Metric and Scale Design as Choice Architecture Tools

Adrian R. Camilleri and Richard P. Larrick

Interest is increasing in using behavioral decision insights to design better product labels. A specific policy target is the fuel economy label, which policy makers can use to encourage reduction in carbon dioxide emissions from transport-related fossil-fuel combustion. In two online experiments, the authors examine whether vehicle preferences can be shifted toward more fuel-efficient vehicles by manipulating the metric (consumption of gas vs. cost of gas) and scale (100 miles vs. 15,000 miles vs. 100,000 miles) on which fuel economy information is expressed. They find that preference for fuel-efficient vehicles is highest when fuel economy is expressed in terms of the cost of gas over 100,000 miles, regardless of whether the vehicle pays for its higher price in gas savings. The authors discuss the underlying psychological mechanisms for this finding, including compatibility, anchoring, and familiarity effects, and conclude that policy makers should initiate programs that communicate fuel-efficiency information in terms of costs over an expanded, lifetime scale.

Keywords: choice, choice architecture, scale expansion, fuel economy, labeling metrics

In recent years, the extent, cause, and reaction to climate change has been a hot-button issue. Despite continued doubts among some members of the general public, scientists almost universally concur that anthropogenic climate change is occurring and will have a devastating impact on human civilization. The accumulation of greenhouse gases in the atmosphere, especially carbon dioxide (CO_2) produced from fossil fuel combustion, is the primary human cause of climate change. Transport, particularly passenger vehicle transport, is one of the main sources of CO_2 emissions. In light of this evidence, various policies have been advanced to reduce CO_2 emissions and curb the threats associated with climate change. In the context of passenger vehicle transport, one of the earliest and longest-lived policy tools has been to provide consumers with fuel consumption information through fuel economy labels.

In the current research, we examine how the manipulation of vehicle fuel economy labels' metric and scale information can shift consumer's preferences. We were especially interested in discovering what particular combination of metric and scale information produces the strongest preferences for fuel-efficient vehicles—and why. Our primary finding is that the provision of cost information shifts preferences toward fuel efficiency more strongly than the provision of consumption information, and the magnitude of this effect is amplified depending on the time scale used to describe the costs. This article's contributions are threefold. First, we extend previous label design research conducted in the contexts of nutrition and appliance energy efficiency to vehicle fuel economy and find the strongest preference for fuel-efficient vehicles when fuel economy information is presented as the cost of gas over 100,000 miles. Second, we reveal a new psychological mechanism contributing to the effect of scale changes on choice—specifically, anchoring on the provided scale—a phenomenon that may generalize to other domains. Third, we clarify that the benefits associated with an expanded cost metric work by increasing sensitivity to fuel economy information in general rather than to total costs in particular. Our results indicate a clear prescription: vehicle fuel efficiency should be expressed as the cost of gas over 100,000 miles of driving. We elaborate on this recommendation and others in the "General Discussion" section.

Adrian R. Camilleri is Postdoctoral Research Scientist (e-mail: adrian.camilleri@duke.edu), and *Richard P. Larrick* is Professor (e-mail: rick.larrick@duke.edu), Fuqua School of Business, Duke University. This research was supported by NSF grant SES 0951516 to the Center for Research on Environmental Decisions. The first author was also supported by an Australian Endeavour Fellowship received from the Australian Government. The authors thank Elke Weber, David Hardisty, and Joel Huber for helpful feedback. Josh Weiner served as associate editor for this article.

Literature Review

Climate Change as a Public Policy Issue

The scientific community agrees that the Earth's climate is changing, as observed in increases in global temperatures, ocean temperatures, sea level rise, and extreme weather events (Intergovernmental Panel on Climate Change [IPCC] 2007; Karl, Melillo, and Peterson 2009). Moreover, the evidence suggests that these changes can be attributed to humans' production of greenhouse gases. According to the IPCC, global atmospheric concentrations of the greenhouse gases, especially CO_2, now far exceed preindustrial values. Climate change poses risks for a range of human and ecological systems, including lost coastlines, fresh water stress, ecosystem destruction, animal extinction, and an increased number of natural disas-

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ters. The conclusion from all scientific evaluation is that greenhouse gas emissions must quickly be cut to avoid the worst-case climate change scenarios.

A key problem in motivating the required behavior change is that it is human nature to view the future as far less important than the present (Hardisty and Weber 2009). For example, most people prefer receiving $250 today to $300 in ten years. Such temporal discounting is often rational. The money received today could be wisely invested for a much greater profit over a decade than would be earned by waiting. Moreover, the future is full of uncertainty and unanticipated events that could render future promises of money irrelevant. In many cases, however, discount rates observed in research on intertemporal choice are highly myopic and can be detrimental to the person and to society (Thaler and Benartzi 2004). In the context of climate change, discounting can simultaneously diminish fear of future negative effects (e.g., natural disasters) while also diminishing the satisfaction associated with savings to be made in the future (e.g., after purchasing an efficient product).

The increasing consumption of fossil fuels for transportation is a major contributor of greenhouse gas emissions. The International Energy Agency (IEA) estimates that U.S. gasoline and diesel fuel consumption for transportation in 2011 resulted in the emission of 1,519 million metric tons of CO_2, approximately 28% of total U.S. energy-related CO_2 emissions (IEA 2009, 2012). Similar proportions exist for other member countries of the Organisation for Economic Co-operation and Development. Moreover, global demand for transport fuel is projected to increase by nearly 40% by 2035 (IEA 2009, 2012). Because transportation, and passenger transportation in particular, contributes such a large proportion of worldwide emissions, it has been a target of policy intervention. However, behavioral change in this purchase decision is challenging to implement because psychological discounting can make the delayed benefits associated with purchasing a fuel-efficient vehicle difficult to appreciate relative to the larger upfront cost that often comes with such a vehicle.

Labels as a Public Policy Tool

Energy labels—and, in many cases, the standards that accompany the labels—are often considered the best available tools for governments to manage energy-efficiency policies and climate-change-mitigation programs (Stern et al. 1987; Wiel and McMahon 2003). In light of this realization, many countries are reexamining the labels they use to communicate information about fuel efficiency.

One of the most important fuel economy label design decisions is the choice of which metric and scale to use to describe energy consumption. The U.S. fuel economy label reports a gas consumption metric that is tied to one scale (100 miles). The label also reports a cost metric that is based on a different scale (15,000 miles). Although there has been little academic work examining the effectiveness of different combinations of vehicle fuel efficiency metrics and scales, relevant research exists in the areas of nutrition labels and appliance energy labels.

In the domain of nutrition labels, researchers have investigated the impact of providing information about different metrics—such as amount of a substance versus the health consequence—over different scales, such as one serving, per 100 grams, and as a percentage of recommended daily intake scales (for reviews, see Campos, Doxey, and Hammond 2011; Hieke and Taylor 2012). Similarly, in the domain of appliance energy efficiency, researchers have investigated the impact of providing information about energy consumption versus energy cost over single use, annual, and lifetime scales (for a review, see Kaenzig and Wüstenhagen 2010).

These literature streams highlight an increasing interest in metric and scale label design. Importantly, however, the existing research on nutrition and energy efficiency does not translate to fuel economy for at least two reasons. First, as we expand on in the sections that follow, these research domains remain inconclusive. Second, automobiles are sufficiently different from nutrition and energy efficiency fields in both financial and environmental impacts as to make them incomparable. Specifically, vehicles are very rare purchases that represent one of the main sources of individual CO_2 emissions. Moreover, vehicles are associated with much more uncertainty because of variability in the price of fuel over time. Thus, in this research, we systematically explore the effect of presenting different combinations of metric and scale to gain a better understanding of the effectiveness of these two label features.

Choice Architecture as a Public Policy Tool

Our approach to this important problem is inspired by an increased research interest in using behavioral insights derived from psychology to modify "choice architecture" (Thaler and Sunstein 2008). The key principle of this approach is that choices are never made in a vacuum; they are always made in a context. For example, the choice of which product to purchase might be made in the context of a product review magazine. Importantly, the magazine's analysts decide on the characteristics on which the products will be ranked. Therefore, in this example, the product characteristics and their weighting are part of the "choice architecture," and the magazine's analysts are the "choice architects" (Johnson et al. 2012; Thaler and Sunstein 2008). More generally, choice architecture refers to all task and contextual features associated with a decision that can potentially influence the information that is used or how it is processed, including the response mode (e.g., willingness to pay, choice, ranking); the number of attributes, alternatives, and outcomes; the presence of time pressure; the arrangement of the information display; and the correlation between options' attributes.

In recent years, researchers have increased their interest in choice architecture because previous research has established that people often construct their preferences in the immediate choice context (Lichtenstein and Slovic 2006; Payne, Bettman, and Johnson 1993). A key principle of the choice architecture approach is that there is no neutral choice context, and therefore, the people responsible for framing decisions will always influence choices. Thus, a wise choice architect can "nudge" decision makers to make better decisions for themselves and others (Thaler and Sunstein 2008). More specifically, a nudge is any intervention based on behavioral insights that improves personal or group decisions while maintaining freedom of choice, such as the use of "opt out" defaults for organ donations (Johnson and Goldstein 2003). Nudges have been created to help people make better decisions in a variety of domains, including personal health and retirement savings (Johnson et al. 2012; Thaler and Sunstein 2008). Policy makers have become increasingly interested in applying choice architecture to help mitigate the threat of climate change (Newell and Pitman 2010; Weber and Stern 2011), and the current study contributes to that movement.

Metric Design

An important decision in the design of a label is the choice of which metrics to include. There is reason to expect that one metric (e.g., estimated gas cost information) will influence consumer preferences more than another metric (e.g., gas consumption information), even though these two metrics are simple translations of each other. Payne, Bettman, and Johnson (1992), for example, strongly argue that decision makers often form preferences through task-contingent strategies that are tied to the representation of a problem. Such task-continent strategies reflect a trade-off between the effort required to make a decision and the accuracy of the outcome (Payne 1982). Importantly, the required effort is reduced when there is a close match between the problem representation and the problem-solving processes required to resolve the decision problem (Vessey 1991). For example, people make better decisions on analytical, symbolic tasks when data are presented with tables rather than with graphs. Similarly, several researchers have proposed that task, strategy, and information systematically interact to produce "compatibility" effects (Fischer and Hawkins 1993). These contingency perspectives suggest that information metrics that match the problem-solving processes required to form a preference will have the greatest influence on choices.

