13,539 square miles from southern New York to the Delaware Bay and is home to more than 8 million people who both rely on and affect its water quality[50]. Urban watersheds like the Delaware River Basin are increasingly polluted by excess nutrients from private land management decisions[51]. Household actions, such as fertilizing lawns, have increased nitrogen and phosphorus loads through surface runoff[52].

Recruitment for the study occurred at thirteen locations (e.g., Department of Motor Vehicles) and events (e.g., Delaware Ag Day) in the Delaware River watershed between April and July 2017.

In order to participate, individuals were required to be at least 25 years old and self-report maintaining or making decisions regarding a lawn or garden.

Methods

Participants (n = 1239) were provided electronic tablets with the Software Platform for Human Interaction Experiments (SoPHIE) to engage with the study[53] and, although they could see other participants, they were spatially separated. After confirming eligibility, participants were shown a photo and a text block that framed the problem of nutrient pollution in one of two ways. These distinct message frames acted as the experimental treatment in this study. Participants were randomly assigned to treatment at the participant level when a participant logged on to the tablet.

After receiving the treatment, participants watched a five-minute video explaining how the price would be selected for a product, and the advantage of revealing their true values for the landscaping products offered. Next, participants were shown, in random order, four landscaping products that reduce nutrient runoff: slow-release fertilizer, biochar, a soaker hose, and a soil test kit. These items were selected because they have been advocated for household use by the Delaware Center for the Inland Bays, established in 1994 by the U.S. Congress as one of the 28 National Estuary Programs. The details and environmental benefits of each product, as well as a small product photo, were provided to participants (Figures S2 and S3). Participants were told that only one of the four products would be randomly selected for potential purchase, but not until the participant had revealed her willingness-to-pay for all of the products. Participants were instructed to treat each product purchase decision independently because only one would "count" (i.e., they were not constructing a portfolio of products; they would only go home with a maximum of one product). Yet they should take each decision equally seriously because they would not know, a priori, which decision would be binding.

Participants set their value for each product at an amount between $0 and $15. After revealing their values for all four products, participants provided personal information, including age, gender, and address. Finally, participants were informed of the randomly selected product and price. If this price was lower than their revealed value for that product, participants received the product and their original compensation minus the price. If the randomly selected price was higher than their revealed value, participants received the full $15 compensation and no product. All participants complied with the payment rules.

Another study from this experiment tested whether a default starting value of $15 influenced participants' values compared to a starting value of $0 (an 'anchoring effect') and whether participants' awareness of the default affected their values. This manipulation was randomized separately from the framing treatments and is controlled for in the analysis.

This research was approved by Johns Hopkins University, Protocol Number: HIRB00005242 for the project titled, "Inducing Behavioral Change among Residents to Improve the Environmental Quality of the Delaware River Watershed: A Behavioral Science Approach." All participants gave informed consent of their participation in the study.

Value Elicitation

To obtain people's values for nutrient runoff-reducing products, we used a random-price auction—a pricing method that gives participants a strong incentive to reveal their true values[54]. First, a participant revealed the highest amount she would be willing to pay for a product. Then the product price was randomly chosen from a uniform distribution between $0.25 - $11.00, in increments of $0.25. If the participant's revealed value for the product was more than the randomly drawn price, the participant bought the product for the drawn price; otherwise, the participant did not get the product.

Because the value revealed by the participant does not affect what price she pays, but only whether she pays for and receives the product, a participant can never do better than simply revealing her true value (i.e., truth-telling is a weakly dominant strategy). Participants have no incentive to understate their true values. In this case, if the randomly selected price falls between a participant's expressed value and her true value, she would miss an opportunity to purchase the product at a price lower than her true value. Similarly, there is no incentive to overstate the value because then the participant may end up paying for a product at a higher price than her true willingness-to-pay. These incentives were explained to participants in an animated video.

Compensation for participation, which took about 15 minutes, was $15. Through the random-price auction, participants purchased the landscaping products offered or kept the full amount of their compensation, making this an actual purchase decision. All products had a similar market value of about $12 at retail stores.

Experimental Treatments

Before revealing their values, participants were provided brief text that framed the problem of nutrient pollution. They were randomly assigned to see one of two versions: scientific information or narrative. The exact treatments are provided in Figure S4 in *Supplemental Items*.

The scientific information is the baseline status quo, as it represents the way experts—scientists and practitioners—typically communicate environmental problems. It described the importance of the Delaware River Basin, statistics associated with its poor water quality, and impacts on ecosystems, humans, and other species. Content was sourced from public-facing information from government agencies and local news sources.

The narrative is the intervention, and represents an approach used by the media and increasingly advocated for by scientists and practitioners[7,8]. The narrative told the story of an upstanding citizen from the Delaware River Basin who died from an illness contracted through contact with a water-borne pathogen in coastal waters. The narrative included a statement about the potential link between the pathogen and water pollution, which had been published by the Chesapeake Bay Foundation. Although nutrient pollution is a proven contributor to the growth of this pathogen, attributing its presence and, particularly, the man's death to nutrient pollution would be scientifically challenging. This sort of tenuous connection is often the case in cause-and-effect narratives about environmental damage.

Participants in both treatments were informed that nutrient pollution is caused in part by water running off residential lawns and gardens. Both texts concluded with the phrase, "By using bay friendly landscaping products, you can reduce the nutrient runoff from your property."

Participants expressed values for all products, and these values served as our outcome measures. Assuming participants followed the dominant strategy of revealing their true value for the products offered, these values are participants' willingness-to-pay for the pollution-reducing products. We also tested whether the treatment effect was moderated by gender or partisanship.

