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Comparing Effects of Default Nudges and Informing on Recycled Water Decisions

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Despite a serious need for sustainable alternative water supplies in many parts of the world, public opposition remains a barrier to implementing solutions such as safe wastewater recycling schemes. Here, we compared two strategies to increase acceptance of recycled water: default nudges and informing choices. Experiment 1 ($N = 81$) showed that defaults increased acceptance of recycled water. Experiment 2 ($N = 142$) replicated the effect but also indicated that weak educational interventions (simple infographics) interacted with confidence, such that those who switched from the default option had measurably higher confidence in their choice when given the infographic. Experiment 3 ($N = 146$) suggested that in a college undergraduate sample, strong educational interventions (educational videos) eliminated the effect of nudges on recycled water acceptance, increased acceptance, increased knowledge of recycled water, and also interacted with confidence in the same way observed in Experiment 2. Experiment 4 ($N = 271$) showed that strong educational interventions can also increase recycled water acceptance in an MTurk sample. Since both education and defaults may be effective, we suggest that future work would benefit from cost–benefit analyses between strategies.

Public Significance Statement

This research finds that using short, informative videos and setting defaults can encourage acceptance of potable recycled water. These effects highlight the importance for communities considering recycled water to develop good, brief educational materials and find creative applications of defaults. This research also points to a need to better explore potential costs and benefits before recommending decision support strategies.

Keywords: recycled water, potable reuse, libertarian paternalism, information, autonomy

It has been estimated that at least one-third of the world's population currently lives in water-stressed countries (Elimelech, 2006) and nearly 80% of people live in areas where threats to human water security exceed the 75th percentile (Vörösmarty et al., 2010). As such, interest in nonconventional ways to increase potable water capacity has grown globally (Tortajada & Ong, 2016).

One promising and prominent nonconventional source of water involves the treatment and reuse of municipal wastewater, commonly referred to as recycled water, reclaimed water, or reuse water (United States Environmental Protection Agency et al., 2012). Recycled water can be used for nonpotable purposes (i.e., nondrinking purposes such as agriculture, landscaping, toilet flushing), but research and actual implementation has demonstrated that recycled water can also be safely used for potable, drinking purposes (or is at least as safe as typical tap water; e.g., Khan & Roser, 2007). However, despite the water's safety, public acceptance represents a significant barrier to the actual implementation of potable water reuse methods. Thus, there has been much interest from researchers and policy makers in developing programs to help overcome public distaste for recycled water (Dishman et al., 1989).

Here, we evaluate the comparative effectiveness of two kinds of programs that policy makers might use to increase recycled water acceptance: (a) educational decision aids seeking to increase domain-specific knowledge about recycled potable water and (b) libertarian paternalistic default nudges. In four experiments, we provide evidence that using libertarian paternalistic defaults can sometimes be effective at encouraging recycled water acceptance. We also show that some educational interventions can increase acceptance of recycled water while at the same time increasing knowledge about and confidence in accepting recycled water. These results highlight some potential costs and benefits associated with each strategy.

Potable Recycled Water Acceptance

Both direct and indirect potable recycling methods[1] have been implemented and proven effective at providing safe, reliable drinking

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[1] Direct potable water recycling occurs when advanced treated wastewater goes straight to a conventional water treatment plant to be prepared for distribution. Indirect potable recycling happens when treated wastewater is used to augment an existing water source (e.g., a lake, reservoir, or aquifer). The existing water source acts as an environmental buffer before the water is eventually reintroduced into the conventional treatment plant (United States Environmental Protection Agency et al., 2012).

water (i.e., as safe as traditional tap water) in many locations such as Singapore, Namibia, and parts of the United States (Lee & Tan, 2016; Sanchez-Flores et al., 2016; van Rensburg, 2016). Notably, potable recycled water is, in general, less energy-intensive than some other methods of increasing water capacity (e.g., desalination), largely resistant to environmental changes (e.g., drought), and reduces waste discharged back into the environment (Fielding et al., 2019). Despite these advantages, however, public acceptance of recycled water in many cases remains low, especially for potable purposes such as cooking and drinking (see Dolničar & Saunders, 2006). Furthermore, the low public acceptance of recycled water represents a significant barrier to the implementation of water recycling methods, as public opposition has, in some cases, halted proposed water recycling projects (e.g., San Diego; Hurlimann & Dolnicar, 2010; Po et al., 2003; Uhlmann & Head, 2011).

Many decades of research into potable recycled water suggest that public acceptance is often a function of the interplay of many psychological factors such as disgust, perception of health risks and benefits, perceived need for alternative water supplies, trust in authority, and relevant knowledge (see Fielding et al., 2019; Smith et al., 2018, for reviews). Given the importance of these kinds of psychological factors, one may wish to take advantage of some of these psychological factors to help encourage reuse water acceptance. Two prominent methods that take advantage of some of these psychological factors can be broadly categorized into methods that seek to *inform* decision makers to make them more knowledgeable or skilled and methods that seek to *persuade* individuals using nonrational means (see Feltz & Cokely, 2018; Grüne-Yanoff & Hertwig, 2016; Hertwig & Grüne-Yanoff, 2017; Hertwig & Ryall, 2020).

