nature energy

SUPPLEMENTARY INFORMATION

https://doi.org/10.1038/s41560-019-0467-2

In the format provided by the authors and unedited.

Simple interventions can correct misperceptions of home energy use

Tyler Marghetis[1,2,4*], Shahzeen Z. Attari[1] and David Landy[2,3]

[1]O'Neill School of Public and Environmental Affairs, Indiana University Bloomington, Bloomington, IN, USA. [2]Psychological and Brain Sciences, Indiana University Bloomington, Bloomington, IN, USA. [3]Netflix, Los Gatos, CA, USA. [4]Present address: Santa Fe Institute, Santa Fe, NM, USA.
*e-mail: tyler.marghetis@gmail.com

Supplemental Text for
Simple interventions can correct misperceptions of home energy use

Tyler Marghetis, Shahzeen Z. Attari, and David Landy

Supplementary Note 1

For each individual, we followed past work[1,2] and used linear regression to estimate the relationship between appliances' actual energy use and estimated energy use:

$$\log_{10}(\text{estimated}) \sim b_0 + b_{\text{actual}} \log_{10}(\textit{actual})$$

In past work[1], the estimation slope b_{actual} has been used to measure individuals' ability to estimate home energy use. Here, we extend the psychological interpretability of this measure by decomposing it into two components that measure different facets of the estimation process.

The estimation slope, b_{actual}, is equal to:

$$b_{actual} = \rho_{actual,estimated} \frac{\sigma_{estimated}}{\sigma_{actual}}$$

The estimation slope b_{actual} can thus be decomposed into $\rho_{actual,estimates}$, the correlation between individuals' estimates and the true energy use values, and $\sigma_{est}/\sigma_{actual}$, the ratio between the standard deviation of individuals' estimates and the standard deviation of the true values (see Main Text). We used the first of these, ρ, to measure the correctness of individuals' underlying, perhaps implicit, understanding of appliances' relative energy use ('relative ordering'); a correlation of 1 indicates perfect understanding, while values of less than 1 indicate incorrect understanding. We used $\sigma_{est}/\sigma_{actual}$ to measure their use of the response scale; systematic overestimation of small values and underestimation of large values would produce a ratio less than 1, with ratios closer to 0 indicating more compressed use of the response scale.

To evaluate the interventions' impact on these different facets of energy estimation, we used multiple regression. For instance, to evaluate differences in estimation slopes due to the interventions and to sociodemographic differences, we used the model:

$$\begin{aligned} b_{\text{actual}} \sim b_0 + b_1(\textit{Heuristic}) &+ b_2(\text{ScaleUseInfo}) \\ &+ b_3(\textit{Heuristic} \times \text{ScaleUseInfo}) \\ &+ \{\text{socio-demographic controls and numeracy}\} \end{aligned}$$

Analogous models were used to analyze ρ and $\sigma_{est}/\sigma_{actual}$.

To facilitate interpretation of coefficient estimates, both actual and estimated energy use were $\log_{10}$–transformed and centered at the mean actual energy use of all items. As a result, intercepts indicate whether estimates were biased downward (negative intercepts) or upward (positive intercepts). Full model results are summarized in Table S1, S2, and S3.

Supplementary Note 2

To analyze individuals' current conservation behavior, and to evaluate whether individual differences in energy estimation ability might account for individual differences in conservation behavior, we used multiple regression models of three self-reported behaviors: whether they own an energy-star refrigerator, the adoption of energy-efficient lightbulbs in the home, and the length of a typical shower.

To estimate endogenous variability in estimation ability, after accounting for differences due to the interventions, we standardized (i.e., z-scored) *within each intervention condition* the two measures of individual energy estimation ability: underlying understanding of relative energy use (ρ), and scale use ($\sigma_{est}/\sigma_{actual}$). Since these capture individual differences relative to other participants in the same intervention condition, we refer to these as relative understanding and relative scale use.

Full model results are given in Table S4. Models included individuals' relative understanding and relative scale use; control predictors for individual difference measures (sociodemographic, numeracy, and pro-environmental attitudes[3]); and potential moderating effects of all controls on the effects of relative understanding and relative scale use (i.e., interactions with control variables):

$$
\begin{aligned}
\texttt{Conservation behavior} \sim b_0 &+ ß_1(\mathit{RelativeUnderstanding}) \\
&+ ß_2(\mathit{RelativeScaleUse}) \\
&+ b_{\mathrm{Socio}}\{\text{socio-demographic and numeracy}\} \\
&+ b_3(\mathit{RelativeUnderstanding} \times \\
&\qquad \{\text{socio-demographic and numeracy}\} \\
&+ b_4(\mathit{RelativeScaleUse} \times \\
&\qquad \{\text{socio-demographic and numeracy}\}
\end{aligned}
$$

Supplementary Note 3

To analyze individuals' ability to make pairwise choices between conservation-relevant activities and behavioral changes, we used a generalized linear mixed-effects model of choice accuracy with a logistic linking function (i.e., a mixed-logit model):

$$\begin{aligned}\texttt{Accuracy} \sim b_0 &+ b_1(\textit{SubjectiveEnergyRatio}) \\ &+ b_2(\textit{Heuristic}) + b_3\,(\textit{ScaleUseInfo}) \\ &\quad + b_4(\textit{Heuristic}\times\textit{ScaleUseInfo}) \\ &+ b_{socio}\{\texttt{socio-demographic and numeracy}\} \\ &+ (b_{0j} \mid \textit{subjectID}) \\ &+ (b_{0i} \mid \textit{applianceID})\end{aligned}$$

To capture the subjective difficulty of each item, for each participant, we calculated the ratio between the energy usage of the more energy-intensive option and the energy usage of the less energy-intensive option, based on the participant's $\log_{10}$-transformed estimates for the relevant appliances ("`SubjectiveEnergyRatio`"). If a participant's previous energy estimates suggested that the two options would involve equivalent energy usage, this ratio would equal 1; as participants' previous energy estimates more clearly distinguished the correct option, this ratio increased. This is thus a measure of each dilemma's subjective difficulty for the participant, based on the estimates they had given previously. One of the twenty dilemmas involved two parts of a desktop computer (the tower and the monitor) that were not explicitly distinguished in the Estimation Task; this item was removed before analysis.

To evaluate whether underlying understanding of relative energy use mediated the impact of the explicit heuristic on behavioral choice accuracy, we added relative ordering (ρ) to the model.

Full model results are summarized in Table S5 (with relative ordering but without interventions), Table S6 (without relative ordering but with interventions), and Table S8 (with both relative ordering and interventions).

To estimate the targeted impact of the explicit heuristic on those items where the more energy-intensive option involved a large temperature-changing appliance ('targeted' items), we also fit a model that included a predictor for whether for whether the item was targeted, baselined on 'yes.' The results of this model are summarized in Table S7.

Supplementary Note 4

The explicit heuristic's benefit for behavioral choices was totally mediated by its impact on participants' understanding of energy use. When we added the measure of individuals' understanding of relative energy use (i.e., ρ) to the model of behavioral choice accuracy, the effect of the explicit heuristic was small and no longer differed significantly from zero ($b = 0.05 \pm 0.04$ SEM, $P = 0.28$), while participants' relative ordering of appliances by energy use remained a strong predictor of their choice accuracy ($\beta = 0.19 \pm 0.02$ SEM, $P < 0.01$). Of the total effect of the heuristic on behavioral choice accuracy, nearly two thirds was mediated by individuals' understanding of relative energy use (64%, 95% CI [0.27, 1.00], $P = 0.03$). Thus, the explicit heuristic helped individuals choose between conservation behaviors, mediated by an improved understanding of appliances' relative energy use.