Main Analysis

The outcome (dependent) variable is a participant's expressed value for a product. To estimate the treatment effect of the narrative on willingness-to-pay, we used ordinary least squares (OLS) linear regression. Because each participant expressed a value for four products (i.e., not all the values are independent observations), we pooled the values for all products and estimated standard errors clustered at the participant level. Because our dependent variable is continuous (in increments of $0.25) but bounded by the minimum ($0) and maximum ($15) a participant could offer to pay for a product, we also estimated a fractional generalized linear model and a Tobit model (with censoring at $15) to test the robustness of our OLS results (again with clustered standard errors). We tested the null hypothesis that there is no difference in willingness-to-pay between the two framing treatments and constructed 95% confidence intervals of the difference.

We specified our main and moderator analyses, and pre-registered our analysis on Open Science Framework prior to examining the data and conducting the analysis herein. To conduct a power analysis, we ran simulations based on data collected in an earlier experiment that used similar products and a similar elicitation procedure[55]. The analysis indicated that, with a sample size of 1200 participants, we could detect an effect of 0.14 standard deviation with 80% power and a Type 1 error rate of 5%.

Partisanship Moderator Analysis

For Delaware residents, which comprise more than 80% of our sample, we developed a measure of partisanship by matching participants' name, age and zip code with public data on party registration[33]. The participant was considered politically conservative if registered with the Republican party, or liberal if registered with the Democratic party. Participants were otherwise classified as independent (registered, but not with the Democratic or Republican party) or unregistered (no match in the voter data). We included interaction terms for the narrative and all partisan categories except liberal (Democrat). Therefore, results from the partisanship regression are for conservatives compared to a liberal baseline. To control the false positive rate in multiple comparisons, we used the Benjamini-Hochberg procedure with a false discovery rate of five percent[56].

We checked the representativeness of our sample by comparing age and party registration against those of the Delaware population using data from the U.S. Census Bureau and the State of Delaware Elections System Program. The average age of Delaware residents in our sample is 48 years old, which is slightly younger than the average age of all adults 25 years and older in Delaware (52), but similar to adults 25-74 years (49). The distribution of partisanship, which is

17% conservative (Republican) and 45% liberal (Democrat), is close to what would be expected given party registration in Delaware (25% Republican; 43% Democrat).

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Author Contributions

Conceptualization, H.B., P.F., T.L., K.M., and C.W.; Methodology, P.F., T.L., K.M., and C.W.; Investigation, C.W.; Analysis, H.B.; Writing – Original Draft, H.B. and P.F.; Writing – Review & Editing, H.B., P.F., T.L., K.M., and C.W.; Visualization, H.B.; Funding Acquisition, P.F. and K.M.; Supervision, P.F..

Declarations of Interest

The authors declare no competing interests.

Inclusion and diversity

One or more of the authors of this paper self-identifies as an underrepresented ethnic minority in science. One or more of the authors of this paper self-identifies as a member of the LGBTQ+ community. One or more of the authors of this paper received support from a program designed to increase minority representation in science.

References

1. Millennium Ecosystem Assessment (2005). Ecosystems and Human Well-being: Synthesis (Island Press).

2. IPBES (2018). The IPBES regional assessment report on biodiversity and ecosystem services for the Americas. (Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services).

3. IPCC (2018). Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty (World Meteorological Organization).

4. Dunn, R. (2012). In retrospect: Silent Spring. Nature *485*, 578–579.

5. Kuran, T., and Sunstein, C.R. (1998). Availability Cascades and Risk Regulation. Stanford Law Review *51*, 87.

6. Care2 Sign Petition: Demand Justice for Cecil the Lion, Killed in Zimbabwe! https://www.thepetitionsite.com/821/738/351/demand-justice-for-cecil-the-lion-in-zimbambwe/.

7. National Academies of Sciences, Engineering, and Medicine (2017). Communicating Science Effectively: A Research Agenda (National Academies Press).

8. Martinez-Conde, S., and Macknik, S.L. (2017). Opinion: Finding the plot in science storytelling in hopes of enhancing science communication. PNAS *114*, 8127–8129.

9. Kahneman, D. (2003). Maps of Bounded Rationality: Psychology for Behavioral Economics. The American Economic Review *93*, 1449.

10. Petty, R.E., and Cacioppo, J.T. (1986). The Elaboration Likelihood Model of Persuasion. In Advances in Experimental Social Psychology (Academic Press), p. 83.

11. Zaval, L., Keenan, E.A., Johnson, E.J., and Weber, E.U. (2014). How warm days increase belief in global warming. Nature Climate Change *4*, 143–147.

12. Tversky, A., and Kahneman, D. (1981). The framing of decisions and the psychology of choice. Science *211*, 453–458.

13. Epstein, S. (1994). Integration of the cognitive and the psychodynamic unconscious. American Psychologist, 709–724.

14. Lee, S., and Feeley, T.H. (2016). The identifiable victim effect: a meta-analytic review. Social Influence *11*, 199–215.

15. Slovic, P., Finucane, M.L., Peters, E., and MacGregor, D.G. (2007). The affect heuristic. European Journal of Operational Research *177*, 1333–1352.

16. Slovic, P., Västfjäll, D., Erlandsson, A., and Gregory, R. (2017). Iconic photographs and the ebb and flow of empathic response to humanitarian disasters. Proc Natl Acad Sci U S A *114*, 640–644.

17. Lerner, J.S., Li, Y., Valdesolo, P., and Kassam, K.S. (2015). Emotion and decision making. Annu Rev Psychol *66*, 799–823.

18. Dahlstrom, M.F. (2014). Using narratives and storytelling to communicate science with nonexpert audiences. PNAS *111*, 13614–13620.

19. Leiserowitz, A. (2006). Climate Change Risk Perception and Policy Preferences: The Role of Affect, Imagery, and Values. Climatic Change *77*, 45–72.