Informing and Recycled Water Acceptance

One common approach to increasing acceptance of recycled water involves providing enough relevant information about the topic so that people can make an informed decision for themselves. For instance, the Deficit Model holds that domain-specific knowledge (i.e., understanding of relevant facts about a given topic) is integral to the public's acceptance of scientific innovations, and public doubt about these innovations are often largely attributable to misunderstanding or ignorance about key scientific facts (Sturgis & Allum, 2004). While other social, cultural, economic, and political factors are also often influential in forming attitudes toward science (Hayes & Tariq, 2000; Priest, 2001), the body of research suggests that overall, knowledge has a modest, positive correlation with attitudes toward often polarizing scientific issues (Allum et al., 2008; Nisbet, 2005; Nisbet & Goidel, 2007). Thus, the Deficit Model would predict that while knowledge is not the only factor involved in acceptance of recycled water, understanding relevant facts about recycled water might be a foundational piece of acceptance.

Research also suggests that transparent decision aids, simple interventions, and training programs are often able to convey relevant facts and sometimes dramatically improve decision-making (i.e., increase decisions that are in line with one's own best interest or values) among a wide variety of people (Cokely et al., 2018; Garcia-Retamero & Cokely, 2013, 2017; see also Bruine de Bruin & Bostrom, 2013; Bruine de Bruin et al., 2007; Fischhoff et al., 2011; Petrova et al., 2014, 2015; Trevena et al., 2013). For this reason, providing people with decision aids containing relevant information about recycled water may help them to better understand the science, which may in turn promote recycled water acceptance.

The current body of literature contains a few experiments where the effects of information-based decision aids on reuse water decisions were examined (Dolnicar et al., 2010; Fielding & Roiko, 2014; Price et al., 2015; Roseth, 2008; Simpson & Stratton, 2011). Generally, consistent with theory, these studies have found educational aids to be effective in encouraging water reuse acceptance; however, the overall magnitude of their effects has tended to be small (Dolnicar et al., 2010; Price et al., 2015; Roseth, 2008). One potential explanation for the overall small effects is that methods of informing have varied widely across these studies, with the decision aids ranging anywhere from brief statements about the wastewater recycling process (Dolnicar et al., 2010) to 47-page online booklet containing detailed recycled water information (Simpson & Stratton, 2011).

Persuading and Recycled Water Acceptance

While knowledge of relevant facts is likely to be important to recycled water acceptance, an alternative to increasing acceptance of recycled water could involve intentionally exploiting heuristics (i.e., mental shortcuts) or biases (i.e., decision-making tendencies; see Cokely et al., 2018) to persuade people to choose a desired option (see Thaler & Sunstein, 2003; Tversky & Kahneman, 1974). Approaches that intentionally take advantage of heuristics and biases often fall in the general category of *libertarian paternalistic strategies*. Libertarian paternalistic strategies construct decision-making environments that steer decision makers toward a specific choice without specifically forbidding any choices, thus technically respecting an individual's right to choose differently (Sunstein, 2014).

Of note, there are several conceptions of what constitutes a libertarian paternalistic intervention (see Hausman & Welch, 2010; Sunstein, 2014; Thaler & Sunstein, 2008). For the purposes of this paper, we adopt a view similar to Hausman and Welch (2010), where a libertarian paternalistic intervention is one that attempts to predictably influence behavior while still leaving open the ability to choose, *but also involves the violation of some moral rule*. Without a violation of a moral rule, the strategy usually does not count as paternalistic (Gert & Culver, 1976, 1979). Often, autonomy is thought to be violated with libertarian paternalistic policies because those policies often do not engage rational agency while influencing choices (Hausman & Welch, 2010). Likewise, commonly accepted moral obligations concerning informed consent (i.e., the right of an individual to make decisions based on sufficiently rich information; see Doyal, 2001; Feltz, 2015; Herrera, 1999; Levine, 1975) are often thought to be violated, as not all libertarian paternalistic policies are educative (i.e., work by informing people; see Sunstein, 2015) or provide enough relevant information to individuals.

One particularly powerful and popular application of Libertarian Paternalistic strategies is the use of default rules (often referred to as "default nudges," e.g., Blumenthal-Barby & Burroughs, 2012; Ghesla et al., 2019; Venema et al., 2018), which holds that as a result of factors such as heuristics, biases, and inertia (the tendency to stay with an option because it is easier to take no action than it is to perform some action to actively switch options; see Madrian & Shea, 2001; Thaler & Sunstein, 2008) people often stick with default options (Johnson & Goldstein, 2003). That is, when individuals have the choice to stay with the default option, they often tend to stay with the default, even though they are perfectly free to choose something other than the default option (Johnson & Goldstein, 2013). As such, by carefully designing the default option, individuals and organizations can often steer decision makers toward a desired choice while still technically leaving open the option to choose differently (see Thaler & Sunstein, 2008). Under these theoretical assumptions, informing typically does not qualify as libertarian paternalistic because it usually does not involve violating moral rules concerning informed consent and often critically engages rational agency, while default nudging often qualifies as libertarian paternalistic because it often fails to provide sufficient information and sometimes does not engage rational agency (Hausman & Welch, 2010).