Supplementary Note 5

We used multiple linear regressions to analyze pro-environmental attitudes, beliefs, and policy support. We collected three measures: New Environmental Paradigm (NEP) scores[3], a measure of pro-environmental attitudes; beliefs in climate change; and support for climate policy. All three dependent measures were re-centered so that neutral attitudes and beliefs were equal to 0 (e.g., neither supporting or opposing climate policy), and then standardized so that coefficient estimates indicate a difference of one standard deviation in the dependent measure.

To estimate the relations between these measures of pro-environmental attitudes, beliefs, and policy support, on the one hand, and the ability to estimate home energy use, on the other hand, we adopted the same approach as we used for self-reported conservation behavior: To estimate endogenous variability in estimation ability, after accounting for differences due to the interventions, we standardized (i.e., z-scored) *within each intervention condition* the two measures of individual differences in energy estimation ability: underlying understanding of relative energy use (ρ), and scale use ($\sigma_{est}/\sigma_{actual}$). Since these capture individual differences relative to other participants in the same intervention condition, we refer to these as relative understanding and relative scale use.

Full model results are summarized in Table S9. The full models was as follows:

```
attitude/belief/support ~ b0 + ß1(RelativeUnderstanding)
                             + ß2(RelativeScaleUse)
                             + bSocio{socio-demographic and numeracy}
                             + b3(RelativeUnderstanding×
                                  {socio-demographic and numeracy}
                             + b4(RelativeScaleUse ×
                                  {socio-demographic and numeracy}
```

Supplementary Table 1: Multiple regression model of energy use estimation slopes

predictors	est	se	t	p	sig
Intercept	0.30	0.01	29.71	0.00	***
Heuristic	0.05	0.01	3.90	0.00	***
ScaleUseInfo	0.13	0.01	10.78	0.00	***
Heuristic x ScaleUseInfo	0.00	0.02	-0.20	0.84	
Male	0.04	0.01	4.56	0.00	***
Age	0.04	0.00	9.92	0.00	***
Education	0.00	0.00	0.30	0.77	
Relevant Degree	0.02	0.02	1.06	0.29	
Political Ideology	0.00	0.00	1.86	0.06	
Income	0.00	0.00	0.29	0.77	
Numeracy	0.05	0.00	10.41	0.00	***
Electrician	0.03	0.03	1.21	0.23	

Supplementary Table 2: Multiple regression model of underlying understanding of relative energy use (ρ)

predictors	est	se	t	p	sig
Intercept	0.52	0.01	53.59	0.00	***
Heuristic	0.05	0.01	4.36	0.00	***
ScaleUseInfo	0.02	0.01	2.15	0.03	*
Heuristic x ScaleUseInfo	-0.01	0.02	-0.73	0.47	
Male	0.06	0.01	6.92	0.00	***
Age	0.04	0.00	8.98	0.00	***
Education	0.00	0.00	-1.03	0.30	
Relevant Degree	0.02	0.02	1.46	0.14	
Political Ideology	0.00	0.00	2.07	0.04	*
Income	0.01	0.00	2.04	0.04	*
Numeracy	0.06	0.00	14.17	0.00	***
Electrician	-0.04	0.03	-1.70	0.09	

Supplementary Table 3: Regression model of scale-use in home energy use estimation ($\sigma_{est}/\sigma_{actual}$)

predictors	est	se	t	p	sig
Intercept	0.56	0.01	43.47	0.00	***
Heuristic	0.04	0.02	2.32	0.02	*
ScaleUseInfo	0.21	0.02	13.54	0.00	***
Heuristic x ScaleUseInfo	0.00	0.02	0.13	0.90	
Male	-0.01	0.01	-0.64	0.52	
Age	0.03	0.01	5.45	0.00	***
Education	0.01	0.01	1.06	0.29	
Relevant Degree	-0.02	0.02	-1.09	0.28	
Political Ideology	0.00	0.00	0.89	0.37	
Income	-0.01	0.01	-1.51	0.13	
Numeracy	0.01	0.01	2.41	0.02	*
Electrician	0.05	0.03	1.60	0.11	

Notes for Tables S1-3: Actual and estimated energy use were log_{10}-transformed and centered at the mean of all items' actual energy use; the sign of the intercept thus indicate overall overestimation. Dichotomous predictors are dummy coded [interventions: did not receive = 0, did receive = 1; male: no = 0, yes = 1; electrician: no = 0, yes =1; relevant college training, no = 0, yes = 1]; sociodemographic measures were then mean-centered. Political ideology was centered at the liberal end of the spectrum (range = [0,6]). All other predictors were mean-centered and standardized (i.e., z-scored). ($p < .05$, ** $p \leq .01$, *** $p \leq .001$)*

Supplementary Table 4: Regression analyses of self-reported conservation behaviors.

predictors	Shower Length		Efficient Bulbs		Energy-Star Fridge	
Intercept	11.66 (0.35)	***	0.35 (0.12)	**	0.43 (0.14)	**
Relative Ordering	-0.4 (0.16)	*	0.24 (0.06)	***	0.22 (0.07)	***
Scale Use	0.62 (0.15)	***	0.04 (0.05)		-0.03 (0.06)	
Male	-1.11 (0.32)	***	-0.07 (0.11)		0 (0.13)	
Age	-1.41 (0.15)	***	0.05 (0.05)		0.23 (0.06)	***
Education	-0.38 (0.16)	*	0.01 (0.06)		-0.1 (0.07)	
Relevant Degree	1.44 (0.58)	*	-0.17 (0.2)		0.41 (0.25)	
Political Ideology	0.12 (0.09)		-0.02 (0.03)		0.03 (0.04)	
Income	-0.57 (0.16)	***	0.17 (0.06)	**	0.45 (0.07)	***
NEP	-0.39 (0.23)		0.26 (0.08)	**	0.22 (0.09)	*
Numeracy	0.01 (0.16)		0.01 (0.06)		-0.01 (0.07)	
Electrician	-1.12 (0.91)		0.07 (0.33)		-0.32 (0.37)	

Notes: Column titles indicate the dependent variable in three separate multiple regressions: length of shower (in minutes); adoption of efficient lightbulbs (as a percentage), and owning an energy-star fridge. Values indicate coefficient estimates, with standard errors in parentheses. Dichotomous predictors were dummy coded and mean-centered. Political ideology was centered at the liberal end of the spectrum (range = [0,6]). Relative Ordering and Scale Use were mean-centered and normalized within each intervention condition. All other predictors were mean-centered and normalized (i.e., z-scored). ($p < .05$, ** $p \leq .01$, *** $p \leq .001$)*

Supplementary Table 5: Mixed-logit model of behavioral dilemmas, without the interventions

predictors	est	se	z	p	sig
Relative Ordering	0.19	0.02	11.19	0.000	***
subjectiveEnergyRatio	0.12	0.05	2.63	0.008	**
Male	-0.04	0.03	-1.05	0.292	
Age	0.04	0.02	2.37	0.018	*
Education	0.01	0.02	0.82	0.413	
Degree	-0.01	0.06	-0.17	0.867	
Political Ideology	0.01	0.01	0.95	0.340	
Income	0.00	0.02	-0.15	0.880	
Numeracy	0.03	0.02	1.59	0.113	
NEP	0.02	0.02	0.92	0.356	
Electrician	0.16	0.10	1.61	0.106	