20. van der Linden, S. (2014). On the relationship between personal experience, affect and risk perception:The case of climate change. European Journal of Social Psychology *44*, 430–440.

21. van Valkengoed, A.M., and Steg, L. (2019). Meta-analyses of factors motivating climate change adaptation behaviour. Nature Climate Change *9*, 158.

22. Chapman, D.A., Lickel, B., and Markowitz, E.M. (2017). Reassessing emotion in climate change communication. Nature Climate Change *7*, 850.

23. Schwartz, D., and Loewenstein, G. (2017). The Chill of the Moment: Emotions and Pro-environmental Behavior. Journal of Public Policy & Marketing.

24. Gustafson, A., Ballew, M.T., Goldberg, M.H., Cutler, M.J., Rosenthal, S.A., and Leiserowitz, A. (2020). Personal Stories Can Shift Climate Change Beliefs and Risk Perceptions: The Mediating Role of Emotion. Communication Reports *33*, 121–135.

25. Byerly, H., Balmford, A., Ferraro, P.J., Hammond Wagner, C., Palchak, E., Polasky, S., Ricketts, T.H., Schwartz, A.J., and Fisher, B. (2018). Nudging pro-environmental behavior: evidence and opportunities. Frontiers in Ecology and the Environment *16*, 159–168.

26. Palm-Forster, L.H., Ferraro, P.J., Janusch, N., Vossler, C.A., and Messer, K.D. (2019). Behavioral and Experimental Agri-Environmental Research: Methodological Challenges, Literature Gaps, and Recommendations. Environ Resource Econ *73*, 719–742.

27. Gelman, A., and Carlin, J. (2014). Beyond Power Calculations: Assessing Type S (Sign) and Type M (Magnitude) Errors. Perspect Psychol Sci *9*, 641–651.

28. McCright, A.M., Dentzman, K., Charters, M., and Dietz, T. (2013). The influence of political ideology on trust in science. Environ. Res. Lett. *8*, 1–9.

29. Farwell, L., and Weiner, B. (2000). Bleeding Hearts and the Heartless: Popular Perceptions of Liberal and Conservative Ideologies. Pers Soc Psychol Bull *26*, 845–852.

30. McCarthy, J. (2016). Americans' Concerns About Water Pollution Edge Up (Gallup, Inc.).

31. Gustafson, A., Rosenthal, S.A., Ballew, M.T., Goldberg, M.H., Bergquist, P., Kotcher, J.E., Maibach, E.W., and Leiserowitz, A. (2019). The development of partisan polarization over the Green New Deal. Nat. Clim. Chang. *9*, 940–944.

32. Feinberg, M., and Willer, R. (2013). The Moral Roots of Environmental Attitudes. Psychol Sci *24*, 56–62.

33. Bolsen, T., Ferraro, P.J., and Miranda, J.J. (2014). Are Voters More Likely to Contribute to Other Public Goods? Evidence from a Large-Scale Randomized Policy Experiment. American Journal of Political Science *58*, 17–30.

34. Costa, D.L., and Kahn, M.E. (2013). Energy Conservation “Nudges” and Environmentalist Ideology: Evidence from a Randomized Residential Electricity Field Experiment. Journal of the European Economic Association *11*, 680–702.

35. Friesdorf, R., Conway, P., and Gawronski, B. (2015). Gender Differences in Responses to Moral Dilemmas: A Process Dissociation Analysis. Pers Soc Psychol Bull *41*, 696–713.

36. Xiao, C., and McCright, A.M. (2015). Gender Differences in Environmental Concern. Environment and Behavior *47*, 17–37.

37. Cinner, J. (2018). How behavioral science can help conservation. Science *362*, 889–890.

38. Zabala, A. (2018). Bridging behavioural science–policy gaps. Nature Sustainability *1*, 728.

39. van der Linden, S. (2018). Warm glow is associated with low- but not high-cost sustainable behaviour. Nature Sustainability *1*, 28–30.

40. McCright, A.M., Xiao, C., and Dunlap, R.E. (2014). Political polarization on support for government spending on environmental protection in the USA, 1974-2012. Soc Sci Res *48*, 251–260.

41. Jenni, K., and Loewenstein, G. (1997). Explaining the identifiable victim effect. Journal of Risk and Uncertainty *14*, 235–257.

42. Sinaceur, M., Heath, C., and Cole, S. (2005). Emotional and Deliberative Reactions to a Public Crisis: Mad Cow Disease in France. Psychol Sci *16*, 247–254.

43. Slovic, P. (2007). “If I look at the mass I will never act”: Psychic numbing and genocide. Judgment and Decision Making *2*, 79–95.

44. Tversky, A., and Kahneman, D. (1974). Judgment under Uncertainty: Heuristics and Biases. Science *185*, 1124–1131.

45. Hamill, R., Wilson, T.D., and Nisbett, R.E. (1980). Insensitivity to Sample Bias: Generalizing From Atypical Cases. Journal of Personality and Social Psychology *39*, 578–589.

46. Johnson, E.J., Hershey, J., Meszaros, J., and Kunreuther, H. (1993). Framing, Probability Distortions, and Insurance Decisions. Journal of Risk & Uncertainty *7*, 35–51.

47. Merry, M.K. (2010). Emotional Appeals in Environmental Group Communications: American Politics Research.

48. Plumer, B. (2019). How the Weather Gets Weaponized in Climate Change Messaging. The New York Times.

49. Allcott, H., and Kessler, J.B. (2019). The Welfare Effects of Nudges: A Case Study of Energy Use Social Comparisons. American Economic Journal: Applied Economics *11*, 236–276.