To illustrate default nudges with a real-world example, Halpern et al. (2013) conducted a field experiment in which they used default rules to influence seriously ill patients' choice between comfort-oriented end-of-life care or life-extending care. Some of the ill patients received a form where the box to select either the comfort-care option or the life-extending option was already checked with an "X." In total, 77% of patients with the preselected comfort option chose the comfort option, while only 43% of patients with the preselected life-extending option switched and chose the comfort care, suggesting that the default influenced choice.

The effect of defaults has been observed across many domains, including contributing to retirement plans, consenting to be organ donors, and end of life health and financial decisions (Feltz, 2015, 2016; Johnson & Goldstein, 2003; Madrian & Shea, 2001). To our knowledge, no studies have attempted to examine the viability of default nudges in the context of recycled water acceptance. Given the pervasiveness of default nudges, these nudges may also be useful in encouraging acceptance of recycled water. Thus, by carefully setting default options, one could theoretically take advantage of heuristic-based decision processes and essentially circumvent other relevant psychological barriers to acceptance of recycled potable water.

Hypotheses

Our main objective was to evaluate and compare the effectiveness of educational interventions and noneducative defaults in encouraging the acceptance of recycled water. We operationalized acceptance of recycled water as enrollment in a hypothetical recycled water program. Specifically, we hypothesized:

> H_1: Defaulting individuals *into* a hypothetical recycled water program would increase acceptance of recycled water compared to being defaulted *out* of the program.

> H_2: Relevant educational interventions would increase recycled water acceptance compared to not receiving a relevant educational intervention.

Another goal was to compare how each method affected confidence in one's recycled water decision. We hypothesized:

> H_3: Individuals would be more confident and knowledgeable in educationally informed choices than default-influenced choice.

We tested these hypotheses in a series of four experiments. Experiment 1 tested the effectiveness of the default nudge alone to demonstrate that defaults can influence choices about recycled water. Experiment 2 tested and compared the effects of defaults and an educational intervention containing simple, brief information about recycled potable water (i.e., an infographic). Experiment 3 tested and compared the effects of defaults and a longer, more complex educational intervention (i.e., a short educational video) using college undergraduates. Finally, Experiment 4 replicated the methodology of Experiment 3, using a general population survey.

Experiment 1

Method

Participants

Participants for this study were recruited using Amazon's Mechanical Turk[2] (MTurk). Participants responded to an online survey in exchange for $0.50 USD.[3] Responses were collected from 106 participants, but a total of 25 participants were excluded for answering a multiple-choice attention check question incorrectly:

> The scenario I just responded to involved which of the following? *(Correct answer = water bill)*

Of the remaining 81 participants, 54% were female ($N = 44$). Mean age was 37.85 ($SD = 12.10$), with a range of 21–67. A post hoc power analysis indicated that the present study could detect a medium sized effect ($power = .8$, $\alpha = .05$, $V = 0.31$).

Procedure

Participants were asked to imagine they were paying their water bill and were presented with the following hypothetical prompt:

> Our city is implementing a program to begin using high-quality reclaimed (i.e., recycled) water for various purposes, including use in residential taps. Our records indicate that you may be affected by this change. You (are/are not) currently enrolled in this program, but you have the option to (enroll/unenroll). Please indicate your enrollment preference below.

One group ($N = 40$) was randomly assigned to the *default-out* condition, while the other group ($N = 41$) was assigned to the *default-in* condition. Participants in the default-out condition were informed that they *were not* automatically enrolled in this program, but would be given the option to enroll if they desired. Participants in the default-in condition were informed that they *were* automatically enrolled in the program, but would be given the option to unenroll. Participants were then asked to indicate whether they would prefer to stay with their respective default option ("I would like to remain enrolled/unenrolled") or switch to the alternate option ("I would like to switch and enroll/unenroll"). Participants also provided basic demographic information. Materials and data for all four experiments are available on the following page: http://dx.doi.org/10.17605/OSF.IO/YRB8X.

[2] Amazon's Mechanical Turk can be a reliable, quality source of experimental data (Buhrmester et al., 2011, 2018; Crump et al., 2013; Mason & Suri, 2012; Paolacci et al., 2010; Rouse, 2015).

[3] Procedures and materials for all experiments reported in this paper were approved by the Institutional Review Board (IRB) at the University of Oklahoma.

Results and Discussion

In total, 26 out of 41 (63%) participants in the default-in condition chose to enroll in the program while only 13 out of 40 (33%) participants in the default-out condition chose to enroll in the program, $\chi^2(1) = 7.75$, $p = .005$, $V = .31$, 90% CI [0.13, 0.49]. These data were consistent with Hypothesis 1—defaulting people into the reuse program was associated with greater acceptance of the program compared to defaulting people out of the program.