Notes: Dependent variable is accuracy on each behavioral dilemma. ($p < .05$, ** $p \leq .01$, *** $p \leq .001$)*

Supplementary Table 6: Mixed-logit model of behavioral dilemmas, with the interventions but not relative ordering

predictors	est	se	z	p	sig
Heuristic	0.10	0.05	2.16	0.031	*
ScaleUseInfo	0.02	0.05	0.53	0.599	
Heuristic * ScaleUseInfo	-0.02	0.06	-0.33	0.744	
subjectiveEnergyRatio	0.12	0.05	2.51	0.012	*
Male	0.03	0.03	0.95	0.344	
Age	0.08	0.02	4.72	0.000	***
Education	0.01	0.02	0.46	0.646	
Degree	0.02	0.06	0.31	0.753	
Political Ideology	0.02	0.01	1.83	0.067	
Income	0.01	0.02	0.41	0.684	
Numeracy	0.09	0.02	5.29	0.000	***
NEP	0.05	0.03	1.82	0.069	
Electrician	0.10	0.10	1.02	0.310	

Notes: Dependent variable is accuracy on each behavioral dilemma. ($p < .05$, ** $p \leq .01$, *** $p \leq .001$)*

Supplementary Table 7: Mixed-logit model of behavioral dilemmas, with the interventions but not relative ordering, baselined on dilemmas that were targeted by the explicit heuristic.

predictors	est	se	z	p	sig
Heuristic	0.15	0.07	2.17	0.030	*
ScaleUseInfo	0.02	0.05	0.53	0.599	
Heuristic * ScaleUseInfo	-0.02	0.06	-0.33	0.744	
HeuristicTargeted	1.44	0.44	3.29	0.001	**
Heuristic * HeuristicTargeted	0.07	0.07	1.00	0.319	
subjectiveEnergyRatio	0.12	0.05	2.51	0.012	*
Male	0.03	0.03	0.94	0.345	
Age	0.08	0.02	4.72	0.000	***
Education	0.01	0.02	0.46	0.646	
Degree	0.02	0.06	0.32	0.753	
Political Ideology	0.02	0.01	1.83	0.067	
Income	0.01	0.02	0.41	0.684	
Numeracy	0.09	0.02	5.29	0.000	***
NEP	0.05	0.03	1.82	0.069	
Electrician	0.10	0.10	1.02	0.309	

Notes: Dependent variable is accuracy on each behavioral dilemma. To measure the targeted impact of the heuristic on dilemmas involving heuristic-targeted appliances, the model is baselined on those items (i.e., HeuristicTargeted: no = -1, yes = 0). ($p < .05$, ** $p \leq .01$, *** $p \leq .001$)*

Supplementary Table 8: Mixed-logit model of behavioral dilemmas, with both interventions and relative understanding.

predictors	est	se	z	p	sig
Heuristic	0.05	0.04	1.08	0.280	
ScaleUseInfo	0.00	0.04	-0.04	0.966	
Heuristic * ScaleUseInfo	-0.01	0.06	-0.15	0.879	
Relative Ordering	0.19	0.02	10.91	0.000	***
subjectiveEnergyRatio	0.12	0.05	2.63	0.009	**
Male	-0.03	0.03	-1.00	0.319	
Age	0.04	0.02	2.43	0.015	*
Education	0.01	0.02	0.73	0.467	
Degree	-0.01	0.06	-0.15	0.882	
Political Ideology	0.01	0.01	0.96	0.340	
Income	0.00	0.02	-0.11	0.916	
Numeracy	0.03	0.02	1.61	0.107	
NEP	0.02	0.02	0.88	0.380	
Electrician	0.15	0.10	1.55	0.121	

Notes: Dependent variable is accuracy on each behavioral dilemma. ($p < .05$, ** $p \leq .01$, *** $p \leq .001$)*

Supplementary Table 9: Results of multiple regression models of New Environmental Paradigm (NEP) attitudes, climate change beliefs, and support for climate policy.

		NEP		Climate Change Beliefs		Pro-Climate Policy	
Intercept		1.12 (0.03)	***	1.23 (0.02)	***	1.19 (0.02)	***
Effects on Intercept	Male	-0.21 (0.03)	***	-0.05 (0.03)		-0.1 (0.03)	***
	Age	0.01 (0.02)		-0.03 (0.02)		0.01 (0.01)	
	Education	-0.02 (0.02)		-0.02 (0.02)		0 (0.01)	
	Degree	-0.16 (0.07)	*	0.09 (0.06)		-0.05 (0.06)	
	Political Ideology	-0.18 (0.01)	***	-0.22 (0.01)	***	-0.18 (0.01)	***
	Income	0.02 (0.02)		0.03 (0.02)		0.05 (0.01)	**
	Numeracy	0.03 (0.02)		0.04 (0.02)	*	0.01 (0.02)	
	Electrician	0.14 (0.1)		0.17 (0.09)		-0.05 (0.09)	
Relative Understanding		0.1 (0.03)	***	0.05 (0.03)		0.1 (0.02)	***
Interaction w/ Relative Understanding	Male	0.02 (0.03)		0.02 (0.03)		0.06 (0.03)	*
	Age	-0.01 (0.02)		0 (0.02)		-0.02 (0.01)	
	Education	0 (0.02)		0 (0.02)		-0.01 (0.02)	
	Degree	-0.05 (0.07)		-0.03 (0.07)		-0.11 (0.06)	
	Political Ideology	-0.03 (0.01)	**	-0.02 (0.01)	**	-0.04 (0.01)	***
	Income	-0.01 (0.02)		0 (0.01)		0.01 (0.01)	
	Numeracy	-0.04 (0.02)	*	-0.01 (0.02)		-0.03 (0.02)	*
	Electrician	0.1 (0.07)		0.15 (0.07)	*	0.12 (0.06)	
Relative Scale Use		0.04 (0.03)		0.03 (0.03)		0.03 (0.02)	
Interaction w/ Relative Scale Use	Male	0.02 (0.03)		0.04 (0.03)		-0.01 (0.03)	
	Age	0.01 (0.02)		0 (0.02)		-0.03 (0.01)	*
	Education	-0.02 (0.02)		0 (0.02)		0 (0.02)	
	Degree	0.08 (0.08)		0 (0.07)		0 (0.07)	
	Political Ideology	-0.01 (0.01)		-0.02 (0.01)	*	-0.01 (0.01)	
	Income	0.01 (0.02)		0.01 (0.02)		0 (0.01)	
	Numeracy	-0.04 (0.02)	*	-0.02 (0.02)		-0.01 (0.02)	
	Electrician	-0.11 (0.08)		-0.15 (0.07)	*	0.12 (0.07)	

Notes: Values indicate coefficient estimates, with standard errors in parentheses. All three dependent measures were standardized and centered at the neutral value. Dichotomous predictors are dummy coded [male: no = 0, yes = 1; electrician: no = 0, yes =1; relevant college degree, no = 0, yes = 1]. Political ideology was centered at the liberal end of the spectrum (range = [0,6]). Relative Ordering and Scale Use were mean-centered and normalized within each intervention condition. All other predictors were mean-centered and standardized (i.e., z-scored). ($p < .05$, ** $p \leq .01$, *** $p \leq .001$)*