50. Hutson, S.S., Linsey, K.S., Ludlow, R.A., Reyes, B., and Shourds, J.L. (2016). Estimated use of water in the Delaware River Basin in Delaware, New Jersey, New York, and Pennsylvania, 2010 (U.S. Geological Survey).

51. Dubrovsky, N.M., Burrow, K.R., Clark, G.M., Gronberg, J.M., Hamilton, P.A., Hitt, K.J., Mueller, M.D., Munn, B.T., Nolan, L.J., Rupert, M.G., et al. (2010). The quality of our nation's waters-nutrients in the nation's streams and groundwater, 1992–2004 (US Geological Survey).

52. Hobbie, S.E., Finlay, J.C., Janke, B.D., Nidzgorski, D.A., Millet, D.B., and Baker, L.A. (2017). Contrasting nitrogen and phosphorus budgets in urban watersheds and implications for managing urban water pollution. PNAS *114*, 4177–4182.

53. Hendriks, A. (2012). SoPHIE-Software platform for human interaction experiments. University of Osnabrueck, working paper.

54. Shogren, J.F., Margolis, M., Koo, C., and List, J.A. (2001). A random nth-price auction. Journal of Economic Behavior & Organization *46*, 409–421.

55. Li, T., Fooks, J.R., Messer, K.D., and Ferraro, P.J. (2019). A field experiment to estimate the effects of anchoring and framing on residents' willingness to purchase water runoff management technologies. Resource and Energy Economics, 101107.

56. Benjamini, Y., and Hochberg, Y. (1995). Controlling the False Discovery Rate: A Practical and Powerful Approach to Multiple Testing. Journal of the Royal Statistical Society. Series B (Methodological) *57*, 289–300.

Figure Legends

Figure 1 Average willingness-to-pay for landscaping products that reduce nutrient runoff after participants read scientific information (yellow; n = 616) or a narrative (blue; n = 623) about poor water quality. Error bars represent standard errors of the mean. Mean and standard error values are from the OLS regression model that includes covariates.

Figure 2 Effect of framing on willingness-to-pay for landscaping products that reduce nutrient pollution. Values are the regression-adjusted means for all products from the OLS model including covariates ($n_{information}$ = 2464 values; $n_{narrative}$ = 2492 values). Error bars represent 95% confidence intervals.

Figure 3 Treatment effects of the narrative on willingness-to-pay (WTP) for landscaping products that reduce nutrient pollution conditional on political partisanship. Coefficients are from the OLS model that includes covariates. Sample is limited to participants from the state of Delaware (n = 1006). Error bars represent 95% confidence intervals.

Tables

Table 1 Descriptive statistics of the full sample and each treatment arm.

	Full Sample		**Scientific Information**		**Narrative**	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*
All products ($)	7.10	4.65	6.86	4.62	7.33	4.67
Fertilizer ($)	6.85	4.41	6.55	4.32	7.15	4.48
Biochar ($)	6.99	4.60	6.72	4.62	7.27	4.57
Soil test kit ($)	5.91	4.26	5.75	4.22	6.07	4.30
Soaker hose ($)	8.63	4.89	8.41	4.90	8.86	4.88
Age (years)	47.4	14.9	47.6	14.8	47.2	15.1
Female	0.55	—	0.58	—	0.52	—
Conservative	0.17	—	0.16	—	0.17	—
Liberal	0.45	—	0.46	—	0.44	—
Independent	0.17	—	0.16	—	0.18	—
Unregistered	0.21	—	0.22	—	0.21	—
Participants (count)	1239	—	616	—	623	—

Notes: The first five rows show the average revealed willingness-to-pay (USD $) for all four products per person (Total Number of Observations = 4956, Scientific Information = 2464, Narrative = 2492) and each individual product; Partisan categories are associated with party registration (see Methods) and have fewer observations because only Delaware residents were matched with party data (Full Sample = 1006, Scientific Information = 496, Narrative = 510). Female and partisanship values are proportions.

Table 2 Estimated average treatment effect of framing on willingness-to-pay for landscaping products that reduce nutrient runoff, and estimated average treatment effects conditional on gender or political partisanship.

	Average Treatment Effect	Conditional Average Treatment: Gender	Conditional Average Treatment: Partisanship
	(1)	(2)	(3)
Narrative	0.77**	0.63	1.17**
	[0.27, 1.27]	[-0.07, 1.34]	[0.41, 1.93]
Narrative * Female		0.24	
		[-0.62, 1.10]	
Narrative * Conservative			-2.22**
			[-3.54, -0.90]
Narrative * Independent			-0.63
			[-1.96, 0.70]
Narrative * Unregistered			0.36
			[-0.96, 1.67]
Constant	6.57	6.65	6.04
Participant characteristics	Yes	Yes	Yes
Session covariates	Yes	Yes	Yes
Participants	1,239	1,239	1,006
Observations in regression	4,956	4,956	4,024

Notes: The estimated effect is the difference in willingness-to-pay between the narrative framing and the scientific information framing. The estimated moderating effect of Conservative partisanship is the difference between registered Republicans and registered Democrats (omitted category). Ordinary least squares (OLS) estimation. Dependent variable is the willingness-to-pay (USD $) for one of four products. To increase the precision of the estimates, all specifications include controls for participant-level characteristics (gender, age, state of residence, and date and location of participation) and session covariates (additional treatments not in this study, product, and order in which products were presented). Column 3 (Partisanship) has fewer observations and does not include a state covariate because we only matched Delaware residents with partisanship data. Covariates for conservative, independent (not Democrat or Republican) and unregistered participants (not matched) were included in the Partisanship regression. Standard errors are clustered at the participant level. 95% confidence intervals in brackets.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Figure 1