As we described previously, scholars in several literature streams have documented the effects of presenting different metrics on labels, although the direction of the effects has not always been consistent. In the domain of nutrition labels, the results of metric changes seem to depend on the specific outcome under examination (Campos, Doxey, and Hammond 2011; Hieke and Taylor 2012). For example, consumers tend to prefer more detailed information (e.g., nutrient content rather than summary ratings or percent recommended daily values), and yet the more information provided, the less consumers are able to comprehend or attend to the labels. Burton, Biswas, and Netemeyer (1994) find that providing labels with reference value information, such as recommended daily intake, increases preference for the high nutrition options. In contrast, Barone et al. (1996) argue that daily intake value information causes misperceptions and that an average-brand value reference point is more useful.

In the domain of appliance energy efficiency labels, the results suggest that providing life-cycle cost information may increase the tendency to select more energy-efficient products (Kaenzig and Wüstenhagen 2010). For example, Anderson and Claxton (1982) conducted a field study in which refrigerator labels were presented that stated either kilowatt-hours consumed per month or dollars spent per year. People showed a stronger preference for the energy-efficient refrigerator when information was expressed as cost per year. However, metric (energy consumption vs. cost) and scale (per month vs. per year) were confounded in this study, and the authors observed significant differences for small refrigerators but not larger ones. More recently, Bull (2012) teased these two variables apart and found that that consumers provided with washing machine running costs or emissions information chose more efficient products than consumers who viewed consumption information alone. A limitation of this study, however, is that participants were always presented with cost or emission information in addition to consumption information, which confounds type of metric and number of presented energy efficiency metrics. Recent research has shown that people often rely on a simple counting heuristic and are swayed by highly correlated attributes, rather than their meaning (Ungemach et al. 2013). Thus, Bull's study confounds number of attributes with the metric of interest.

Most fuel economy labels in use today report metrics associated with fuel consumption. Only two countries, the United States and New Zealand, also provide a cost of fuel estimate. The absence of cost information is surprising given that most consumers are concerned with fuel economy because of financial reasons (Institute for European Environmental Policy 2006). Indeed, fuel consumption information can be considered a "means" value, whereas gas cost can be considered an "ends" value (Keeney 1996). Most consumers are concerned with fuel economy primarily because they are motivated to minimize the amount of money they spend on fuel.

Although the cost of gas can be calculated from miles per gallon (MPG), research has suggested that consumers are very poor at translating MPG to gas consumption (Larrick and Soll 2008) and may never calculate gas cost at all. Indeed, research on numeracy has found that many people are challenged by simple calculations involving ratios and division (Kirsch et al. 2002). Provision of estimated fuel cost information acknowledges this limitation and provides direct calculations so that consumers do not have to perform them (Peters et al. 2007). In summary, previous research on processing compatible information and on consumer car preferences has suggested that consumers will prefer more fuel-efficient vehicles if gas cost information (vs. gas consumption information) is provided.

Scale Design

A second important decision in label design is the choice of scale used to express metrics. An increasing body of research in cognitive psychology and marketing has shown that rescaling identical information can systematically change preferences (Burson, Larrick, and Lynch 2009; Gourville 1998; Pandelaere, Briers, and Lembregts 2011). The consistent finding in this literature is that decision makers tend to perceive differences as larger when they are expressed on an expanded scale (e.g., costs per year) than when they are expressed on a contracted scale (e.g., costs per week). Larger differences, in turn, prompt greater reliance on that dimension in choice, thereby increasing preference for the option favored on that dimension.

People often narrowly bracket their decisions and thus fail to aggregate repeated costs and benefits in the long run (Read, Loewenstein, and Rabin 1999). The adoption of a larger time scale can broaden narrow consumption frames. For example, the typical American owns a vehicle for approximately eight years and drives approximately 13,000 miles annually. Thus, to appreciate gas consumption and costs incurred from regular use, consumers should adjust a small scale such as per 100 miles upward to an annual or lifetime figure. Potentially, aggregating gas consumption and costs on larger, meaningful scales can command more attention and play a greater role in choice.

Previous research has also reported that small outcomes are discounted more heavily than large outcomes (Thaler 1981). For example, people are willing to forgo $100 now to receive $150 in a year, but they are unwilling to forgo $10 now to receive $15 in a year (Loewenstein and Thaler 1989). This asymmetry in preference implies that people apply a steeper discount rate to smaller outcomes. Metrics describing future costs or savings expressed on a larger scale may therefore induce less discounting and promote more weighting of future accounting.

When making decisions, people can come to implicitly rely on an initial piece of information, regardless of its validity, to make subsequent judgments (Tversky and Kahneman 1974). In an example of this anchoring bias, people were asked whether Mahatma Gandhi died before or after age 9, or before or after age 140. Although clearly incorrect anchors, those in the former group produced estimates that were 17 years younger than those in the latter group (Strack and Mussweiler 1997). The judgments seemed to suggest that the initial number was a starting point, away from which participants (insufficiently) adjusted their estimates to reach the final response. Scales may similarly serve as anchors that influence decision makers' judgments of choice-relevant information such as expected driving behavior.

Recent research has shown, however, that larger scales may not always lead to increased attribute weight. In some cases, there are very familiar scales—what might be called "default units"—that consumers are accustomed to using when evaluating products (e.g., mobile phone battery life is usually described in terms of days rather than hours). Research has indicated that people are able to more fluently process scales that are familiar to them; consequently, attributes expressed on familiar scales receive more weight (Lembregts and Pandelaere 2013). Thus, at least in some cases, the familiarity effect can overwhelm the scale expansion effect. In the current research, we investigate both effects.

As noted previously, several literature streams have documented the effects of different scales on labels, although the direction of the effects has not always been consistent. For example, in the domain of nutrition labels, researchers have investigated whether caloric content should be expressed in absolute terms, such as calories per serving or calories per 100 grams, or in relative terms, such as relative to recommended daily intake. Again, the literature does not provide a clear answer in terms of which scale is better. For example, Burton, Biswas, and Netemeyer (1994) fail to find any difference in purchase likelihood between situations providing reference values on a per-meal basis rather than a daily basis. In contrast, Van Kleef et al. (2007) find that consumers prefer the number of calories per serving or per 100 grams over references to daily needs.

In the domain of appliance energy efficiency labels, the results indicate that providing life-cycle running cost information increases the tendency to select more fuel-efficient products (Kaenzig and Wüstenhagen 2010). For example, Bull (2012) reports that the beneficial effects of presenting running cost information are more pronounced when the information is expressed on a lifetime rather than an annual scale. Notably, Heinzle (2012) finds that people tend to overestimate annual savings associated with purchasing an efficient television when presented with the product wattage and cost of electricity per kilowatt hour. As a result, people are *less* likely to purchase an efficient product when efficiency savings are expressed as annual costs than when the products' energy consumption information is expressed in terms of watts. In contrast, people are *more* likely to purchase an efficient product when efficiency savings are expressed as lifetime energy operating cost rather than when the products' energy consumption information is expressed in terms of watts. A limitation of this study design is that energy consumption information was not provided on scales that matched the cost conditions (i.e., annual or lifetime).

Most existing fuel economy labels provide fuel consumption information in terms of the amount of gas consumed over some distance (e.g., "liters per 100 kilometers" in Canada, China, Australia, and most European countries). In contrast, the United States, India, and Chile have historically presented fuel efficiency information as an efficiency measure, such as MPG or kilometers per liter, which has a curvilinear relationship to gas use and leads to inaccurate perceptions when people estimate gas savings from more fuel-efficient vehicles (Larrick and Soll 2008). In response to this finding, the new U.S. label has added a consumption metric "gallons per 100 miles" (GPHM), thereby making the U.S. label more comparable to the labels in most other countries. Unlike MPG, the gas consumption metric GPHM is linearly related to both driving costs and greenhouse gas emissions and enables consumers to accurately calculate gas savings between vehicles simply by calculating differences. In summary, several lines of previous research have suggested that scale size could be harnessed to nudge consumers toward preferring more fuel-efficient vehicles if the gas consumption metric GPHM were expressed on a larger scale.

The Experiments

To explore how manipulation of the vehicle fuel economy label's architecture can influence people's preferences, we conducted two online studies. In each study, we presented participants with a binary choice between two vehicles that traded off on price and fuel economy. We asked participants to behave as if they were making a real decision for themselves and thus assumed that all participants were highly motivated to minimize the total cost of purchasing and running the vehicle. Note that the mental process required to estimate such total costs relies on combining vehicle cost and running costs. We reasoned that gas cost information would provide a better cognitive fit in solving this cost-minimization problem than gas consumption information.

Our initial pilot work revealed that consumers typically intend to own their next vehicle for approximately eight years and drive it approximately 13,000 miles annually for a total of 104,000 miles. Thus, in the current study, we elected to examine three key scale points: the current global standard for expressing gas consumption (“per 100 miles”), the scale approximating yearly driving behavior that is used to calculate annual fuel cost on the new U.S. Environmental Protection Agency (EPA) label (“per 15,000 miles”), and a scale that approximates the lifetime usage, as estimated from our pilot research (“per 100,000 miles”).

When examining the impact of manipulating the choice architecture of a product label, it is important to clearly identify the response being assessed because different labels may independently affect label liking, label comprehension, likelihood of considering the label, ability to detect the cost-minimizing option, or preference for the socially beneficial option (i.e., efficient product). In the current set of experiments, we were primarily concerned with the latter. As a result, the main dependent variable in all studies was the participant’s preference, and we analyze all data in terms of whether the fuel-efficient option was selected.

In light of the preceding discussion, we hypothesized that (1) on average, more fuel-efficient vehicles will be selected when vehicle fuel economy is expressed in terms of gas cost than gas consumption; (2) on average, more fuel-efficient vehicles will be selected when vehicle fuel economy is expressed on a “per 100,000 miles” scale than on “per 15,000 miles” or “per 100 miles” scales; and (3) these two metric and scale effects will interact such that the difference between gas cost and gas consumption in preference for the fuel-efficient vehicle will be larger at the 100,000 miles scale than at the 15,000 miles or 100 miles scales.