Supplementary Table 10: Mean estimates in watt-hours for each appliance in each condition.

appliance	actual	control	scale-use	heuristic	both	only high-end
clock	3	26 [31, 31]	20 [18, 23]	36 [31, 41]	20 [18, 24]	38 [32, 45]
charging smartphone	3	55 [62, 64]	9 [9, 10]	71 [62, 82]	10 [9, 12]	96 [80, 114]
DVD player	9	81 [95, 94]	95 [82, 111]	110 [95, 126]	94 [82, 109]	118 [100, 140]
modem	12	58 [67, 68]	64 [65, 74]	78 [67, 91]	75 [65, 88]	97 [81, 116]
LED lightbulb	15	31 [31, 36]	36 [31, 41]	35 [31, 40]	33 [31, 37]	40 [34, 47]
compact fluorescent lightbulb	23	45 [46, 51]	48 [42, 54]	51 [46, 56]	47 [42, 54]	58 [49, 68]
laptop	32	190 [199, 220]	239 [218, 277]	228 [199, 261]	251 [218, 289]	302 [255, 357]
cable TV box	33	89 [96, 103]	96 [93, 113]	112 [96, 129]	108 [93, 126]	146 [124, 172]
stereo	33	116 [131, 133]	144 [129, 168]	150 [131, 172]	148 [129, 171]	173 [146, 205]
TV	68	227 [248, 263]	335 [340, 391]	285 [248, 326]	388 [340, 444]	396 [335, 467]
fan	69	97 [123, 111]	126 [117, 146]	140 [123, 160]	136 [117, 157]	162 [136, 193]
incandescent lightbulb	100	83 [84, 91]	89 [91, 98]	90 [84, 97]	95 [91, 100]	83 [71, 97]
videogame console	111	164 [170, 192]	229 [196, 267]	195 [170, 224]	206 [196, 237]	258 [220, 303]
desktop computer	138	249 [273, 290]	325 [355, 378]	312 [273, 358]	403 [355, 459]	420 [356, 496]
humidifier	185	130 [184, 152]	200 [178, 234]	212 [184, 245]	209 [178, 245]	271 [230, 320]
electric blanket	197	115 [146, 134]	131 [165, 153]	167 [146, 191]	192 [165, 224]	220 [189, 257]
projector	197	152 [187, 176]	201 [186, 235]	214 [187, 246]	216 [186, 252]	285 [242, 336]
crockpot	318	119 [165, 137]	141 [170, 164]	189 [165, 216]	197 [170, 229]	211 [178, 252]
fridge	364	411 [688, 483]	935 [1243, 1095]	806 [688, 943]	1436 [1243, 1660]	1096 [935, 1286]
freezer	384	302 [541, 354]	663 [910, 777]	626 [541, 725]	1066 [910, 1248]	757 [638, 899]
clothes washer	478	417 [542, 487]	1461 [1452, 1704]	621 [542, 712]	1657 [1452, 1891]	1621 [1379, 1906]
dehumidifier	734	141 [195, 163]	228 [228, 267]	224 [195, 258]	265 [228, 307]	304 [256, 362]
vacuum	809	175 [204, 205]	274 [250, 320]	234 [204, 270]	288 [250, 332]	313 [266, 369]
microwave	1101	288 [374, 336]	525 [497, 610]	428 [374, 491]	571 [497, 656]	541 [457, 640]
coffee maker	1134	93 [117, 108]	107 [106, 125]	133 [117, 152]	123 [106, 143]	165 [140, 194]
window AC	1157	470 [723, 546]	1215 [1408, 1413]	834 [723, 963]	1597 [1408, 1812]	1275 [1081, 1504]
iron	1198	109 [123, 128]	118 [133, 140]	143 [123, 166]	155 [133, 180]	164 [139, 194]
dishwasher	1201	340 [448, 396]	980 [992, 1136]	517 [448, 597]	1131 [992, 1289]	1059 [901, 1245]
toaster	1213	100 [131, 118]	119 [127, 142]	151 [131, 174]	147 [127, 171]	166 [140, 197]
portable heater	1290	313 [461, 365]	617 [669, 718]	535 [461, 620]	777 [669, 902]	684 [569, 822]
electric kettle	1390	101 [133, 118]	125 [137, 147]	153 [133, 175]	160 [137, 186]	173 [146, 204]
electric oven	3050	412 [631, 482]	1107 [1262, 1290]	729 [631, 843]	1455 [1262, 1678]	1172 [992, 1384]
central AC	3797	699 [1074, 822]	1934 [2674,	1242 [1074,	3035 [2674,	2057 [1735,

			2259]	1436]	3445]	2438]
clothes dryer	3938	537 [731, 633]	2286 [2414, 2651]	843 [731, 973]	2694 [2414, 3005]	2152 [1841, 2516]
water heater	4284	370 [576, 433]	771 [1113, 912]	671 [576, 782]	1297 [1113, 1511]	888 [751, 1050]
charging Tesla	11520	860 [1082, 1036]	2193 [2164, 2644]	1275 [1082, 1502]	2591 [2164, 3101]	2180 [1793, 2651]

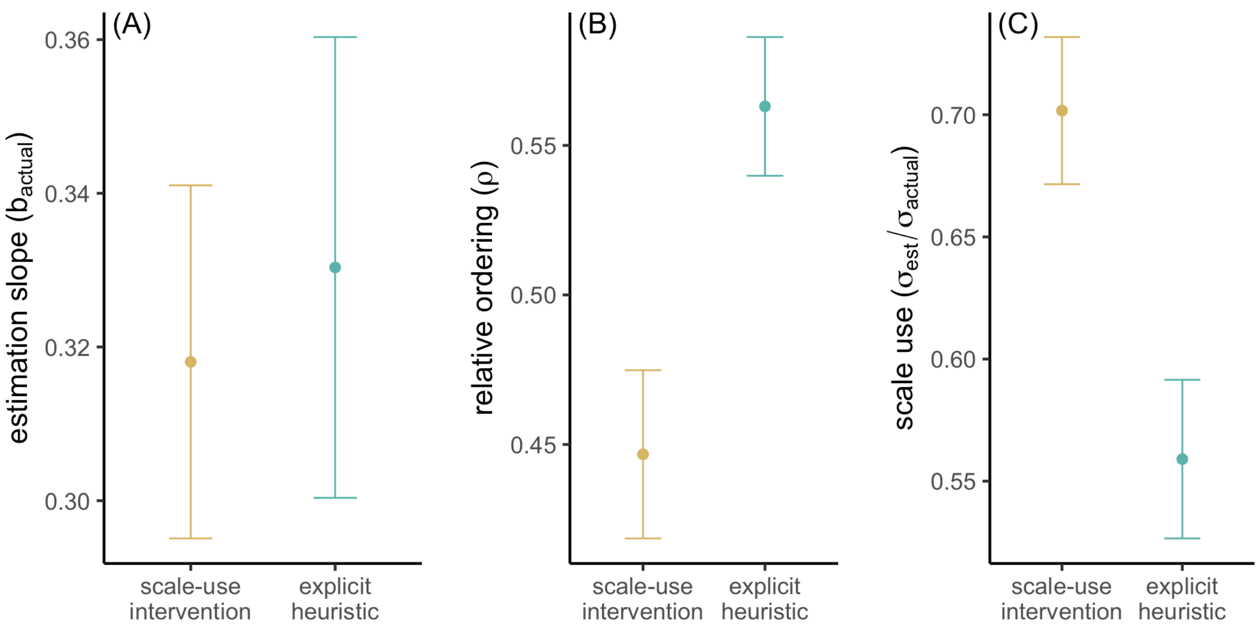
Notes: Values indicate means in watt-hours, with 95% confidence intervals in brackets. Following the main text, estimates were first log-transformed; reported values are back-transformed to a linear watt-hours scale to facilitate interpretation.