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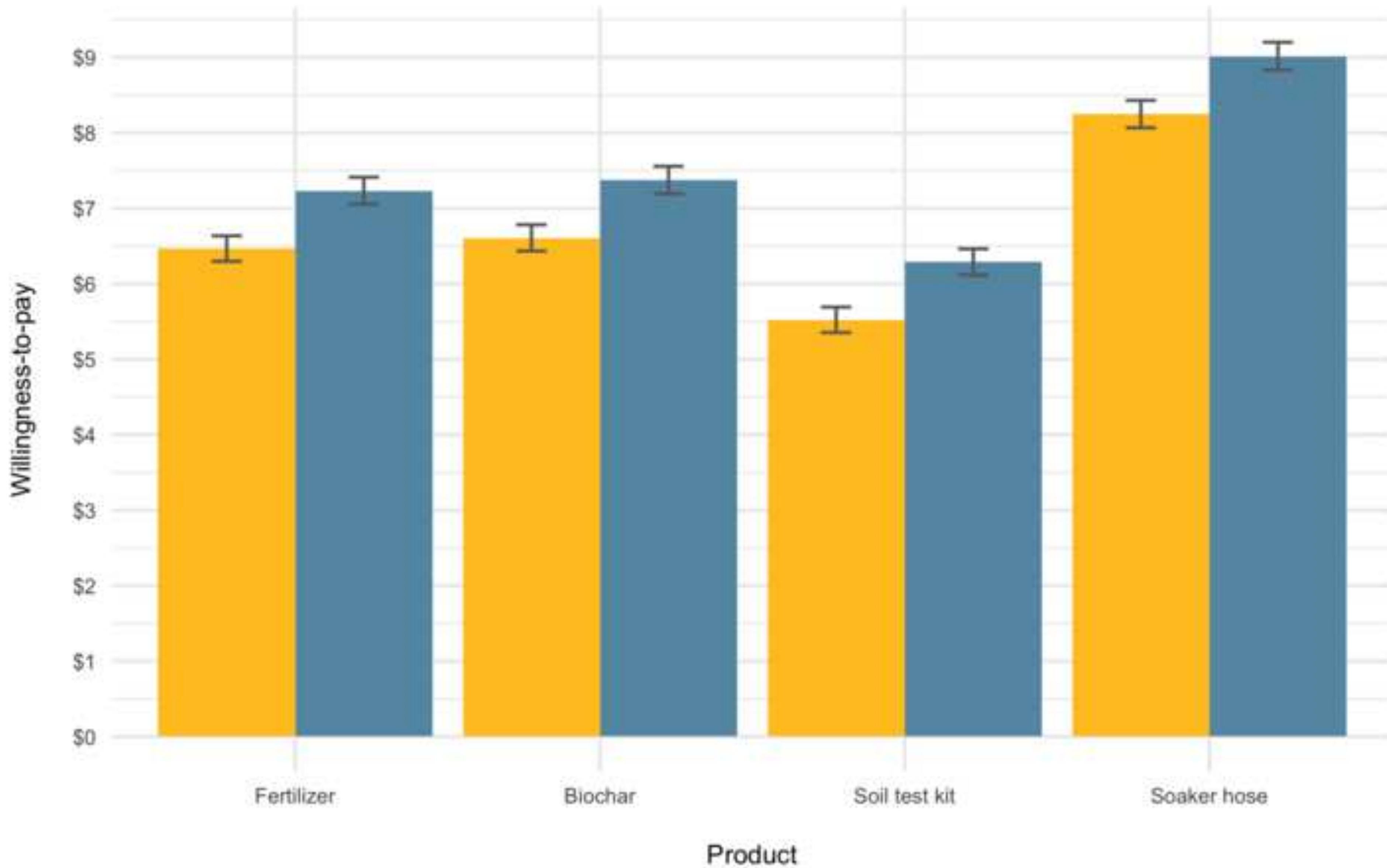