In Experiment 1, we implemented a partially within-subject design in which all participants were presented with each vehicle choice pair twice: once with the gas cost metric and again with the gas consumption metric. In Experiment 2, we implemented a completely between-subjects design in which participants were presented with each vehicle choice pair once: either with the gas cost metric or the gas consumption metric. Note that in all experiments, the scale manipulation (100 miles, 15,000 miles, 100,000 miles) was between subjects. The main reason we decided to use different designs is that each is associated with unique benefits and costs: the within-subject design enabled us to compare participants with themselves, which minimizes variability and determines whether changes are occurring in different segments of the group or within individuals; the between-subjects design enabled us to eliminate order effect concerns, such as learning and demand characteristics, that can occur when using within-subject designs. The complementary observations made using both designs strengthen our conclusions.

Experiment 1

In Experiment 1, we conducted an online study in which we presented participants with binary choices between two vehicles that traded off on price and fuel economy. To emphasize the trade-off between cost and fuel economy, we also presented half the participants with the numerical difference between the two options on the price and fuel economy attributes. We also measured several individual difference variables that may be relevant to car purchase decisions, including expected future driving behavior, environmental attitudes, and cognitive reflection (Frederick 2005). We predicted stronger preferences for the more fuel-efficient vehicle for participants who expected to drive more and who held proenvironmental attitudes. In addition, greater cognitive reflection has been associated with fostering an increased appreciation of later, larger rewards, so we expected participants with a stronger tendency to reflect to show a greater tendency to prefer the more fuel-efficient option. We added these measures as control variables in the data analysis.

Method

Participants

The participants were 424 U.S. respondents (56% female) recruited from Amazon.com’s Mechanical Turk (MTurk). Participants were given US$.50 for completing the study. The “Experiment 1” column of Table 1 summarizes some of the key characteristics of our sample. In general, MTurk participants are more nationally representative of the gen-

Table 1. Experiments 1 and 2 Sample Characteristics

	Experiment 1		Experiment 2	
	M	SD	M	SD
Age (years)	32.9	11.7	32.1	10.5
Political orientation on economic issues[a]	3.8	1.6	3.9	1.5
Political orientation on social issues[a]	3.1	1.6	3.2	1.6
NEPr score[b]	52.0	11.4	50.3	11.1
Expected total miles driven (miles)	99,422	67,079	95,698	61,779
Currently own a vehicle (%)	83	—	82	—
Intending to purchase within three years (%)	63	—	59	—
CRT score[c]	1.3	1.2	—	—
Discount rate (k)	—	—	.032	.043

[a]Measured on a seven-point scale anchored at 1 = “extremely liberal,” and 7 = “extremely conservative.”
[b]Possible range = 15 and 75.
[c]Out of 3.

eral population than typical in-person convenience samples, such as college students (Berinsky, Huber, and Lenz 2012). In general, however, MTurk participants tend to underrepresent older and wealthier members of the population. For example, the median age in our sample was 29 years, compared with the most recent U.S. Census's median age of 36.8 years.

Design

We employed a 2 (metric: gallons vs. dollars) × 3 (scale: 100 miles vs. 15,000 miles vs. 100,000 miles) × 2 (vehicle differences: calculated vs. not calculated) complete factorial design. Metrics varied within subject, whereas scale and vehicle differences varied across subjects. Specifically, participants first completed the six choices with the gallons metric and then the same six choices with the dollars metric, or vice versa. Note that across these 12 choice sets, the same scale and presence (or absence) of calculated vehicle differences were presented to a given participant. The primary dependent variable was preference, which we operationalized as the proportion of vehicle choices in favor of the more fuel-efficient vehicle. We counterbalanced the order of the metrics and problems.

Materials

Choice problems. We designed a set of six choice problems, which appear in Table 2. Each problem consisted of a base model vehicle and a more fuel-efficient model. The base model had a lower price but poorer fuel economy. All other features were described as being identical. Assuming 13,000 miles driven annually, eight years of ownership, a gas cost of $4.00/gallon, and no discount rate, the fuel-efficient vehicle was the cost-minimizing option in all problems.[1] When a reasonable discount rate was applied (i.e., 6% continuously compounded over eight years), however, the fuel-efficient vehicle was the cost-minimizing option in Problems 1, 2, 4, and 6, whereas the base model vehicle was cost minimizing in Problems 3 and 5.

Driving behavior. We inferred how many miles a participant expected to drive his or her next vehicle across lifetime of ownership from two questions. The first question asked how many miles participants intended to drive their next vehicle annually. Participants responded by selecting from one of eight ranges, anchored by "less than 4,000 miles" and "more than 28,000 miles." The second question asked how many years participants intended to own their next vehicle. Participants responded by selecting from one of six ranges, anchored by "less than 3 years" and "more than 15 years." We calculated the expected total miles driven by multiplying the implied median expected intended years of ownership and implied median intended miles driven annually (see Table 1).

Environmental attitudes. We measured environmental attitudes with the New Ecological Paradigm–revised scale (NEPr; Dunlap et al. 2000). Participants answered 15 questions on a five-point scale ranging from "strongly agree" to "strongly disagree." For example, one item presents the statement "Humans were meant to rule over the rest of nature." We observed a Cronbach's alpha of .86, which is in the acceptable range of item reliability, assuming a unidimensional construct. However, some have argued that the NEPr might best be conceptualized as correlated scales involving five facets (Amburgey and Thoman 2011). To evaluate this possibility, we conducted several exploratory factor analyses using principal axis factoring and direct oblimin rotation, which assumes correlated factors. We found that a one-factor model explained 34% of the variance. Additional factors emerged when we tested more complex models, but none explained more than 7% additional variance. From this analysis, we were comfortable treating NEPr items as a unidimensional construct. Thus, scores on the NEPr ranged from 15 to 75, with higher scores indicating more proenvironmental attitudes.

[1]The difference in total cost (i.e., price and gas, assuming 100,000 miles driven, $4 per gallon of gas, and no discount rate) was $1,000 in Problem 1, $2,000 in Problem 2, $3,000 in Problem 3, $4,000 in Problem 4, $5,000 in Problem 5, and $6,000 in Problem 6. We did not include this systematic difference as a variable in our analyses.

Table 2. Set of Choice Problems Used in Experiment 1

	Base Model			More Fuel-Efficient Model		
Choice Set	**Price**	**Gallons of Gas**	**Cost of Gas**	**Price**	**Gallons of Gas**	**Cost of Gas**
1	$18,000	5.0[a] (750)[b] [5,000][c]	$20[a] ($3,000)[b] [$20,000][c]	$21,000	4.0 (600) [4,000]	$16 ($2,400) [$16,000]
2	$23,999	5.6 (840) [5,600]	$22 ($3,300) [$22,000]	$26,999	4.2 (630) [4,200]	$17 ($2,550) [$17,000]
3	$27,299	4.8 (720) [4,800]	$19 ($2,850) [$19,000]	$32,299	3.4 (510) [3,400]	$14 ($2,100) [$14,000]
4	$19,520	5.3 (795) [5,300]	$21 ($3,150) [$21,000]	$21,520	3.8 (570) [3,800]	$15 ($2,250) [$15,000]
5	$16,898	5.9 (885) [5,900]	$24 ($3,600) [$24,000]	$24,898	3.7 (555) [3,700]	$15 ($2,250) [$15,000]
6	$21,477	6.3 (945) [6,300]	$25 ($3,750) [$25,000]	$25,477	3.6 (540) [3,600]	$14 ($2,100) [$14,000]

[a]Per 100 miles.
[b]Per 15,000 miles.
[c]Per 100,000 miles.
Notes: All participants were asked to assume $4.00 per gallon of gas. The table does not explicitly present differences.

Cognitive ability. We measured the cognitive ability to resist the intuitive incorrect response in favor of a deliberative correct response with the Cognitive Reflection Test (CRT; Frederick 2005). A sample item is "A bat and a ball cost $1.10 in total. The bat costs $1.00 more than the ball. How much does the ball cost?" (Answer: $0.05.) Scores on the CRT range from 0 to 3, with higher scores indicating better performance. We observed a Cronbach's alpha of .76.

Procedure

Each participant was presented with instructions indicating that he or she would be choosing between pairs of vehicles that consisted of a base model (e.g., "A") and a more fuel-efficient model (e.g., "A*"). Descriptions of each vehicle consisted of price information and an expression of fuel economy information (gas consumption or gas costs) (see Table 1). Fuel economy information was scaled either to 100 miles, 15,000 miles, or 100,000 miles. The scales were never linked to a period of time (e.g., "annual" driving for 15,000). Half the participants were shown an additional column in which the difference between the vehicles was calculated on fuel economy and price (e.g., "Vehicle A costs $3,000 less than Vehicle A*"). The other half were not provided with these differences. The participants indicated their preference for each option in six choice sets with one metric (i.e., gallons or dollars) and then did so again with the other metric, for a total of 12 choices.

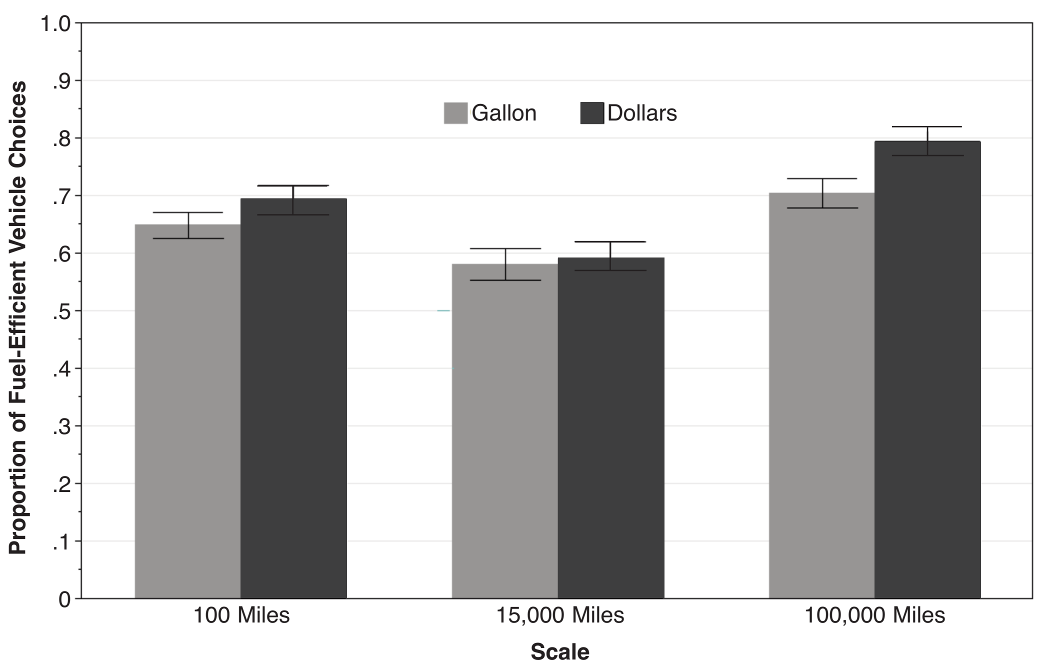
After the choice stage, participants were presented with questions about their driving behavior (i.e., number of owned vehicles, intended time of next vehicle purchase, intended length of ownership for next vehicle, and intended number of miles driven with next vehicle). They then provided the following information regarding their demographics and attitudes: gender, age, political orientation, and environmental attitudes. Next, participants answered questions intended to provide some indication of cognitive ability. Finally, they were provided with an opportunity to make comments in an open-ended text box. On average, it took participants 10 minutes to complete the experiment.