Experiment 2

Experiment 2 sought to replicate the results of Experiment 1 and to compare the effectiveness of default nudges versus informing people of some facts about recycled water.

Method

Participants

Participants for this experiment were recruited using Amazon's Mechanical Turk, and they responded to an online survey in exchange for $0.50 USD. Responses were collected from 172 individuals, but a total of 30 participants were excluded for answering attention check questions incorrectly and displaying additional signs of inattention (e.g., excessive attempts to advance timed survey pages before the option was available). Of the remaining 142 participants, 65% were female ($N = 92$). Mean age was 38.65 ($SD = 13.55$), with a range of 19–73. A post hoc power analysis indicated that the present study could reliably detect a small-sized effect ($power = .8$, $\alpha = .05$, $V = 0.23$).

Procedure

Participants in this experiment were first assigned to either a *relevant information* or *irrelevant information* condition. Those in the relevant information condition were presented with a simple infographic briefly explaining the benefits and reasons for using recycled drinking water (see Figure 1). Participants in the irrelevant information condition were presented with a similar infographic explaining how the internet works (see Figure 2). All participants were then asked a set of five true or false objective knowledge questions about recycled water created in conjunction with water reuse engineers:

1. Highly treated reuse water can be safe to drink. (T)
2. Direct potable water reuse refers to advanced treatment of wastewater that is then sent to water treatment plants and then to the drinking water supply. (T)
3. Cities around the world are using reuse water as a source for drinking water. (T)
4. Highly treated reuse water used for drinking water is resilient to regional droughts. (T)
5. Advanced treatment of reuse water can be less expensive than desalinating water for drinking water. (T)

Next, participants were randomly assigned and responded to one of the default scenarios from Experiment 1. After responding to their scenario, participants were asked three questions to gauge their level of confidence in their choice:

Figure 1

Infographic Used in the Relevant Information Condition of Experiment 2

Note. See the online article for the color version of this figure.

1. I feel confident in my decision.
2. I feel comfortable with my decision.
3. I feel set in my decision.

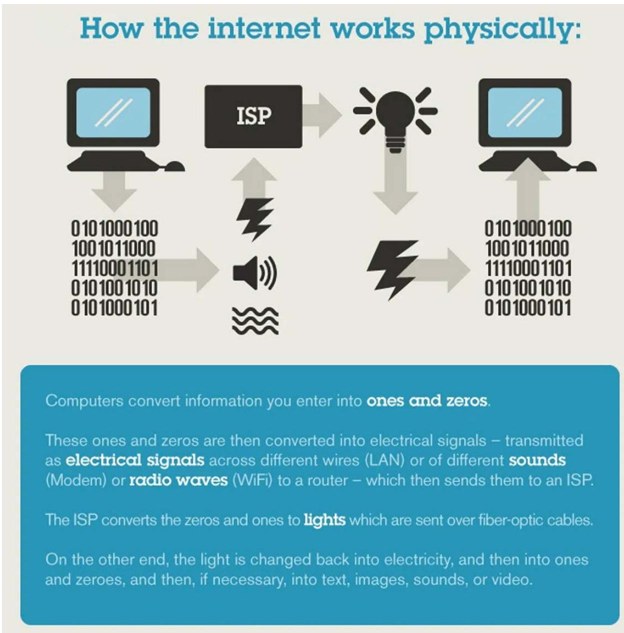
These three questions were adapted from Scherer et al. (2015) and were measured on a 5-point Likert scale (1 = *strongly disagree*, 5 = *strongly agree*).

Then, participants completed the Revised Disgust Scale (DS-R; Haidt et al., 1994, modified by Olatunji et al., 2007), a scale that measures individual sensitivity to potentially disgusting objects and scenarios. Past research suggests that disgust sensitivity is negatively associated with acceptance of recycled water (Alhumoud et al., 2003; Bruvold & Ward, 1972; Dishman et al., 1989; Dolnicar & Schäfer, 2009; Madany et al., 1992; Menegaki et al., 2007; Miller & Buys, 2008; Nancarrow et al., 2009; Po et al., 2005; Schmidt, 2008); thus, we included the disgust measure in the study primarily to check that our indicator of recycled water acceptance was functioning properly (i.e., if enrolling in the hypothetical water program is a valid indicator of recycled water acceptance, we would expect it to be significantly correlated with disgust sensitivity).[4]

[4] Disgust *was* significantly correlated with enrollment choice in each of the remaining experiments (see Table 1), such that higher disgust was associated with lower enrollment in the recycled water program. This provided sufficient evidence to proceed with our analyses in each case. We also checked to ensure there was not an unequal distribution of participants with high disgust across levels of the independent variables (i.e., relevant vs. irrelevant info and default-in vs. default-out) and found no evidence of unequal distributions in any of the remaining experiments, thus reducing the concern disgust may have acted as a confound.

Figure 2

Infographic Used in the Irrelevant Information Condition of Experiment 2



Note. See the online article for the color version of this figure.