Supplementary Table 11: Mean absolute percentage error for each appliance in each condition.

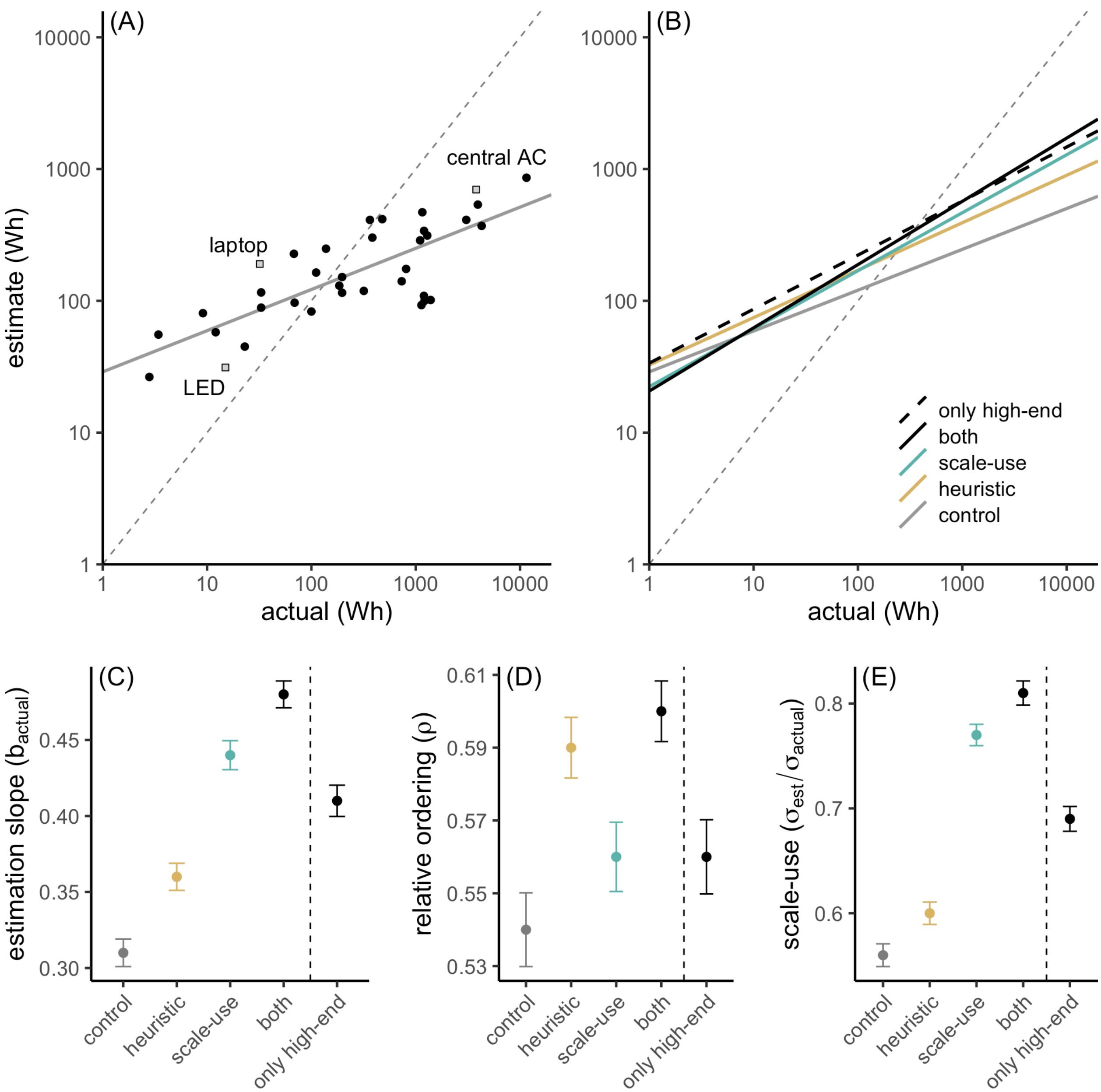
appliance	control	scale-use	heuristic	both	only high-end
clock	2238 [1842, 2634]	2519 [1669, 3370]	7714 [0, 16396]	2461 [1820, 3101]	4778 [3808, 5748]
charging smartphone	3948 [3143, 4754]	1095 [599, 1592]	5369 [4101, 6637]	1448 [901, 1996]	9177 [7507, 10847]
DVD player	3937 [1, 7872]	2643 [2165, 3120]	4933 [709, 9156]	2425 [2003, 2847]	3697 [3055, 4339]
modem	1392 [993, 1791]	1439 [1149, 1730]	2104 [883, 3324]	1985 [1561, 2408]	3097 [2410, 3783]
LED lightbulb	301 [264, 337]	448 [346, 549]	395 [306, 484]	377 [299, 455]	1208 [828, 1589]
compact fluorescent lightbulb	234 [204, 264]	357 [256, 458]	353 [143, 562]	331 [261, 402]	854 [640, 1068]
laptop	1765 [1133, 2397]	1705 [1414, 1996]	1721 [1305, 2137]	1715 [1437, 1993]	2286 [1954, 2619]
cable TV box	1244 [137, 2351]	896 [672, 1119]	1277 [479, 2076]	841 [678, 1005]	1366 [1089, 1644]
stereo	692 [557, 827]	1048 [849, 1247]	974 [757, 1191]	913 [776, 1049]	1981 [518, 3445]
TV	1516 [810, 2222]	2886 [0, 6392]	1057 [749, 1365]	1344 [943, 1746]	2413 [287, 4539]
fan	290 [144, 436]	413 [306, 520]	374 [299, 448]	451 [304, 598]	586 [475, 697]
incandescent lightbulb	26 [0, 64]	88 [0, 208]	12 [6, 18]	18 [5, 31]	208 [150, 265]
videogame console	598 [219, 977]	22303 [0, 65264]	329 [231, 427]	367 [297, 438]	514 [433, 594]
desktop computer	1432 [0, 3176]	465 [393, 536]	557 [341, 773]	601 [416, 785]	661 [565, 757]
humidifier	449 [0, 976]	235 [197, 274]	1610 [0, 4227]	261 [212, 311]	318 [272, 364]
electric blanket	182 [47, 316]	156 [128, 183]	156 [112, 200]	215 [173, 258]	229 [193, 265]
projector	233 [41, 424]	222 [170, 275]	208 [127, 290]	219 [176, 262]	312 [261, 362]
crockpot	103 [64, 141]	92 [79, 105]	166 [14, 318]	123 [102, 144]	134 [100, 167]
fridge	1013 [0, 2028]	532 [439, 625]	4368 [0, 10501]	769 [646, 892]	630 [471, 789]
freezer	858 [0, 1844]	333 [286, 380]	568 [313, 824]	594 [486, 702]	384 [331, 438]
clothes washer	635 [0, 1392]	449 [418, 480]	348 [206, 491]	476 [432, 519]	582 [484, 681]
dehumidifier	99 [71, 128]	86 [77, 94]	98 [67, 128]	90 [77, 103]	90 [80, 100]
vacuum	119 [76, 161]	78 [71, 85]	93 [76, 111]	79 [72, 87]	92 [81, 104]
microwave	171 [47, 294]	72 [65, 80]	101 [73, 129]	95 [74, 115]	89 [80, 97]
coffee maker	102 [71, 133]	81 [79, 83]	81 [77, 86]	83 [78, 87]	79 [74, 84]
window AC	142 [95, 188]	180 [126, 233]	207 [140, 275]	188 [157, 219]	172 [143, 200]