Results

Preferences

Figure 1 presents the proportion of fuel-efficient vehicle choices made in Experiment 1, averaged across all participants. The fuel-efficient vehicle was selected on 67.1% (SD = 30.3%) of occasions, although this tendency varied with the type of metric and scale presented. We statistically analyzed the data across four mixed-effect models using the Markov chain Monte Carlo method with restricted maximum likelihood. We preferred the mixed-effect model because it enables the modeling of correlated data—inherent to the within-subject nature of our design—without the violation of important regression assumptions (Demidenko 2004). The rationale for this hierarchical approach was to first establish the presence of the predicted main effects (Model 1), then assess whether these main effects interacted (Model 2), and, last, assess whether any of the predicted relevant variables (Model 3) or predicted irrelevant variables (Model 4) qualified the main effects. Model 1 included only the key fixed effects with effects coding: metric (reference group = gallons), scale (reference group = 100 miles), vehicle differences (reference group = differences not shown), and metric order (reference group = dollars first). In Model 2, we added the

Figure 1. Proportion of Fuel-Efficient Vehicle Choices as a Function of Metric and Scale in Experiment 1



interaction terms created when crossing metric, scale, and vehicle differences. In Model 3, we added the three individual difference variables that we predicted would affect choice: environmental attitudes, expected total miles driven, and cognitive reflection. Finally, in Model 4, we entered the remaining set of individual differences: age, gender, and political attitudes. We entered participant identification as a random effect in all four models. The dependent variable was always the proportion of choices in favor of the fuel-efficient vehicle (out of 6). For all analyses, we set the critical value at $\alpha = .05$.

Appendix A presents summaries of the model outputs. In all four models, the R-square and adjusted R-square were approximately .80. Model 1 revealed a significant main effect for metric, indicating that participants were more likely to select the fuel-efficient vehicle when the dollar metric was presented. Model 1 also showed a significant main effect for scale: participants were more likely to select fuel-efficient vehicles with the 100,000 miles scale but least likely to do so with the 15,000 miles scale.[2] There was no effect on preferences of providing gas cost or consumption differences between vehicles.

The interaction effects included in Model 2 revealed that the metric effect was moderated by the scale: the increased frequency of fuel-efficient choices associated with the dollar metric was large with the 100,000 miles scale, smaller with the 100 miles scale, and not present with the 15,000 miles scale.[3] Model 3 revealed a significant effect for environmental attitudes, indicating that participants with more proenvironmental attitudes were more likely to select the fuel-efficient vehicle. Finally, Model 4 revealed that younger participants were more likely to select the fuel-efficient vehicle.[4]

Expected Driving Behavior

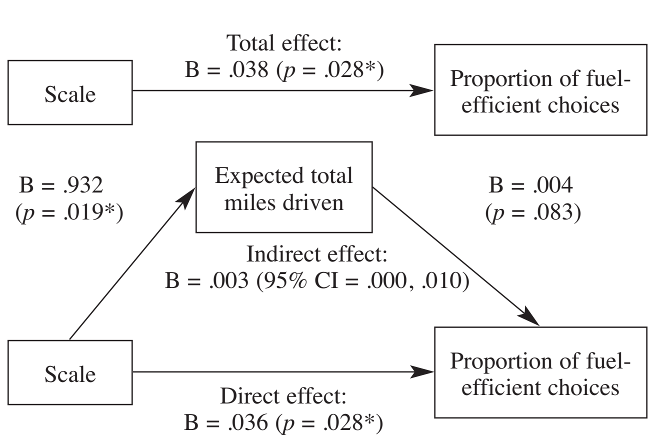
The median expected total miles driven across lifetime of ownership was 90,000 (M = 99,422, SD = 67,079). Notably, this median value differed across scale conditions: 70,000 miles (M = 91,678, SD = 57,300) in the 100 miles condition, 88,000 miles (M = 96,251, SD = 67,977) in the 15,000 miles condition, and 100,000 miles (M = 110,323, SD = 73,701) in the 100,000 miles condition. Because participants were randomly assigned to the conditions, this effect implies that the scale may have influenced expected driving behavior and thus potentially influenced choice.

To formally test for this mediation, we employed Hayes and Preacher's (2010) bootstrapping MEDCURVE tool for SPSS using the default values to assess the direct and indirect effects of scale on choice, with expected total driving as a mediating variable. We selected this method in light of Preacher and Hayes's (2004) discussion of the superiority of bootstrap methods over informal decision rules and other tests that make unrealistic assumptions. We defined the dependent variable, proportion of fuel-efficient choices, as the average choice across all 12 problems (i.e., averaging across metric conditions). We tested both linear and quadratic models and found that linear assumptions provided the best fit. As Figure 2 illustrates, expected total miles driven partially mediated the effect of scale on choice. More specifically, an additional 30,000 miles of expected miles driven—that is, the median difference between the 100 miles and 100,000 miles conditions—was associated with a 3.0% increase in proportion selecting the more fuel-efficient option.

Discussion

As we expected, people were more likely to select the fuel-efficient vehicle when fuel economy was presented in terms of gas cost than gas consumption. This metric effect was strongest when expressed on the lifetime 100,000 miles scale, smaller when expressed on the 100 miles scale, and absent when expressed on the 15,000 miles scale. Also as we expected, people were more likely to select the fuel-

Figure 2. The Total, Direct, and Indirect (Through Total Intended Miles Driven) Effects of Scale on Proportion of Fuel-Efficient Options



$^*p < .05$.
Notes: Expected total miles driven is in per 10,000 miles units.

[2]Follow-up contrasts revealed that participants were significantly more likely to select the fuel-efficient option in the 100,000 miles condition than in either the 15,000 miles condition (75.1% vs. 58.7%, respectively; $F(1, 409) = 26.11$, $p < .001$) or the 100 miles condition (75.1% vs. 67.2%, respectively; $F(1, 409) = 6.29$, $p = .01$); they were significantly more likely to select the fuel-efficient option in the 100 miles condition than in the 15,000 miles condition (67.2% vs. 58.7%, respectively; $F(1, 418) = 6.94$, $p = .001$).

[3]Follow-up contrasts revealed that participants were significantly more likely to select the fuel-efficient option with the dollars metric than the gallon metric with the 100 miles scale (69.5% vs. 65.0%, respectively; $F(1, 418) = 4.89$, $p = .03$) and the 100,000 mile scale (79.7% vs. 70.5%, respectively; $F(1, 418) = 19.9$, $p = .005$), but not with the 15,000 miles scale (59.2% vs. 58.2%, respectively; $F(1, 418) = .2$, $p = .6$). Follow-up contrasts also revealed that, with the dollars metric, participants were significantly more likely to select the fuel-efficient option with the 100,000 miles scale than with either the 15,000 miles scale ($F(1, 574) = 33.8$, $p < .001$) or the 100 miles scale ($F(1, 574) = 8.7$, $p = .003$); they were also more likely to select the fuel-efficient option with the 100 miles scale than the 15,000 miles scale ($F(1, 577) = 8.4$, $p = .004$). The same set of follow-up contrasts for the gallons metric revealed that participants were significantly more likely to select the fuel-efficient option with the 100,000 miles scale compared with the 15,000 miles scale ($F(1, 574) = 12.1$, $p < .001$) but not compared with the 100 miles scale ($F(1, 574) = 2.6$, $p = .1$); they chose the fuel-efficient vehicle marginally more often with the 100 miles scale than the 15,000 miles scale ($F(1, 577) = 3.5$, $p = .06$).

[4]We also attempted to gauge participant's numeracy ability with a single question taken from the Berlin Numeracy Test (Cokely et al. 2012). However, the item was not diagnostic, and we dropped it from the analysis.

efficient vehicle when fuel economy was expressed on a large, lifetime scale (100,000 miles) than on smaller scales (100 or 15,000 miles). We did not find any effect of cognitive reflection or presence of calculated differences on people's choices.

Perhaps most strikingly, we did not observe a linear shift in preference to match the linear expansion of scale; indeed, the fewest fuel-efficient vehicles were selected when expressed on the 15,000 miles scale. This U shape is noteworthy because annual fuel costs on the new American EPA label are expressed on the 15,000 miles scale, which yields the weakest preference for energy-efficient vehicles in our study. An unanticipated reason for this U-shaped effect of scale expansion on preference was that the scale influenced how much participants expected to drive, and those driving expectations in turn influenced the appeal of the more fuel-efficient option. To our knowledge, such an anchoring effect has not previously been implicated in the explanation of scale effects and is thus novel and noteworthy. Label designers need to be aware of the anchoring effect because it represents a possible tool for changing preferences.

Our second study was motivated primarily by the finding that the fuel-efficient option was cost minimizing over 100,000 miles in all of Experiment 1's choice sets. Thus, our results do not reveal whether expressing fuel economy as gas cost over 100,000 miles either increased people's weighting of fuel economy information in general or heightened awareness that the total costs of the fuel-efficient vehicle were lower than for the inefficient vehicle.