For exploratory purposes, participants next completed the 7-item version of the Berlin Numeracy Test (BNT; Cokely et al., 2012; Schwartz et al., 1997). The BNT is part of the standard battery of instruments administered to participants in our lab. The BNT measures statistical numeracy, or the ability to understand and apply basic probabilistic information, which has been shown to predict better understanding and choices across many domains (Cokely et al., 2012; Garcia-Retamero et al., 2019; Peters, 2012).[5] Finally, participants provided basic demographic information.

Results and Discussion

Consistent with our first hypothesis and results from the previous experiment, the default manipulation was statistically significant, $\chi^2(1) = 4.81$, $p = .03$, $V = .18$, 90% CI [0.04, 0.32]. Specifically, 42 of 73 (58%) participants in the default-in condition chose to enroll, while only 27 of 69 (39%) participants in the default-out condition chose to enroll in the hypothetical water reuse program.

Contrary to our second hypothesis, receiving relevant information was not associated with measurably higher enrollment in the program, $\chi^2(1) = 0.33$, $p = .57$, $V = 0.05$, 90% CI [0, 0.18]. However, there was also no significant difference between information groups in the amount of objective knowledge questions participants correctly answered, relevant: $M = 3.39$, $SD = 1.27$; irrelevant: $M = 3.29$, $SD = 1.39$; $t(140) = -.421$, $p = .68$, $d = .08$, 90% CI [−0.20, 0.35], meaning the educational intervention might not have been strong or interesting enough to prompt deliberation and learning.

An additional goal of this experiment was to examine characteristics of confidence in light of the added information conditions. Responses to the three confidence questions had good internal consistency (Cronbach's $\alpha = .89$), so confidence scores were averaged into a composite score. Composite confidence ratings were significantly correlated with scores on the objective knowledge test ($r = .26$, $p < .01$; see Table 1 for correlations among variables in Experiment 2). To illustrate this difference, we split participant by median knowledge score (high scores > 3). High knowledge participants ($N = 67$) were more confident in their choice ($M = 2.93$, $SD = 0.87$) than low knowledge participants, $M = 2.48$, $SD = 0.80$; $t(140) = 3.17$, $p < .01$, $d = .54$, 90% CI [0.26, 0.82], suggesting that at least some participants were adequately calibrated in their confidence judgement (i.e., they were likely not overconfident).

Because of the relation between confidence and knowledge, a two-way ANOVA was conducted comparing the effects of switching from/staying with the default and information condition on confidence. Results revealed a significant main effect of switching from/staying with the default on confidence, $F(1, 138) = 3.91$, $p = .05$, $\eta^2 = .03$, 90% CI [0, 0.09], such that confidence among those switching from the default ($M = 2.87$, $SD = .88$) was greater than it was among those who stayed with the default ($M = 2.58$, $SD = .83$). The information condition also had a significant main effect, $F(1, 138) = 3.78$, $p = .05$, $\eta^2 = .03$, 90% CI [0, 0.08], with those in the relevant information condition reporting higher confidence ($M = 2.81$, $SD = .88$) than those in the irrelevant information condition ($M = 2.58$, $SD = .84$). However, these effects were qualified by a significant interaction, $F(1, 138) = 4.24$, $p = .04$, $\eta^2 = .03$, 90% CI [0, 0.09], such that those who stayed with the default reported almost equivalent confidence regardless of their information condition (relevant: $M = 2.57$, $SD = .89$; irrelevant: $M = 2.58$, $SD = .79$), while those who switched from the default had higher confidence in the relevant information condition ($M = 3.14$, $SD = .75$) than did those in the irrelevant condition ($M = 2.57$, $SD = .93$; see Figure 3). These results provide some support for our third hypothesis that informed decision makers would be more confident in their choice than nudged decision makers.

In sum, Experiment 2 replicated the results of the prior experiment. Defaults influenced choices to accept recycled water. While the effect of defaults observed in this experiment was not as large as that observed in Experiment 1, these results still provide additional evidence that default nudges may be effective tools to encourage acceptance of potable recycled water. The simple infographic did not reliably influence the choice to accept recycled water in this experiment; however, the relationship between objective knowledge and choosing to enroll in the program was significant, $r(142) = .21$, $p = .01$, suggesting that the lack of a reliable effect may be because the simple infographic did not increase objective knowledge of recycled water. Finally, the infographic did increase confidence for those who decided to switch from the default relative to those who did not receive the infographic, introducing potential ethical considerations in selection of the interventions (see General Discussion section).

Experiment 3

Experiments 1 and 2 provided novel, converging evidence that default nudges may encourage acceptance of potable recycled water,

[5] Numeracy was not significantly related to any variables of interest across any of the studies; thus, we only report correlations (see Table 1) and do not include it in any of our analyses.