iron	87 [80, 95]	83 [79, 87]	104 [64, 143]	76 [74, 79]	76 [72, 79]
dishwasher	257 [0, 556]	107 [97, 116]	114 [85, 144]	132 [106, 158]	125 [100, 150]
toaster	103 [68, 138]	84 [79, 89]	89 [79, 99]	80 [76, 85]	77 [74, 81]
portable heater	120 [73, 166]	93 [81, 105]	3929 [0, 9227]	117 [90, 143]	94 [85, 104]
electric kettle	94 [78, 110]	81 [79, 83]	86 [81, 92]	79 [77, 82]	79 [76, 82]
electric oven	154 [36, 271]	60 [56, 64]	102 [80, 124]	66 [58, 74]	64 [49, 80]
central AC	215 [85, 344]	141 [14, 269]	130 [86, 174]	88 [73, 104]	59 [54, 64]
clothes dryer	169 [66, 272]	23 [18, 29]	96 [79, 113]	18 [15, 22]	20 [15, 25]
water heater	135 [52, 219]	67 [63, 71]	148 [36, 261]	74 [61, 87]	65 [59, 71]
charging Tesla	141 [86, 195]	78 [69, 86]	104 [90, 118]	88 [74, 102]	498 [0, 1334]

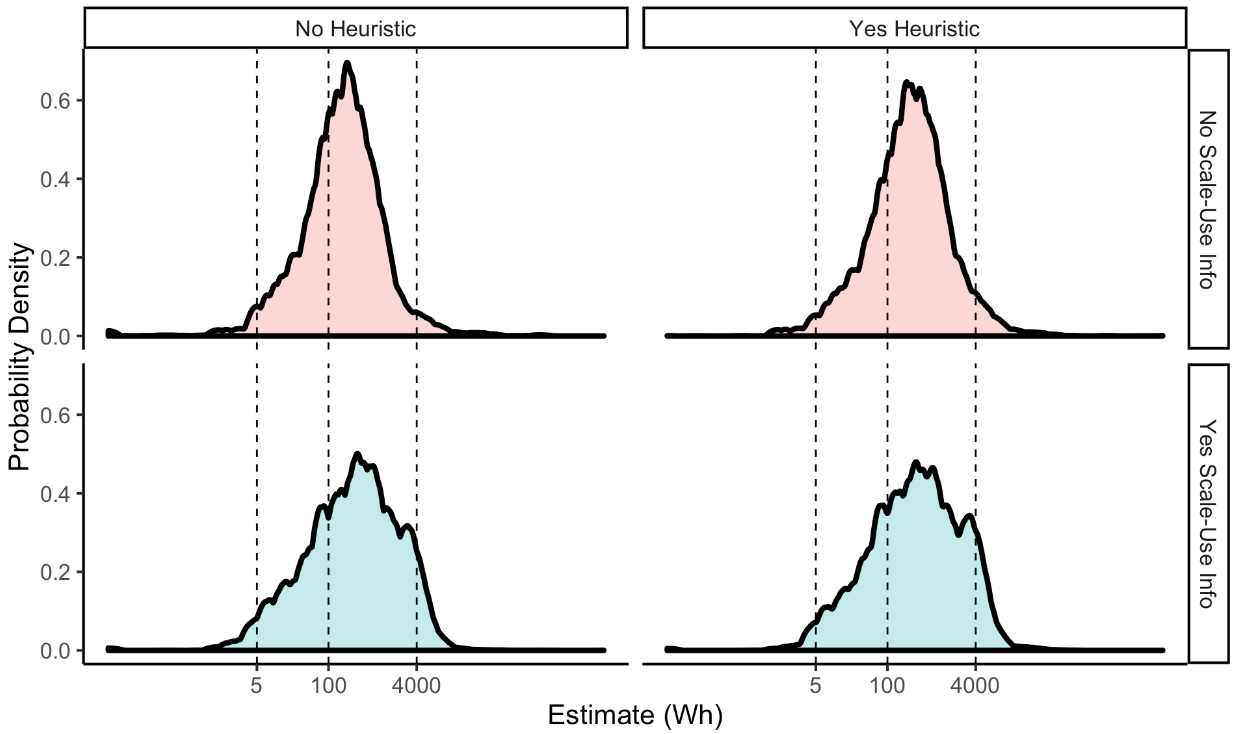
Notes: Values indicate mean absolute percentage error (in %), relative to the true energy use, with 95% confidence intervals in brackets.



Supplementary Figure 1. *Pilot evidence that the explicit heuristic improves underlying understanding of relative energy use and scale-use information improve the use of the response scale.* Volunteer undergraduate students received either the explicit heuristic (n = 50) or the scale-use intervention (n = 57). For each individual, we calculated: (A) estimation slope (i.e., the slope of appliances' actual energy use, predicting estimates of energy use); (B) the correlation between appliances' actual and estimated energy use, a measure of their understanding of the appliances' relative energy use; (C) and the ratio between the standard deviation of their estimates and the standard deviation of the actual values, a measure of their use of the watt-hours response scale. While the two interventions did not lead to differences in their estimation slopes (A), the caused qualitatively different patterns of energy understanding and use of the response scale. Underlying understanding of appliances' relative energy use was better after receiving the explicit heuristic, compared to after receiving the scale-use intervention (B). In contrast, use of the response scale was better after receiving the scale-use intervention, compared to after receiving the heuristic (C). Points indicate means; error bars indicate standard errors.



Supplementary Figure 2. Use of the response scale improved more when participants received information about both ends of the response scale, not just the upper end. To confirm the importance of anchoring both ends of the response scale, we recruited a new sample of participants from Amazon Mechanical Turk (N = 406). They only received information about the higher end of the response scale (i.e., that a clothes dryer uses 4000 units of energy). Unlike the participants in the main experiment reported in the Main Text, therefore, these supplemental participants did not receive information about the low end of the response scale — neither the extreme low-end information supplied in the scale-use intervention (i.e., charging a smartphone), nor the information about incandescent lightbulbs that was offered as a reference point for all participants in the main experiment. Overall, we found that supplying quantitative information about only the higher end of response scale improved estimation slopes by improving their numerical estimates for high-use appliances, although this was less than when we supplied information about both ends of the scale ('scale-use'); and, compared to supplying the explicit heuristic, supplying high-end information had only a moderate benefit for understanding appliances' relative energy use. (A) Estimates for home appliances in the control condition, reproduced for reference from Fig. 2 in the Main Text. (B) Supplying information about only the higher end of the response scale (dashed black line) increased estimation slopes, but it also increased estimates overall (note the higher intercept than control). By contrast, supplying information about both ends of the scale (green line) both improved the estimation slope and mitigated the systematic over-estimation of low-use appliances (note the lower intercept). (C) Participants who received numerical information about the higher end of the response scale had better estimation slopes than those who received the heuristic, but worse than those who received information about *both* ends of the response scale. (D) Participants who received *any* numerical information about the response scale (either both ends or just high-end) had better understanding of relative ordering than in the control condition, but their understanding was notably worse than among participants who received the heuristic. (E) Participants who received information about the higher end of the response scale made better use of the response scale than those who received the heuristic, but worse than those who received numerical information about *both* ends of the response scale. Indeed, participants who only received a higher-end anchor increased *all* their estimates; they doubled their lowest estimate (M_{lowest} = 63) and quadrupled their highest estimate (M_{highest} = 56382), compared to control (M_{lowest} = 29 and M_{highest} = 13127). By contrast, participants who received quantitative information about both ends of the response scale corrected the systematic overestimation of low-use appliances (M_{lowest} = 24) while also correcting the underestimation of high-use appliances (M_{highest} = 32715). Points indicate means; error bars indicate standard errors.