Figure 2 Click here to access/download;Figure;Figure2.tiff

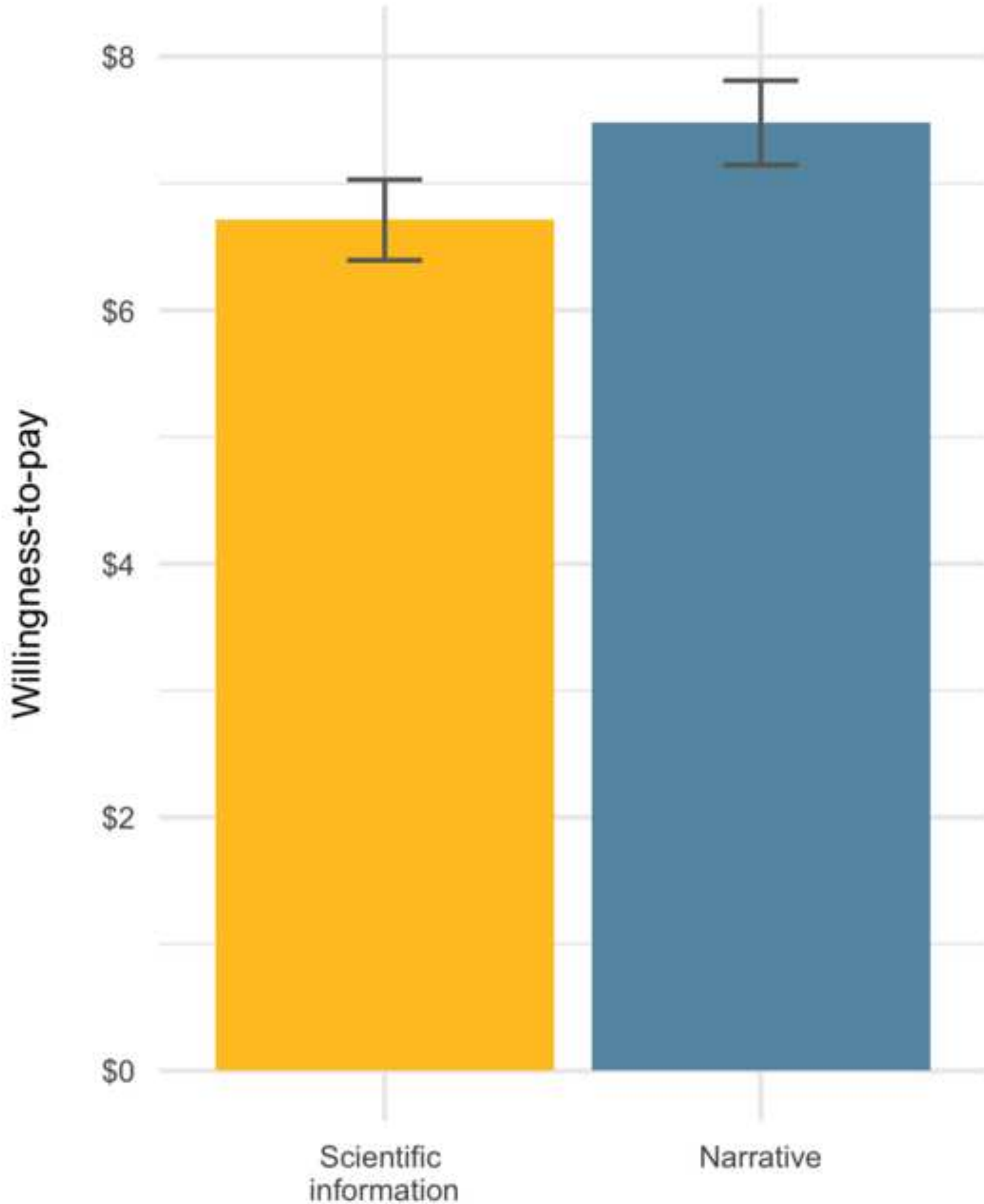
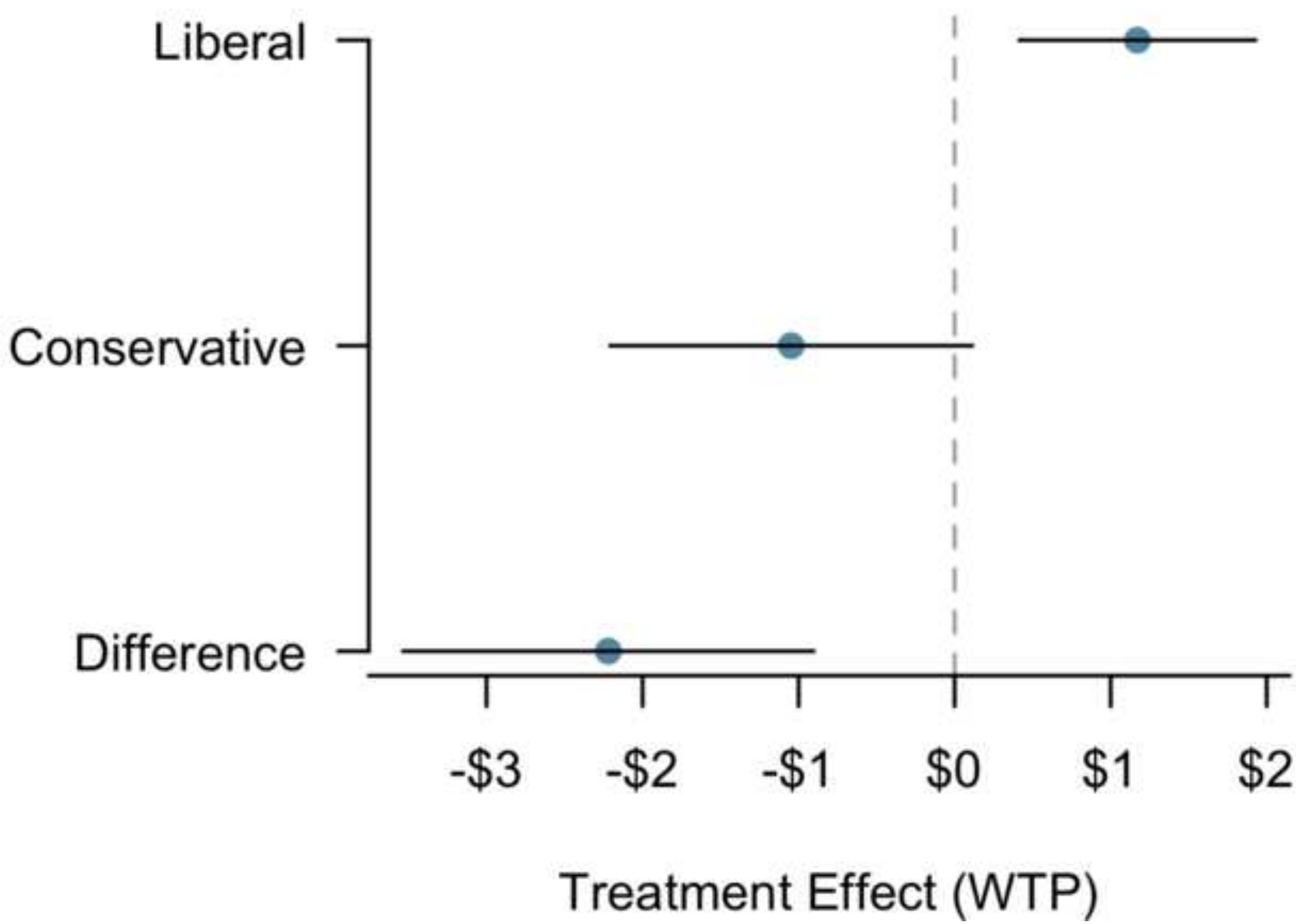


Figure 3


Liberal
Conservative
Difference
-$3
-$2
-$1
$0
$1
$2
Treatment Effect (WTP)

Supplemental Items

Table S1. Alternative specifications for estimating the treatment effect of a narrative compared to scientific information on willingness-to-pay for landscaping products that reduce nutrient runoff.