Experiment 2

In our second experiment, we expanded our investigation to choice sets in which the fuel-efficient vehicle did *not* pay for itself over 100,000 miles. Such an analysis is important for three reasons. First, many fuel-efficient vehicles do not pay for themselves in terms of gas savings over a reasonable driving period. This realization has raised consumer concerns, as exemplified in a recent *New York Times* article arguing that very few of the current market's hybrid vehicles make financial sense in terms of payback (Bunkley 2012). Second, despite such consumer interest, previous work has failed to systematically investigate the effect of metric and scale in contexts in which the efficient product both does and does not pay for itself. For example, in Bull's (2012) study, most of the efficient products did not pay for themselves over the product's lifetime. Third, it is unclear whether the strong preference for the efficient vehicle in the dollar metric/100,000 mile scale condition in Experiment 1 reflects a greater weight being placed on superior fuel economy or on the indication that the vehicles do indeed pay for themselves over 100,000 miles of driving.

For these reasons, in Experiment 2 we presented participants with 12 unique choice sets: in half the choice sets, the fuel-efficient vehicle was cost minimizing over 100,000 miles, and in the other half, the cheaper vehicle was cost minimizing over 100,000 miles (i.e., lower combination of vehicle price plus cost of fuel over 100,000 miles, assuming $4/gallon of gas). If the dollar metric and 100,000 miles scale effects observed in Experiment 1 are due to participants placing more weight on fuel economy, we would expect to observe the most number of fuel-efficient choices in the "cost per 100,000 miles" condition regardless of which vehicle is cost minimizing. In contrast, if the dollar metric and 100,000 miles scale effects are due to participants displaying greater sensitivity to total costs, we would expect the most fuel-efficient choices in the "cost per 100,000 miles" condition when the fuel-efficient vehicle is cost minimizing but would expect the fewest fuel-efficient choices in the "cost per 100,000 miles" condition when the cheaper vehicle is cost minimizing.

In addition to the new and larger choice set, we manipulated metric (gas cost vs. gas consumption) between subjects to eliminate any potential carryover effects that may have occurred in Experiment 1. We also measured the extent to which participants discounted future savings and costs; we expected that those who discounted the future more would be less likely to select fuel-efficient options, because the savings associated with this decision are only experienced in the future. Finally, because explicit presentation of differences in gas cost and gas consumption had no effect in Experiment 1, we dropped this variable for the second experiment.

Methods

Participants

The participants were 484 U.S. respondents (57% female) recruited from MTurk. The "Experiment 2" column of Table 1 summarizes their key characteristics.

Design

We employed a 2 (metric: gallons vs. dollars) × 3 (scale: 100 miles vs. 15,000 miles vs. 100,000 miles) × 2 (cost-minimizing vehicle: cheaper vs. fuel-efficient) complete factorial design. Metric and scale varied between subjects, whereas the cost-minimizing vehicle varied within subject. That is, participants completed 6 choice problems in which the efficient vehicle was cost minimizing and 6 choice problems in which the cheaper vehicle was cost minimizing. The order of the problems was randomized. Note that across these 12 choice problems, the metric and scale remained the same for a given participant. The primary dependent variable was the proportion of vehicle choices in favor of the more fuel-efficient vehicle.

Materials

Choice problems. We designed a new set of 12 choice problems (see Table 3). Each problem consisted of a cheaper vehicle and a fuel-efficient vehicle. The cheaper vehicle always had a lower price but poorer fuel economy. All other features were described as being identical. Assuming 13,000 miles driven annually, eight years of ownership, a gas cost of $4.00/gallon, and no discount rate, the fuel-efficient vehicle was the cost-minimizing option in Problems 1–6, whereas the cheaper vehicle was cost minimizing in Problems 7–12.[5] This even split

[5]The difference in total cost was $1,000 in Problems 1 and 7, $2,000 in Problems 2 and 8, $3,000 in Problems 3 and 9, $4,000 in Problems 4 and 10, $5,000 in Problems 5 and 11, and $6,000 in Problems 6 and 12. As in Experiment 1, we did not include this systematic difference as a variable in our analyses.

Table 3. Set of Choice Problems Used in Experiment 2

	Base Model			More Fuel-Efficient Model		
Choice Set	Price	Gallons of Gas	Cost of Gas	Price	Gallons of Gas	Cost of Gas
1	$20,520	5.3[a] (795)[b] [5,300][c]	$21[a] ($3,180)[b] [$21,200][c]	$23,520	4.3 (645) [4,300]	$17 ($2,580) [$17,200]
2	$32,789	7.0 (1,050) [7,000]	$28 ($4,200) [$28,000]	$34,789	6.0 (900) [6,000]	$24 ($3,600) [$24,000]
3	$27,299	4.8 (720) [4,800]	$19 ($2,880) [$19,200]	$32,299	2.8 (420) [2,800]	$11 ($1,680) [$11,200]
4	$20,477	7.8 (1,170) [7,800]	$31 ($4,680) [$31,200]	$28,477	4.8 (720) [4,800]	$19 ($2,880) [$19,200]
5	$18,898	5.9 (885) [5,900]	$24 ($3,540) [$23,600]	$21,898	3.9 (585) [3,900]	$16 ($2,340) [$15,600]
6	$23,999	6.5 (975) [6,500]	$26 ($3,900) [$26,000]	$29,999	3.5 (525) [3,500]	$14 ($2,100) [$14,000]
7	$26,300	7.3 (1,095) [7,300]	$29 ($4,380) [$29,200]	$39,300	4.3 (645) [4,300]	$17 ($2,580) [$17,200]
8	$28,200	6.1 (915) [6,100]	$24 ($3,660) [$24,400]	$42,200	3.1 (465) [3,100]	$12 ($1,860) [$12,400]
9	$24,450	4.9 (735) [4,900]	$20 ($2,940) [$19,600]	$31,450	3.9 (585) [3,900]	$16 ($2,340) [$15,600]
10	$17,987	6.2 (930) [6,200]	$25 ($3,720) [$24,800]	$25,987	5.2 (780) [5,200]	$21 ($3,120) [$20,800]
11	$16,877	7.6 (1,140) [7,600]	$30 ($4,560) [$30,400]	$29,877	5.6 (840) [5,600]	$22 ($3,360) [$22,400]
12	$32,956	4.5 (675) [4,500]	$18 ($2,700) [$18,000]	$46,956	2.5 (375) [2,500]	$10 ($1,500) [$10,000]

[a]Per 100 miles.
[b]Per 15,000 miles.
[c]Per 100,000 miles.
Notes: All participants were asked to assume $4.00 per gallon of gas.

remained true even after a reasonable discount rate was applied (i.e., 6% continuously compounded over eight years).

Driving behavior, environmental attitudes, and discount rate. We inferred expected total miles driven from the same questions used in Experiment 1. We again measured environmental attitudes using NEPr (Dunlap et al. 2000) and observed a Cronbach's alpha of .86. We assessed participants' discount rate—that is, their tendency to discount future costs and savings—using a monetary-choice questionnaire and scored this measure using the procedure described by Kirby, Petry, and Bickel (1999; see also Kirby and Maraković 1996). Participants were required to choose from 27 hypothetical payment schedules offering a smaller, immediate reward (SIR) versus a larger, delayed reward (LDR). A sample item is "Would you prefer $55 today, or $75 in 61 days?" We calculated the discount rate, k, that would produce indifference between the options with the formula k = [(LDR/SIR) – 1]/Delay. Thus, in the aforementioned sample item, anyone with a k = ([$75/$55] – 1)/61 = .0060 should be indifferent between the SIR and LDR. By examining the point at which people switched from preferring the SIR to the LDR across several choices in which indifference points imply different discount rates, we estimated the participant's implied discount rate. Note that a higher discounting rate was associated with greater discounting of future costs and savings.

Procedure

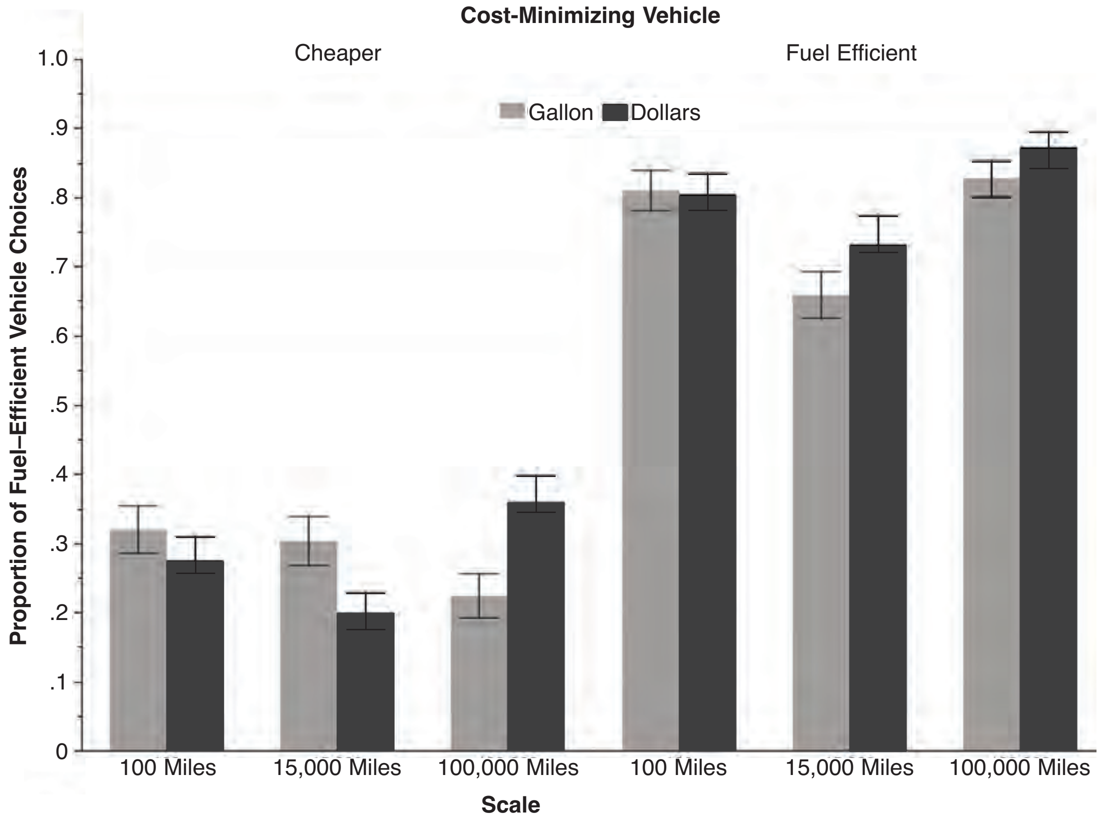
The procedure was similar to that used in Experiment 1. In this experiment, however, participants first progressed through a tutorial in which they were introduced to the metric and scale that would appear during the experiment. To progress to the actual experiment, participants were required to answer two comprehension questions correctly (e.g., "In the table below you will see a set of four vehicle options. Which option has the highest vehicle price?"). Rather than labeling the cheaper vehicle "A" and fuel-efficient vehicle "A*," we represented each vehicle using an arbitrary letter (e.g., A vs. B). As in Experiment 1, after the choice stage, participants were asked questions about their driving behavior, demographics, and attitudes. Unlike Experiment 1, we did not assess numeracy and cognitive reflection.