Supplementary Figure 3. Evidence for anchoring-and-adjustment in energy estimation. As an exploratory analysis, we investigated whether estimates were clustered around the values supplied in the scale-use intervention. Panels show kernel density plots of $\log_{10}$-transformed energy use estimates, split by intervention condition. Appliances mentioned in the scale-use intervention were excluded (phone charger, incandescent lightbulb, and clothes dryer); for reference, the values for their actual energy use are indicated by dashed vertical lines (5, 100, and 4000 Wh, respectively). Note the increased density around 4000 Wh among participants who received the scale-use intervention (bottom panels), suggesting that they may have adopted an 'anchor and adjust' heuristic[4] for higher-energy-use appliances: first anchoring their estimate at 4000 Wh and then adjusting their estimates upwards or downwards from there.

Supplementary Methods

Actual energy data

Actual energy used in one hour was estimated from a sample of appliances available for sale online and at local stores. A list of specific products used to estimate typical appliances' energy use are available upon request. (All values are in Wh.)

Compact Fluorescent Light (CFL) bulb: 23; Desktop computer: 138; Laptop computer: 32; Stereo: 33; Window air conditioner: 1157; Central air conditioner: 3797; Clothes dryer: 3938; Dishwasher: 1201; Charging a Tesla Model-S electric car: 11520; Dehumidifier: 734; Humidifier: 185; Vacuum: 809; 100-watt incandescent light bulb: 100; Slow cooker (crockpot): 318; Electric oven: 3050; Portable heater: 1290; Charging a smartphone: 5; 40" flat screen television: 68; Ceiling fan: 69; Water heater: 4284; Modem: 12.1; Television Cable box: 33; Alarm clock: 2.8; Iron: 1198; Projector: 197; Full-sized fridge: 364; Storage freezer: 384; Washing machine: 478; Video game console: 111; Electric blanket: 197; DVD player: 9.13; Microwave: 1101; Toaster: 1213; LED light bulb: 15; Electric kettle: 1390; Coffee maker: 1134.

Energy Estimation Task

Main Instructions

[If no 'Scale Use' intervention:] A 100-watt incandescent light bulb uses 100 units of energy in one hour.
[If yes 'Scale Use' intervention:] A 5-watt phone charger uses 5 units of energy to charge a smartphone in one hour. Similarly, a 100-watt incandescent light bulb uses 100 units of energy in one hour, and a typical clothes dryer uses about 4,000 units of energy in one hour.
When you are asked to estimate units of energy, please compare each appliance to the appliance listed above. Think about whether each appliance below uses less energy or more energy than the appliance listed above. Please use this number to help you make your estimates.
How many units of energy do you think each of the following devices typically uses in one hour?
Your best estimates are fine. Please enter whole numbers with no other text (not decimals, ranges, or percentages).
[If yes 'Explicit Heuristic' intervention:] Note that LARGE appliances that primarily HEAT or COOL things use a lot more energy than people think.

Questions after completing all energy estimations

1. How confident are you about your overall estimates? *(Not at all confident; Somewhat confident; Confident; Extremely confident)*
2. Walk us through how you estimated the amount of energy used for the washing machine: *(free response)*
3. Walk us through how you estimated the amount of energy used for the projector: *(free response)*

Behavioral Dilemma Task

{Intervention text was repeated before every set of five pairwise behavioral dilemmas, listed below}
[If no 'Scale Use' intervention:] A 100-watt incandescent light bulb uses 100 units of energy in one hour.
[If yes 'Scale Use' intervention:] A 5-watt phone charger uses 5 units of energy to charge a smartphone in one hour. Similarly, a 100-watt incandescent light bulb uses 100 units of energy in one hour, and a typical clothes dryer uses about 4,000 units of energy in one hour.
[If yes 'Explicit Heuristic' intervention:] Note that LARGE appliances that primarily HEAT or COOL things use a lot more energy than people think.

For the following pairs, please choose the task or appliance that you think uses the least amount of electricity. Assume they are used for the same amount of time, unless otherwise stated.
(a) watching a movie on a laptop (b) watching a movie on a projector
(a) warming yourself with an electric blanket (b) warming yourself with a portable space heater
(a) a desktop computer's tower (b) a desktop computer's monitor
(a) cooking with an electric oven (b) cooking with a crockpot
(a) ironing your clothes (b) vacuuming your carpets

{Repeat intervention text, above}
For the following pairs, please choose the task or appliance that you think uses the least amount of electricity. Assume they are used for the same amount of time, unless otherwise stated.
(a) cooling yourself with a window air conditioner (b) cooling yourself with a ceiling fan
(a) watching a movie on a 40" flat screen television (b) watching a movie on a projector
(a) watching your favorite shows on a 40" flat screen television (b) watching your favorite shows on your laptop computer
(a) playing video games on your console (only consider the console) (b) watching cable television (only consider the cable box)
(a) charging a Tesla Model S electric vehicle for one hour (b) cooking a casserole in an electric oven for one hour

{Repeat intervention text, above}
For the following pairs, please choose the task or appliance that you think uses the least amount of electricity. Assume they are used for the same amount of time, unless otherwise stated.
(a) a water heater running at full capacity for one hour (b) vacuuming your carpets for one hour
(a) a central air conditioning unit running at full capacity for 8 hours throughout one day (b) 25 Compact Fluorescent Light (CFL) bulbs left on for 8 hours in one day
(a) warming a room with a portable space heater (b) washing clothes in a washing machine
(a) vacuuming carpets (b) a refrigerator
(a) drying a load of laundry in a clothes dryer once a week (b) 20 Light Emitting Diode (LED) bulbs left on for 60 hours each week

{Repeat intervention text, above}
For the next set of questions, please consider which action would allow you to save the most electricity. Read each option carefully and be sure to consider varying time components within the questions.
(a) Purchasing a space heater that is 20% more efficient (b) purchasing a television that is 20% more efficient
(a) replacing 20 of your Compact Fluorescent Light (CFL) bulbs for LED bulbs, left on for 8 hours each day for one week (b) hand washing your dishes with cold water rather than using the dishwasher
(a) line drying your clothes rather than using an electric clothes dryer (once a week) (b) reading a book rather than watching television (20 hours a week)
(a) turning off your cable box when not in use (b) turning off an idle laptop when not in use
(a) replacing your morning coffee (coffee maker runs at full capacity for 10 minutes) with a glass of water (b) unwinding with a book at the end of the day rather than watching television for one hour

Energy and Electricity Questions

1. Describe the difference between total energy use and electricity use in the home? *(free response)*
2. What are some appliances in an average home that might not primarily use electricity? *(free response)*
3. What percent of total energy used in an average home in the United States is electricity? *(free response)*

National Energy Statistics Questions

For the Following questions, please think about total energy use, not just electricity.