	(1)	(2)	(3)	(4)	(5)
Narrative	0.48^{*}	0.74^{**}	0.77^{**}	0.86^{**}	0.05^{**}
	(0.23)	(0.27)	(0.26)	(0.28)	(0.02)
Participant characteristics	No	No	Yes	Yes	Yes
Session covariates	No	Yes	Yes	Yes	Yes
Observations	4956	4956	4956	4956	4956

Dependent variable is participants' willingness-to-pay values (USD $) for landscaping products that reduce nutrient runoff (Columns 1-4) and proportion of the $15 maximum value (Column 5), pooling all values of the four products offered. Columns 1-3 show results from ordinary least squares (OLS) estimation, with Column 3 representing the estimator specified in the pre-registered analysis plan. Column 4 shows results from a Tobit model with an upper bound of $15 (9% of expressed values were at $15). Column 5 shows results from a fractional generalized linear model. Participant characteristics include gender, age, state of residence, and date and location of participation. Session covariates include controls for additional treatments not in this study, product, and order products were presented. Standard errors in parentheses, clustered at the individual level. $^{*}\ p < 0.05$, $^{**}\ p < 0.01$, $^{***}\ p < 0.001$

Notes: The change in the estimated effect between Column 1, with no controls, and the other columns, with controls, stems largely from the inclusion of the session variable that captures the order in which the products were presented. The value of that variable was imbalanced between the two treatment arms because the same randomization code was used for each session. Since many sessions were small, the same treatment combination was given to many participants, resulting in a correlation between the product order and treatment. Because we know the order in which each participant saw the products, we are able to fully control for this potential source of bias by including it as a covariate.

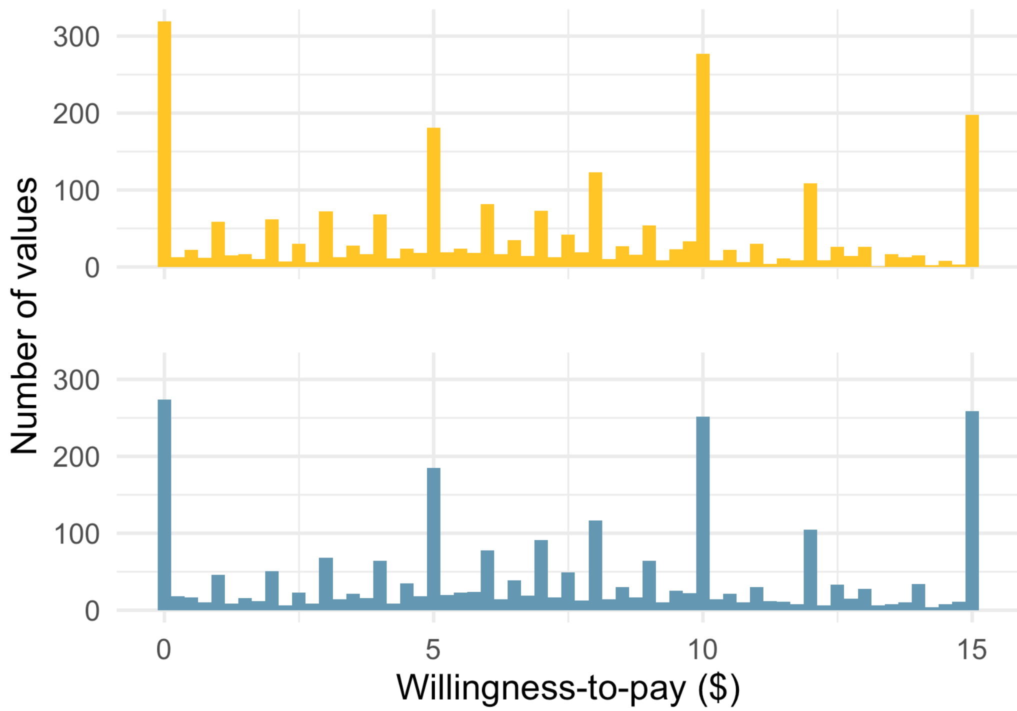


Figure S1. Distribution of values for nutrient-reducing products expressed by participants according to whether they viewed the scientific information (yellow, top) or narrative (blue, bottom) framing before expressing their values. Values were expressed in increments of $0.25 and limited to a maximum of $15.

Figure S2. Screenshots of the purchasing screen for the biochar (top) and slow-release fertilizer (bottom), two of the four products for which participants expressed their willingness-to-pay.