Results

Preferences

Figure 3 presents the proportion of fuel-efficient vehicle choices made by all participants in Experiment 2. Participants selected the fuel-efficient vehicle on 53.2% (SD = 24.6%) of occasions, although this tendency varied with the type of metric, scale, and cost-minimizing vehicle presented. As in Experiment 1, we statistically analyzed the data across four mixed-effect models using the Markov chain Monte Carlo method with restricted maximum likelihood. Model 1 included only the key main effects with effects coding: metric (reference group = gallons), scale (reference group = 100 miles), and cost-minimizing option (reference group = cheaper vehicle). In Model 2, we added the interaction terms created when crossing metric, scale, and cost-minimizing vehicle. In Model 3, we added the three individual difference variables that we predicted would affect choice: environmental attitudes, expected total miles driven, and temporal discounting attitude. Finally, in Model 4, we entered the remaining set of individual difference variables: age, gender, and political attitudes. We entered participant identification as a random effect in all four models. The dependent variable was the proportion of

Figure 3. Proportion of Fuel-Efficient Vehicle Choices as a Function of Metric, Scale, and Cost-Minimizing Option in Experiment 2



choices in favor of the fuel-efficient vehicle. We set the critical value at $\alpha = .05$.

Appendix B presents summaries of the model outputs. In all four models, the R-square and adjusted R-square were between approximately .72 and .74. Model 1 revealed a significant main effect for metric, indicating that participants were more likely to select the fuel-efficient vehicle when the dollar metric was presented than when the gallon metric was presented. Model 1 also revealed a significant main effect for scale: fuel-efficient vehicles were selected at the highest rate in the 100,000 miles condition and the lowest rate in the 15,000 miles condition.[6] Thus, we replicated the basic pattern observed in Experiment 1. Model 1 also revealed a significant effect for cost-minimizing vehicle, indicating that participants were more likely to select the fuel-efficient vehicle when it was also the cost-minimizing option.

The two-way interaction effects included in Model 2 revealed yet again that the metric effect was moderated by the scale. Moreover, the three-way interaction effect indicated that this moderated metric effect also depended on whether the cost-minimizing option was the cheaper or fuel-efficient vehicle. Specifically, when the cost-minimizing option was the fuel-efficient car, the rate of fuel-efficient choices was highest with the 100,000 miles scale and lowest with the 15,000 miles scale for both dollar and gallon metric conditions.[7] However, when the cost-minimizing option was the cheaper car, the highest rate of fuel-efficient choices occurred when the cost metric was expressed on a 100,000 miles scale, and the lowest rate of

[6]Follow-up contrasts revealed that participants were significantly more likely to select the fuel-efficient option in the 100,000 miles condition than in the 15,000 miles condition (57.0% vs. 47.3%, respectively; $F(1, 471) = 12.11$, $p < .001$) but not compared with the 100 miles condition (57.0% vs. 55.2%, respectively; $F(1, 471) = 0.41$, $p = .5$). Participants selected the fuel-efficient option more often in the 100 miles condition than in the 15,000 miles condition (55.2% vs. 47.3%, respectively; $F(1, 471) = 8.12$, $p = .005$).

[7]When the cost-minimizing option was the fuel-efficient car, follow-up contrasts revealed no significant differences in selecting the fuel-efficient option between dollars and gallons conditions with the 100 miles scale (80.4% vs. 80.9%, respectively; $F(1, 844.3) = .97$, $p = .3$), the 15,000 miles scale (73.1% vs. 65.8%, respectively; $F(1, 844.3) = 2.48$, $p = .1$), or the 100,000 mile scale (87.2% vs. 82.7%, respectively; $F(1, 844.3) = .01$, $p = .9$). With the dollar metric, the fuel-efficient option was selected significantly more often with the 100,000 miles scale than with the 15,000 miles scale ($F(1, 844.3) = 9.11$, $p = .003$) but not with the 100 miles scale ($F(1, 844.3) = 2.12$, $p = .14$); there was no significant difference between the 100 miles scale and the 15,000 miles scale ($F(1, 844.3) = 2.38$, $p = .12$). The same set of follow-up contrasts, this time with the gallons metric, revealed that participants were significantly more likely to select the fuel-efficient option with the 100,000 miles scale than with the 15,000 miles scale ($F(1, 844.3) = 13.6$, $p < .001$) but not with the 100 miles scale ($F(1, 844.3) = .14$, $p = .7$), and they were more likely to select the fuel-efficient option with the 100 miles scale than with the 15,000 miles scale ($F(1, 844.3) = 11.09$, $p < .001$).

fuel-efficient choices occurred when the gallons metric was expressed on a 100,000 miles scale.[8]

Model 3 revealed a significant effect for environmental attitudes, indicating that participants with proenvironmental attitudes were more likely to select the fuel-efficient model. Finally, Model 4 revealed that those who intended to drive more were more likely to select the fuel-efficient option than were older participants. There was no effect on choice of the (log-transformed) discount rate, nor did the discount rate interact with metric or scale (both *p*s > .1).

Expected Driving Behavior

The median expected total miles driven across lifetime ownership was 88,000 (M = 95,698, SD = 61,779). Again, this median value differed across scale conditions: 98,000 miles (M = 95,894, SD = 61,479) in the 100 miles condition, 70,000 miles (M = 87,675, SD = 56,012) in the 15,000 miles condition, and 98,000 miles (M = 103,380, SD = 56,012) in the 100,000 miles condition. We ran a mediation analysis similar to the one described in Experiment 1. We defined the dependent variable, proportion of fuel-efficient choices, as the average choice across all 12 problems (i.e., averaging across cost-minimizing vehicle). We tested both linear and quadratic models as described by Hayes and Preacher (2010). The model that provided the best fit was one in which expected total miles driven (M) was a quadratic function of scale (X): $\hat{M} = 8.765 + .374(X) + 1.196(X^2)$, model $p = .07$; and preference for the fuel-efficient option (Y) was a linear function of expected total miles driven, controlling for the curvilinearity in the association between scale and the choice of efficient options: $\hat{Y} = .439 + .008(X) + .08(X^2) + .004(M)$, $p < .001$.

Similar to Experiment 1, total intended miles driven partially mediated the effect of scale on choice. As Hayes and Preacher (2010) discuss, however, when nonlinear relationships are present, it is not sensible to speak generally about the indirect effect; the estimate of the indirect effect must be conditioned at specific values of X: when scale was 100 miles, the indirect effect of –.0078 was nonsignificant (95% confidence interval [CI]: –.068, .0003); when scale was 15,000 miles, the indirect effect of .0014 was nonsignificant (95% CI: –.0008, .0062); and when scale was 100,000 miles, the indirect effect of .0107 was significant (95% CI: .0007, .0315). In summary, a scale size increase to 100,000 miles leads to an increase in the proportion of fuel-efficient choices partly through the increase in expected total miles driven.

Discussion

In Experiment 2, we replicated our central finding that people tend to prefer more fuel-efficient vehicles when fuel economy is expressed in terms of gas cost over 100,000 miles, and we extended this finding to cases in which the fuel-efficient option does not pay for itself over 100,000 miles. This result supports the conclusion that an expanded dollar metric causes consumers to place more weight on vehicle fuel economy rather than help them identify the cost-minimizing option. Notably, the metric effect was weaker on smaller scales and, when the fuel-efficient vehicle was not cost minimizing, even reversed: the cost metric reduced preference for the fuel-efficient car relative to the gallons metric when the scale was 100 miles or 15,000 miles. We discuss reasons for this pattern of results in the "General Discussion" section.

As in Experiment 1, there was no simple linear scale effect such that preference for the fuel-efficient option increased with scale. Rather, we again observed an unexpected U shape, indicating that participants preferred the fuel-efficient vehicle least when fuel economy was expressed on a 15,000 miles scale. However, this pattern was not readily apparent with the gallons metric when the cheaper vehicle was the cost-minimizing option. As in Experiment 1, some of this U-shaped pattern can be attributed to how scale influenced future driving expectations. More specifically, participants displayed a U-shaped estimation in terms of how many miles they expected to drive their next vehicle as a function of scale such that those in the 15,000 scale expected to drive least, those in the 100,000 miles scale expected to drive most, and those in the 100 mile scale were somewhere in between. The fact that this U-shaped pattern emerged in both driving behavior and choice is strong evidence that the former mediates the latter. In our "General Discussion" section, we expand on this relationship and also discuss a second explanation for the U-shaped function: the relative familiarity of the scales.

Of course, some consumers will be heavily influenced by environmental concerns and will even be prepared to sacrifice on behalf of the environment (Davis, Le, and Coy 2011). Indeed, and consistent with Experiment 1, we found that people with stronger proenvironmental attitudes selected more fuel-efficient vehicles. Contrary to our expectations, however, we found no evidence that preferences were moderated by the tendency to discount future costs and savings.