Table 1
Correlation Matrix From Experiments 2 (Top), 3 (Middle), and 4 (Bottom)

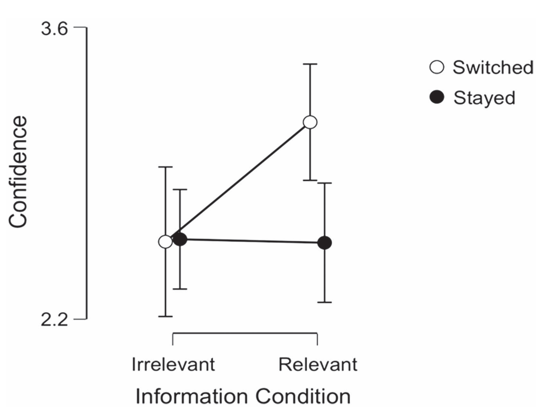
Variable	1	2	3	4	5	6	7	8	9
1. Acceptance	1								
2. Default	.18*	1							
	.03								
	.25**								
3. Info condition	.03	.03	1						
	.18*	.30**							
	−.03	.06							
4. Knowledge	.21*	−.06	.04	1					
	.28**	.05	.46**						
	.11	−.01	.28**						
5. Disgust	−.21*	−.03	.11	−.01	1				
	−.21*	−.03	−.14*	−.09					
	.01	.14	.07	.12*					
6. Numeracy	.03	−.10	−.08	.06	−.17*	1			
	−.07	−.12	−.02	−.05	.08				
	.02	−.07	−.08	.04	−.25**				
7. Confidence	.07	.14	.14	.26**	.13	−.16	1		
	−.12	.12	.21**	.24**	.16	−.09			
	−.08	.02	.06	.25**	.19**	−.02			
8. Gender	.20*	.10	.01	.07	−.21*	.13	.02	1	
	−.02	−.06	.13	−.03	.04	.24**	−.05		
	.09	.08	.09	−.04	−.15*	.09	.09		
9. Age	−.13	−.06	.08	.12	.07	.02	.15	−.11	1
	.05	.03	−.10	−.06	.01	.05	.01	.19*	
	−.16*	−.02	−.00	.13*	−.00	.05	.04	−.02	

Note. Variables were coded as follows: acceptance (0 = did not enroll in water program, 1 = enrolled); default (0 = out, 1 = in); info condition (0 = irrelevant, 1 = relevant); gender (0 = Female, 1 = Male; for Experiment 4, participants who selected nonbinary or "prefer not to specify" ($N = 4$) were not included in the correlations).
* $p < .05$. ** $p < .01$.

but Experiment 2 suggested that using defaults to increase recycled water acceptance may come at a cost in terms of confidence in choices.

Experiment 3 was designed to further explore potential costs in terms of confidence between nudged and informed choices. Experiment 3 also explored one potential reason why the educational intervention in Experiment 2 did not have a main effect on decisions to enroll in the reuse water program: the infographic in Experiment 2 was a relatively weak intervention. Price et al. (2015) found that support for general potable reuse schemes increased only when participants received "complex information containing more detailed justification of the positive aspects of recycled water" (p. 2180). The infographic used in Experiment 2 contained only general arguments supporting potable reuse water, rather than detailed justifications, which could explain its relative ineffectiveness. Likewise, it would be easy for participants to skip over the infographic, not read it carefully, or not fully internalize the limited information that was presented in the infographic. For these reasons, a stronger information manipulation was used in Experiment 3 in the form of an educational video about recycled potable water in a controlled, lab-based experiment.

Figure 3
Confidence Results From Experiment 2 With 95% Confidence Intervals



Method

Participants

Participants for this experiment were recruited from the undergraduate participants' pool of a large university in the United States. We selected these participants partially because we predicted they were more likely to sit through a longer video than Mturk participants. Participants responded to a Qualtrics hosted survey in exchange for partial research participation credit. Responses were collected from 165 participants, but a total of 19 participants were excluded for answering attention check questions incorrectly, displaying additional signs of inattention (e.g., excessive attempts to advance timed survey pages before the option was available), and failing to meet the minimum age requirement. Of the remaining 146 participants, 60% were female ($N = 87$). The mean age was 19.57

(SD = 3.53), with a range of 18–60. A post hoc power analysis indicated that the present study could reliably detect a small-sized effect (*power* = .8, α = .05, V = 0.23).

Procedure

All materials and procedures for this experiment were identical to those described in Experiment 2, except the infographics were replaced with short videos. Previous research has suggested that videos can be effective at conveying information, engaging participants, increasing domain-specific knowledge, and encouraging behavioral change (e.g., Acierno et al., 2004; Curbow et al., 2004; Eaden et al., 2002; Geller et al., 2010; Occa & Suggs, 2016; O'Donnell et al., 1995). Thus, participants in Experiment 3 watched a short video providing detailed information about potable reuse water. In the relevant information condition, participants watched a short (less than 5 min), publicly available video that explained such concepts as direct and indirect potable reuse, the advanced treatment of wastewater in order to make it safe for drinking, and the costs and benefits of using these methods (https://www.youtube.com/watch?v=5VZt431qUZQ&t=146s). Meanwhile, those in the irrelevant information condition watched a video edited to be of equal length describing how the internet works (https://www.youtube.com/watch?v=7_LPdttKXPc).