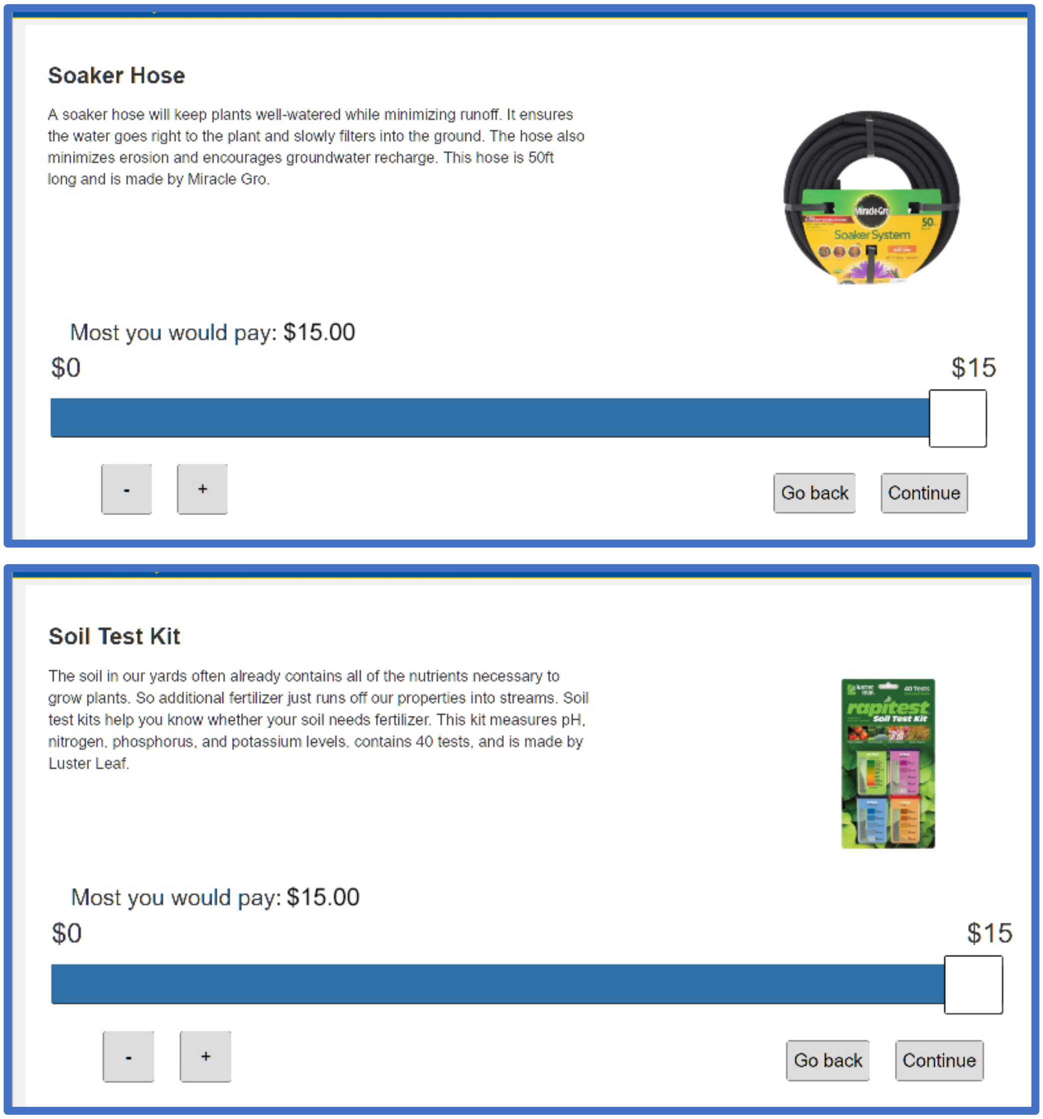


Figure S3. Screenshots of the purchasing screen for the soaker hose (top) and soil test kit (bottom), two of the four products for which participants expressed their willingness-to-pay.

Water Run Off from our Lawns and Gardens Causes Problems Downstream

The Delaware River watershed, where you are sitting right now, provides drinking water to 17 million people—roughly 6% of the population of the United States.

Scientists have designated over 8,000 miles of streams in the watershed as "impaired." Their water quality is so poor you cannot safely drink from them, fish or swim in them, or even use them for agriculture or industrial uses. A substantial part of this damage is caused by water running off our lawns, gardens and streets.

The runoff carries with it nutrients, like nitrogen and phosphorous. While these nutrients can help plants grow in our yards, nutrient-rich runoff can make drinking water unsafe and causes enormous algae growth in our lakes, streams and bays. These algae block the light for aquatic plants, which then die and literally remove oxygen from the water. Without oxygen, fish, crabs, oysters, and other aquatic animals die.

By using bay friendly landscaping products, you can reduce the nutrient runoff from your property that harms our aquatic plants and wildlife.

Sources: Delaware River Basin Commission, Delaware Online, National Oceanic and Atmospheric Administration, Philadelphia Water Department.

Go back Continue

Water Run Off from our Lawns and Gardens Causes Problems Downstream

John Doe was a Navy and police officer, as well as a business owner and chamber of commerce president. In his spare time, John helped the homeless and the Oxford SILO (Serving Inspiring Loving Others) project. Many expected John to become the Mayor of Oxford, PA, just 13 miles from Delaware.

But John died last summer from the flesh-eating Vibrio bacteria, which he received after being scratched by a crab trap and washing it out with bay water. According to the Chesapeake Bay Foundation, Vibrio grows from a "combination of warmer waters, nutrient pollution, and other factors". Nutrient pollution comes from water running off of our lawns, gardens and streets.

USA Today reports that the survival rate for an infection from *Vibrio* is only about 50%. Despite John's treatment at a Veterans Affairs clinic, local hospital and the University of Maryland Medical Center, he died just three days after getting his original scratch.

By using bay friendly landscaping products, you can reduce nutrient runoff from your property.

Sources: Chester County Press, USA Today

[photo of victim]

Go back Continue

Figure S4. Screenshots of the framing treatments participants received before expressing their willingness-to-pay for landscaping products. Scientific information (top) and narrative (bottom) frame the problem of nutrient pollution in different ways. The name and photo of the victim in the narrative have been redacted in this manuscript.