General Discussion

Summary of Results

This research examines the influence of two basic tools of choice architecture—metric and scale—and how they can be leveraged to promote proenvironmental choice in the context of vehicle purchases. The clearest result from our research is that consumers prefer fuel-efficient vehicles more often when vehicle fuel economy is expressed in terms of the cost of gas on an expanded 100,000 miles

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[8]When the cost-minimizing option was the cheaper car, follow-up contrasts revealed no difference in selecting the fuel-efficient option between dollars and gallons conditions at the 100 miles scale (27.5% vs. 31.9%, respectively; $F(1, 844.3) = .92$, $p = .3$), significantly less fuel-efficient choices at the 15,000 miles scale (19.9% vs. 30.3%, respectively; $F(1, 844.3) = 4.99$, $p = .03$), and significantly more fuel-efficient choices at the 100,000 miles scale (35.9% vs. 22.3%, respectively; $F(1, 844.3) = 8.77$, $p = .003$). With the dollar metric, participants were significantly more likely to select the fuel-efficient option with 100,000 miles scale than with the 15,000 miles scale ($F(1, 844.3) = 11.8$, $p < .001$) but not with the 100 miles scale ($F(1, 844.3) = 3.27$, $p = .07$), and there was no difference between the 100 miles scale and the 15,000 miles scale ($F(1, 844.3) = 2.57$, $p = .10$). The same set of follow-up contrasts, this time with the gallons metric, revealed that participants were less likely to select the fuel-efficient option with the 100,000 miles scale than with the 100 miles scale ($F(1, 844.3) = 4.45$, $p = .03$).

scale. This result appears to hold regardless of whether the fuel-efficient vehicle pays for itself over 100,000 miles. Our finding is important because no current fuel economy label in the world uses this specific metric and scale combination, and thus, there exists an actionable, simple, effective nudge that policy makers can implement.

Metric Design

We observed that people tended to select the more fuel-efficient vehicle when fuel economy was expressed in terms of the cost of gas rather than the amount of gas consumed. This pattern was present in Experiment 1 and in Experiment 2 when the fuel-efficient option was cost minimizing. The metric effect is compatible with contingency explanations of information processing, such as the theory of cognitive fit (Vessey 1991) and the scale-compatibility hypothesis. In general, metrics that match the problem-solving processes required to form a preference will have the greatest influence on choice. In making a vehicle choice, some people use fuel efficiency as a proxy for gas cost; however, they may not do so accurately. Others may never try to translate fuel efficiency to cost because it is too difficult or because it never comes to their attention. Thus, providing gas cost information directly helps consumers fully appreciate how differences in fuel efficiency translate into differences in fuel costs, which is neglected when the proxy metric of gallons is used instead.

Note that in Experiment 2, the metric effect was less apparent in cases in which the fuel-efficient option was not cost minimizing. Presumably, the reason for the conditional effect is that the cost information helped consumers appreciate that the fuel-efficient vehicle did not pay for itself over a reasonable amount of time. The effect of this realization, at least at the 100 and 15,000 miles scales, was that participants were better able to identify the cost-minimizing option and thus make the fuel-efficient option relatively undesirable. Presenting fuel economy in terms of the cost of gas could therefore motivate vehicle manufacturers to invest in the production of fuel-efficient vehicles that will pay for themselves over a reasonable amount of time.

Note, however, that even when the fuel-efficient option was not cost minimizing, expressing fuel economy as the cost of gas over 100,000 miles still produced a clear metric effect such that participants were more likely to select fuel-efficient options. For reasons discussed in the following subsection, with the 100,000 miles scale, consumers place a larger amount of decision weight on fuel economy despite the realization that the fuel-efficient option may not pay for itself over 100,000 miles. Moreover, this decision can be a rational reaction if consumers either place some value on the environment or intend to hold the car for more than 100,000 miles; in either case, the cost of driving information can make it clear that the initial price premium is close to being offset by the more efficient vehicle.

An alternative reason that our participants were more influenced by dollars than by gallons of gas is that they are not used to thinking about gas consumption but rather think in terms of mileage (MPG). This is a testable hypothesis; however, even if people attended more to MPG than they do to gas consumption, we would argue that relying on MPG as the sole metric for representing a vehicle's fuel economy creates new problems. Compared with their true gas savings, improvements on inefficient cars are undervalued and improvements on efficient cars are overvalued (Larrick and Soll 2008). In contrast, labels such as the new one the EPA uses strike a compromise by providing multiple fuel economy metrics, including the familiar MPG figure and the translations that are linearly related to gas consumption, including GPHM, annual fuel cost, and greenhouse gas emissions.

Scale Design

The second effect we identified was a change in preference that comes from shifting the scale of gas consumption or gas costs between 100 miles, 15,000 miles, and 100,000 miles. Specifically, across Experiments 1 and 2, we observed a U-shaped function in which the proportion of fuel-efficient options was smallest at 15,000 miles and largest at 100,000 miles; the preference at 100 miles was somewhere in between. This result partially replicates prior research on scale-induced preference changes (Burson, Larrick, and Lynch 2009; Gourville 1998; Pandelaere, Briers, and Lembregts 2011) and demonstrates the positive value of scale expansion as a tool of choice architecture. In short, consumers seem to place more decision weight on fuel economy information when it is expressed on an expanded, per 100,000 miles scale. Presumably, this scale helps consumers overcome biases that would otherwise decrease the desirability of fuel-efficient vehicles, such as discounting of future savings.

We propose two explanations for the nonlinear scale effect. First, scale may have influenced choice indirectly by (nonlinearly) influencing consumers' expected future driving behavior. Indeed, in both Experiments 1 and 2, we found that the effect of scale on choice was mediated by expected total miles driven. In Experiment 2, in particular, we observed nonlinearity in expected future driving such that participants in the 15,000 miles condition expected to drive less than those in either the 100 miles or 100,000 miles conditions. We argue that decision makers nonconsciously use the scale to partially inform expected future behavior. The scale may serve as an arbitrary initial anchor from which the decision maker imperfectly adjusts to reflect his or her behavior (Epley and Gilovich 2006; Tversky and Kahneman 1974). Some evidence suggests that anchors are most influential when they are semantically informative, which may explain the nonlinearity we observed: 100 miles is not as strong an anchor as 15,000 miles (Strack and Mussweiler 1997). Notably, and in contrast to most existing anchoring studies, we did not explicitly direct our participants' attention to the scale, and yet it nonetheless exerted influence. To our knowledge, this is the first demonstration of anchoring in the context of scale effects.

Second, some scales may be more familiar to consumers than others, which can affect processing fluency and, thus, the weight allocated to the accompanying metric (Lembregts and Pandelaere 2013). To examine this explanation, we asked 30 Americans recruited from MTurk to rate how familiar they were with each of the scales ("per 100 miles," "per 15,000 miles," and "per 100,000 miles") in describing a vehicle's fuel economy on a seven-point scale (1 = "totally not familiar," and 7 = "totally familiar"). Participants rated 100 miles as significantly more familiar (M = 4.33) than both 15,000 miles (M = 2.30; $t(29) = 5.91$, $p < .001$) and 100,000 miles (M = 2.53; $t(29) = 5.51$, $p < .001$). There was no rating difference between 15,000 miles and 100,000 miles ($p > .3$). In some respects, this result is unsurprising given that "per 100" units of distance is the current global standard for expressing fuel economy information. Importantly, however, this information may help explain why participants made more fuel-efficient choices in the 100 miles condition than the 15,000 miles condition. The 100 miles scale may be more familiar and easier to use, thereby increasing its effect on choice.

Thus, our data suggest that scale effects are driven by two (not necessarily congruent) forces: scale expansion, which allocates more weight to larger numbers, and scale familiarity, which allocates more weight to more familiar numbers. In our data, scale expansion seems to be the stronger force. Regardless of the underlying psychological reasons, there is an important practical implication of these data. A metric currently in use on the U.S. fuel economy label describes fuel economy in terms of a 15,000 miles scale—the annual fuel cost metric. Our results suggest that if this metric (and others using a 15,000 miles scale) were expanded to a larger scale, consumers would increase their preference for fuel-efficient vehicles. In addition, as the 100,000 miles scale becomes more common over time, it too would benefit from scale familiarity effects.

Limitations

The main limitation of our study is that we relied on a convenience sample's hypothetical decisions made during an online experiment. Although recent research has suggested that experimental marketing lab results such as ours replicate reasonably well when tested in the field (r = .59; Mitchell 2012), we acknowledge that field experiments would be a useful extension of this line of research. It would be especially beneficial for further research to target a representative population of consumers who are actively seeking to buy a vehicle, which would eliminate any concerns that some of our results were driven by social desirability effects.

A second limitation is that we relied on multiple paired options defined by a narrow set of attributes. Outside the laboratory, consumers may make purchase decisions while simultaneously comparing several vehicles defined by multiple attributes, and these additional factors may alter the decision strategy used. For example, some research has suggested that when consumers are under high cognitive load or time pressure, they tend to pay less attention to environmental information (Verplanken and Weenig 1993). Studies that present consumers with broader choice contexts would further improve understanding of how metric and scale affect choice. We speculate that the metric and scale effects we observed in these studies could become stronger in more complex tasks if consumers respond to increased information by focusing on the most important metrics (e.g., cost) and salient outcomes (e.g., large differences on expanded scales).

A third limitation of our stimuli is that we presented our participants with only the costs associated with purchasing and fueling a vehicle. In reality, there are other financial and environmental costs that might be important to consider, including the environmental costs of constructing a vehicle as well as financial maintenance costs. For example, hybrid vehicles require less maintenance on average. Future studies could experiment with the inclusion of this additional information.

Policy Recommendations

Provide Meaningful Metrics

One important message from our work is that policy makers should provide consumers with meaningful metrics. We define "meaningful" as information that provides the consumer with the ability to assess how well he or she is achieving personal goals. As we discussed previously, it is useful to distinguish two classes of goals (Keeney 1996): "means" goals and "ends" goals. The former refers to short-term goals achieved not for their own sake but as a way of reaching a related true end goal. The amount of gas consumed is best construed as a "means" goal, whereas the cost of gas is best construed as an "ends" goal. In our discussions, we have assumed that consumers are primarily concerned with fuel economy because they are motivated to minimize the cost of gas. Thus, to provide consumers with meaningful metrics that match consumers' true end goals, we suggest that policy makers should provide consumers with information regarding the cost of gas.

A potential issue associated with providing consumers cost information is that it relies on specific assumptions. One of the assumptions required for the calculation is the estimated price of gasoline. Unlike the cost of electricity, the cost of gas is politically charged, and some consumers may react against cost information and even ignore it if they fail to believe the assumed cost of gas. The solution to this problem lies in appropriate political marketing and education of the public to use estimated cost information relatively; that is, as a unit of comparison. Even if the assumed price of gasoline is incorrect, the estimated gas cost is still a useful metric to make directional and degree of difference comparisons across products.