Results and Discussion

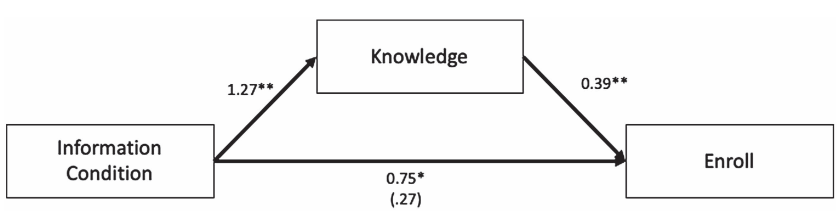
Inconsistent with the previous two experiments and our first hypothesis, the respective defaults were not significantly predictive of reuse water choice, $\chi^2(1) = 0.15$, $p = .70$, $V = .03$, 90% CI [0, 0.05]. Specifically, 46 out of 74 participants (62%) in the default-out condition chose to enroll in the program, while 47 out of 72 participants (65%) in the default-in condition chose to enroll.

Consistent with our second hypothesis, information condition significantly influenced water choice, $\chi^2(1) = 4.60$, $p = .03$, $V = .18$, 90% CI [0.04, 0.31], such that 39 out of 71 participants (55%) in the irrelevant information condition chose to enroll in the water reuse program while 54 out of 75 participants (72%) in the relevant information condition chose to enroll. Additionally, the number of correctly answered knowledge questions significantly differed between information condition groups, such that the participants in relevant information conditions answered more questions correctly ($M = 3.48$, $SD = 1.1$) than did those in irrelevant information conditions, $M = 2.21$, $SD = 1.4$; $t(144) = 5.05$, $p < .001$, $d = 1.02$, 90% CI [0.72, 1.30]. A mediation analysis suggested, as one would expect, that the relation between the information condition and enrollment choices was mediated by increased knowledge (see Figure 4 for the mediation model). The average causal mediation effect of knowledge on information condition and enrollment = .11, 95% CI [0.02, 0.19], $p = .01$ (with quasi-Bayesian confidence intervals with 500 simulations).

Confidence characteristics were fairly consistent with those observed in Experiment 2. Responses to the three confidence questions were averaged into one composite score (Cronbach's α = .87). Confidence ratings were significantly correlated with scores on the objective knowledge test ($r = .24$, $p < .01$; see Table 1 for correlations among variables in Experiment 3). Splitting the sample by median knowledge score (high score > 3) again illustrated that high knowledge participants ($N = 51$) were more confident ($M = 2.65$, $SD = 0.77$) than low knowledge participants, $M = 2.19$, $SD = 0.86$; $t(144) = 3.16$, $p < .01$, $d = .55$, 90% CI [0.26, 0.84], suggesting adequate confidence calibration. Likewise, a two-way ANOVA comparing the effects of switching from/staying with the default and information condition on confidence yielded a main effect of information condition on confidence, $F(1, 142) = 7.45$, $p < .01$, $\eta^2 = .05$, 90% CI [0.01, 0.12], such that confidence among those in the relevant information conditions ($M = 2.53$, $SD = .83$) was greater than it was among those who stayed with the default ($M = 2.16$, $SD = .84$). There was no effect of switching from/staying with the default on confidence, $F(1, 142) = 0.002$, $p = .97$, $\eta^2 < .001$; however, these results were again qualified by a significant interaction, $F(1, 142) = 5.47$, $p = .02$, $\eta^2 = .04$, 90% CI [0, 0.10], in which those who stayed with their default reported almost equivalent levels of confidence regardless of information condition (relevant: $M = 2.37$, $SD = .81$; irrelevant: $M = 2.32$, $SD = .84$), while those who switched from the default had higher confidence in the relevant information condition ($M = 2.68$, $SD = .83$) than did those in the irrelevant information condition ($M = 1.99$, $SD = .82$; see Figure 5).

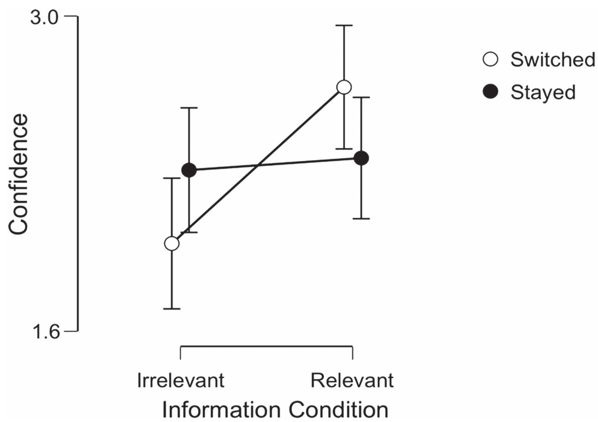
In sum, contrary to results from Experiment 2, default nudges had little effect on recycled water acceptance, but the relevant educational intervention did. The complexity and depth of the information provided in this experiment may explain this discrepancy. The relevant infographic in Experiment 2 was simple and general, while the relevant video in this experiment contained more relevant information, which likely increased objective knowledge and may have diminished the need to rely on the default. Another potential explanation for these results, however, may be that Experiments 2 and 3 used different samples. There may be differences between the MTurk sample used in Experiment 2 and the undergraduate student sample used in Experiment 3 that could have

Figure 4
GLM Mediation Path Analyses From Study 3



Note. Path values are in logits.
*$p < .05$. **$p < .01$.