1. What percent of total household energy consumption is heating, ventilation, and air-conditioning (HVAC) across the United States?
2. What percent of residential space heating is directly fueled by natural gas in the United States?
3. What percent of residential space heating is directly powered by electricity in the United States?
4. What percent of the total energy consumption of the United States is represented by residential housing?
5. What percent of the total energy production in the United States is represented by renewable energy?
6. What percent of the total energy production in the United States is represented by natural gas?
7. What percent of the total energy production in the United States is represented by coal?

Policy Preference Questions

Please indicate which of the following policies you would support or oppose.

1. Fund more research into renewable energy sources, such as solar and wind power *(Strongly Oppose; Oppose; Support; Strongly Support)*
2. Regulate carbon dioxide (the primary greenhouse gas) as a pollutant *(Strongly Oppose; Oppose; Support; Strongly Support)*
3. Require electric utilities to produce at least 20% of their electricity from wind, solar, or other renewable energy sources, even if it costs the average household an extra $100 a year *(Strongly Oppose; Oppose; Support; Strongly Support)*

Climate Change Attitude Questions

1. Recently, you may have noticed that climate change has been getting some attention in the news. Climate change refers to the idea that the world's average temperature has been increasing over the past 150 years, may be increasing more in the future, and that the world's climate may change as a result. What do you think? Do you think that climate change is happening? *(Yes – Definitely; Yes – Probably; No – Probably; No – Definitely)*
2. Assuming climate change is happening, do you think it is: *(Caused mostly by human activities; Caused mostly by natural changes in the environment; Caused by both human activities and natural changes; None of the above because climate change isn't happening; Don't know; Other)*
3. Which comes closer to your own view? *(Most scientists think climate change is happening; Most scientists think climate change is not happening; There is a lot of disagreement among scientists about whether or not climate change is happening; I don't know enough to say)*
4. How important is the issue of climate change to you personally? *(Very important; Somewhat important; Not too important; Not at all important)*
5. How sure are you that climate change is happening? *(Extremely sure; Very sure; Somewhat sure; Not at all sure)*

Pro-environmental Attitude Scale (New-Ecological Paradigm)

For each statement below, please indicate how strongly you agree or disagree with the statement:
(Strongly Disagree; Disagree; Neutral; Agree; Strongly Agree)

1. We are approaching the limit of the number of people the earth can support
2. Humans have the right to modify the natural environment to suit their needs
3. When humans interfere with nature, it often produces disastrous consequences
4. Human ingenuity will ensure that we do NOT make the earth unlivable
5. Humans are severely abusing the environment
6. The earth has plenty of natural resources if we just learn how to develop them
7. Plants and animals have as much right as humans to exist
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations
9. Despite our special abilities, humans are still subject to the laws of nature
10. Human destruction of the natural environment has been greatly exaggerated
11. The earth has only limited room and resources
12. Humans were meant to rule over the rest of nature
13. The balance of nature is very delicate and easily upset
14. Humans will eventually learn enough about how nature works to be able to control it
15. If things continue on their present course, we will soon experience a major ecological disaster

Schwartz Numeracy[5]

To answer the following questions, please enter whole numbers or decimals with no other text (not ranges or percent signs).

1. Imagine that we flip a fair coin 1,000 times. What is your best guess about how many times the coin would come up heads in 1,000 flips?
2. In the Big Bucks Lottery, the chance of winning a $10 prize is 1%. What is your best guess about how many people would win a $10 prize if 1000 people each buy a single ticket from Big Bucks?
3. In an Acme Publishing Sweepstakes, the chance of winning a car is 1 in 1,000. What percent of tickets to Acme Publishing Sweepstakes win a car?

Berlin Numeracy[6]

1. Out of 1,000 people in a small town 500 are members of a choir. Out of these 500 members in the choir 100 are men. Out of the 500 inhabitants that are not in the choir 300 are men. What is the probability that a randomly drawn man is a member of the choir? Please indicate the probability in percent.
2. Imagine we are throwing a five-sided die 50 times. On average, out of these 50 throws how many times would this five-sided die show an odd number (1, 3 or 5)?
3. Imagine we are throwing a loaded die (6 sides). The probability that the die shows a 6 is twice as high as the probability of each of the other numbers. On average, out of these 70 throws how many times would the die show the number 6?
4. In a forest 20% of mushrooms are red, 50% brown and 30% white. A red mushroom is poisonous with a probability of 20%. A mushroom that is not red is poisonous with a probability of 5%. What is the probability that a poisonous mushroom in the forest is red?

Self-Reported Pro-Environmental Behaviors

1. What percentage of light bulbs in your home are energy-efficient bulbs (such as CFLs or LEDs)?
2. Do you have an Energy Star refrigerator? *(Yes; No; I don't know)*
3. How many times a week do you shower with hot water?
4. How long are your showers in minutes?

5. Imagine the temperature outside was 40 degrees Fahrenheit, at what temperature would you set the thermostat? Answer in degrees Fahrenheit.
6. Imagine the temperature outside was 85 degrees Fahrenheit, at what temperature would you set the thermostat? Answer in degrees Fahrenheit.

Demographics

1. How would you describe your political beliefs? *(Very Liberal; Liberal; Slightly Liberal; Moderate; Slightly Conservative; Conservative; Very Conservative)*
2. What is your gender? *(Male; Female; Other)*
3. What is your age?
4. Have you received any training as an electrician? *(Yes; No*)
5. Do you have any degrees in the physics, math, or engineering? *(Yes; No*)
6. What is the highest level of education you have attained? *(Some schooling, but no diploma or degree; High school diploma or GED; Some college; College degree; Some graduate school; Graduate degree)*
7. During 2016, what was your yearly household income before taxes? Your best estimate is fine. *(None; < $20,000; $20,000 - $40,000; $40,001 - $80,000; $80,001 - $120,000; $120,001 - $200,000; $200,000)*
8. What is your ZIP code?
9. Do you have any additional thoughts or comments about the survey that you would like to share with us?

Supplementary References

1. Attari, S. Z., DeKay, M. L., Davidson, C. I. & De Bruin, W. B. Public perceptions of energy consumption and savings. *Proc. Natl. Acad. Sci.* **107**, 16054–16059 (2010).
2. Attari, S. Z. Perceptions of water use. *Proc. Natl. Acad. Sci.* **111**, 5129–5134 (2014).
3. Dunlap, R. E., Van Liere, K. D., Mertig, A. G. & Jones, R. E. Measuring endorsement of the New Ecological Paradigm: A revised NEP scale. *J. Soc. Issues* **56**, 425–442 (2000).
4. Tversky, A. & Kahneman, D. Judgment under uncertainty: Heuristics and biases. *Science* **185**, 1124–1131 (1974).
5. Schwartz, L. M., Woloshin, S., Black, W. C. & Welch, H. G. The role of numeracy in understanding the benefit of screening mammography. *Ann. Intern. Med.* **127**, 966–972 (1997).
6. Cokely, E. T., Galesic, M., Schulz, E., Ghazal, S. & Garcia-Retamero, R. Measuring risk literacy: The Berlin Numeracy Test. *Judgm. Decis. Mak.* (2012).