Of course, some consumers are interested in fuel economy for reasons other than cost minimization, such as environmental concerns. Indeed, we found that decision makers with greater concern for the environment were more likely to select the fuel-efficient vehicle. Presumably, these consumers are willing to pay a modest premium for, say, a hybrid vehicle if they can achieve their environmental goals (Davis, Le, and Coy 2011). This segment of the population could benefit from provision of meaningful environmental metrics, such as a greenhouse gas rating. Indeed, in other work, we find that the presentation of greenhouse gas ratings in addition to fuel cost information increases the proportion of fuel-efficient choices by activating proenvironmental goals (Ungemach et al. 2013).

Express Metrics on Expanded, Lifetime Scales

A second important message from our work is that policy makers should express meaningful metrics on expanded, lifetime scales. Expansion has the benefit of helping people do relevant math that they might neglect otherwise. By translating what might seem to be a trivial quantity, such as daily gas use, to a meaningful quantity, such as lifetime gas use, expansion can enable consumers to make better decisions. This recommendation is consistent with those made in the domain of appliance energy consumption and the call to express energy consumption on lifetime scales (Kaenzig and Wüstenhagen 2010). In this article, we show that the benefits of scale expansion also apply to vehicle preferences, even in scenarios in which the efficient product does not pay for itself in terms of energy savings over a reasonable amount of time. Thus, scale expansion seems to emphasize the efficiency attribute rather than make salient the most cost-effective option over the long run. Finally, we also reveal a psychological mechanism that contributes to scale expansion (anchoring) as well as one that may hinder scale expansion (unit familiarity).

Using scale changes to influence behavior creates a burden for the choice architect. As scales are increased, decision makers see larger differences between options, shifting their preference to the option favored on the expanded attribute. Similarly, as scales are increased, decision makers may be anchored by the scale, either unconsciously or because they use the number as a source of information about what is normal or typical. All these factors suggest that firms could potentially trick decision makers by expanding scales to extreme—and unlikely—levels. For example, the cost of gas to drive 500,000 miles would yield a difference between a 20 MPG car and 25 MPG car of roughly $15,000; however, 500,000 miles is not a realistic estimate of use. Many consumers would be aware of this and might react to the influence attempt by ignoring the information or even rebelling against the favored option, especially when it conflicts with their own initial impression (Fitzsimons and Lehmann 2004). However, those who are unaware of the extremity of 500,000 miles could be influenced by the numbers in a way that may not serve their interests. Thus, the burden for choice architects is to use a realistic scale because it helps people see relevant differences that they might neglect with smaller scales but does so by matching them to real circumstances and consumption behavior.

Finally, the use of expanded scales creates a second burden when expansion occurs over time, as observed in our examples. A large portion of the gas costs accumulated over 100,000 miles of driving occur in future years and, according to standard economic analysis, should be discounted at some reasonable rate tied to inflation or expected investment returns. An expanded scale over time may help balance attention between the present and the future. It is common practice in energy policy circles to discount future energy savings between 3% and 7% per year. Policy makers could decide to present an expanded, approximately lifetime scale, such as 100,000 miles, but also discount those future costs when reporting them to consumers.

There are two reasons that discounting future gas prices may not be urgent in these examples. First, the global demand for gasoline is likely to outstrip growth in supply, driving up gas prices over the next decade. When we asked a separate group of online participants (n = 88) to predict whether the major stock market indexes or the price of gas would rise more quickly, 72% predicted that gas prices would rise more quickly than the stock market, suggesting that consumers expect a dollar invested today in a fuel-efficient car to yield a higher return than a dollar invested in the stocks tied to the Dow Jones Industrial Average. Indeed, the Energy Information Agency (2012) predicts that motor gasoline prices will increase by 14% more than inflation between 2012 (the time of our studies) and 2022.

Second, a large body of research on judgment and decision making has shown that people are myopic in their intertemporal choices, greatly overvaluing the present compared with the future (Loewenstein, Read, and Baumeister 2003). Research on the cognitive processes underlying these effects has shown that thoughts about the present come to mind first and proactively interfere with thoughts about the future, creating the strong present bias; this bias for the present can be undone when an intertemporal decision task is structured to elicit thoughts about the future first (Weber et al. 2007). In the same way, the larger scale encourages people to weight the present and future in a more balanced way. Thus, choice architects might deliberately select large but realistic time scales to overcome a dysfunctional present bias in intertemporal choice (Kunreuther 2001).

Conclusions

The finding that the presentation format of information can shift preferences is consistent with the idea that people construct many preferences spontaneously (Johnson et al. 2012; Lichtenstein and Slovic 2006). Given the inevitability of constructed preferences, however, the wise design of choice architecture can help people make better decisions for themselves and for others. Policy makers who aim to mitigate climate change by encouraging consumers to invest in more efficient technologies should present efficiency information in terms of costs and on expanded, lifetime scales.

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Appendix A. Regression Coefficients When the Proportion Choosing the Fuel-Efficient Car Is Regressed on Metric, Scale, Difference Column, and Other Individual Difference Variables in Experiment 1

	Model			
Variable	**1**	**2**	**3**	**4**
Intercept	.670 (.013)***	.670 (.013)***	.390 (.063)***	.503 (.088)**
Metric (dollars)	.024 (.005)***	.024 (.006)***	.024 (.006)***	.024 (.006)***
Scale (100,000 miles)	.080 (.018)***	.080 (.018)***	.082 (.018)***	.080 (.018)***
Scale (15,000 miles)	–.083 (.018)***	–.083 (.018)***	–.085 (.018)***	–.081 (.018)***
Differences (shown)	–.013 (.013)	–.013 (.015)	–.015 (.013)	–.015 (.013)
Metric order (gallons first)	–.010 (.013)	–.010 (.013)	–.013 (.013)	–.011 (.013)
Metric (dollars) × Scale (100,000 miles)		.021 (.013)*	.021 (.008)*	.021 (.008)*
Metric (dollars) × Scale (15,000 miles)		–.019 (.008)*	–.019 (.008)*	–.019 (.008)*
Scale (100,000 miles) × Differences (shown)		.020 (.008)	.018 (.018)	.023 (.018)
Scale (15,000 miles) × Differences (shown)		–.031 (.018)	–.031 (.018)	–.035 (.018)
Metric (dollars) × Differences (shown)		–.003 (.006)	–.003 (.006)	–.003 (.006)
Metric (dollars) × Scale (100,000 miles) × Differences (shown)		.007 (.008)	.007 (.008)	.007 (.008)
Metric (dollars) × Scale (15,000 miles) × Differences (shown)		–.012 (.008)	–.012 (.008)	–.012 (.008)
Expected total miles driven (10,000 miles)			.003 (.002)	.003 (.002)
Cognitive reflection score			.003 (.011)	.001 (.012)
Environmental attitudes (NEPr)			.005 (.001)***	.004 (.001)***
Gender (male)				–.012 (.013)
Age				–.002 (.001)*
Political attitudes (economic)				.005 (.011)
Political attitudes (social)				–.011 (.011)

*$p < .05$.
**$p < .01$.
***$p < .001$.
Notes: Standard errors are in parentheses. The categorical predictor variables were effects-coded: metric (–1 = gallons; +1 = dollars), scale of 100,000 miles (–1 = 100; 0 = 15,000; +1 = 100,000), scale of 15,000 miles (–1 = 100; +1= 15,000; 0 = 100,000), vehicle differences (–1 = differences not shown; +1 = differences shown), and metric order (–1 = gallons first; +1 = dollars first).

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Appendix B. Regression Coefficients When the Proportion Choosing the Fuel-Efficient Car Is Regressed on Metric, Scale, Cost-Minimizing Option, and Other Individual Difference Variables in Experiment 2

	Model			
Variable	**1**	**2**	**3**	**4**
Intercept	.532 (.011)***	.532 (.011)***	.282 (.061)***	.343 (.086)***
Metric (dollars)	.009 (.011)***	.008 (.011)	.010 (.011)	.009 (.011)
Scale (100,000 miles)	.038 (.015)*	.038 (.016)*	.039 (.015)*	.037 (.015)*
Scale (15,000 miles)	–.058 (.015)**	–.059 (.016)**	–.058 (.015)***	–.056 (.015)**
Cost minimizing (fuel-efficient car)	.251 (.008)***	.252 (.008)***	.252 (.008)***	.252 (.008)***
Metric (dollars) × Scale (100,000 miles)		.039 (.016)*	.040 (.015)*	.039 (.015)*
Metric (dollars) × Scale (15,000 miles)		–.016 (.016)	–.017 (.015)	–.017 (.015)
Metric (dollars) × Cost minimizing (fuel-efficient car)		.010 (.008)	.010 (.008)	.010 (.008)
Scale (100,000 miles) × Cost minimizing (fuel-efficient car)		.027 (.011)*	.027 (.011)*	.027 (.011)*
Scale (15,000 miles) × Cost minimizing (fuel-efficient car)		–.030 (.011)**	–.030 (.011)**	–.030 (.011)**
Metric (dollars) × Scale (100,000 miles) × Cost minimizing (fuel-efficient car)		–.033 (.011)**	–.033 (.011)**	–.033 (.011)**
Metric (dollars) × Scale (15,000 miles) × Cost minimizing (fuel-efficient car)		.034 (.011)**	.034 (.011)**	.034 (.011)**
Expected total miles driven (10,000 miles)			.003 (.002)	.004 (.002)*
Environmental attitudes (NEPr)			.004 (.001)***	.004 (.001)***
Temporal discounting (log[k])			–.000 (.007)	–.002 (.007)
Gender (male)				.016 (.011)
Age				–.002 (.001)
Political attitudes (economic)				–.014 (.009)
Political attitudes (social)				.014 (.009)

*$p < .05$.
**$p < .01$.
***$p < .001$.
Notes: Standard errors are in parentheses. The categorical predictor variables were effects-coded: metric (–1 = gallons; +1 = dollars), scale of 100,000 miles (–1 = 100; 0 = 15,000; +1 = 100,000), scale of 15,000 miles (–1 = 100; +1= 15,000; 0 = 100,000), and cost-minimizing option (–1 = cheaper vehicle; +1 = efficient vehicle).

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