Figure 5
Confidence Results From Experiment 3 With 95% Confidence Intervals



affected participants' decisions. For example, differences such as age, incentive structure, or supervision could play a role in responses (Chandler et al., 2014). Accordingly, an additional experiment was conducted to address this possibility by replicating Experiment 3 using an MTurk sample.

Experiment 4

Method

Participants

Participants for Experiment 4 were recruited using MTurk. Prior to data collection, we conducted a power analysis in G*Power (Faul et al., 2007), using the effect size of the confidence interaction found in Experiment 2 ($\eta^2 = .03$, $\alpha = .05$, *power* = .80). This analysis suggested a need for 256 participants. In total, data were collected from 436 participants; however, 165 participants were excluded from the analyses for not completing the survey, failing catch questions, or completing the survey unreasonably fast (<2 min). This resulted in a final sample of 271 participants. Of the remaining participants, age ranged from 21 to 83 ($M = 42.12$, $SD = 13.93$), with 150 (55%) participants identifying as female, 117 as male, one identifying as nonbinary, and three participants declining to specify their gender.

Procedure

All materials and procedures were identical to those used in Experiment 3.

Results and Discussion

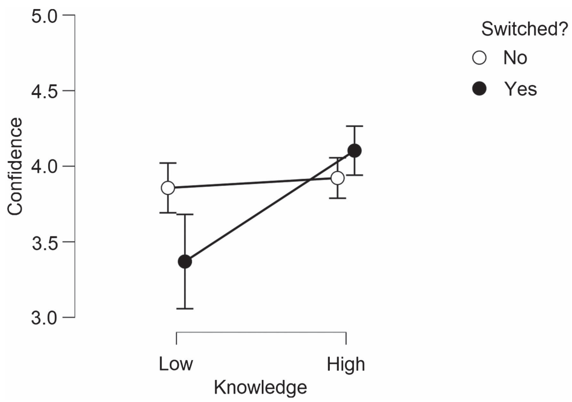
Results from this Experiment suggested that both the default and educational interventions were significantly related to the recycled water choice, default: $\chi^2(1) = 16.42$, $p < .001$, $V = .25$, 90% CI [0.15, 0.34]; education: $\chi^2(1) = 24.21$, $p < .001$, $V = .30$, 90% CI [0.20, 0.39]. Specifically, 74 of 141 (52%) people in the default-out condition chose to enroll, compared to 99 of 130 (76%) in the default-in condition, while 68 of 137 (50%) in the irrelevant information condition enrolled, compared to 105 of 134 (78%) in the relevant information condition. These results confirmed that the educational intervention was effective at increasing the probability of enrolling in the recycled water program even among an MTurk sample. Because the default was also still effective, we further conducted a binary logistic regression to check if education and defaults interacted in predicting enrollment choice. While the overall model was significant, $\chi^2(267) = 42.34$, $p < .001$, *Nagelkerke* $R^2 = .20$, and the main effects of education ($\beta = 1.62$, $p < .001$, $OR = 5.03$) and default ($\beta = 1.38$, $p < .001$, $OR = 3.78$) were both significant, the interaction between education and defaults was not significant ($\beta = -.71$, $p = .21$, $OR = .49$).

Replicating results from the previous experiment, the number of knowledge questions answered correctly significantly differed between information conditions, as participants in the relevant info condition answered more questions correctly ($M = 3.95$, $SD = 1.1$) than did those in irrelevant information conditions, $M = 3.15$, $SD = 1.61$; $t(269) = -4.79$, $p < .001$, $d = 0.58$, 90% CI [0.37, 0.78]. Likewise, confidence ratings (Cronbach's $\alpha = .84$) were significantly correlated with scores on the objective knowledge test ($r = .24$, $p < .001$; see Table 1 for correlations among variables in Experiment 4), and splitting the sample by the median knowledge score (high score > 4) illustrated that high knowledge participants ($N = 162$) were significantly more confident ($M = 4.0$, $SD = 0.66$) than low knowledge participants, ($M = 3.69$, $SD = 0.82$; $t(269) = -3.40$, $p < .001$, $d = .42$, 90% CI [0.21, 0.63], suggesting adequate confidence calibration.

Contrary to the prior experiments, the two-way ANOVA comparing the effects of switching from/staying with the default and information condition on confidence yielded no significant effects (switching from default: $F(1, 267) = 0.42$, $p = .52$, $\eta^2 < .01$, 90% CI [0.00, 0.02]; info condition: $F(1, 267) = 0.05$, $p = .82$, $\eta^2 < .01$, 90% CI [0.00, 0.03]; interaction: $F(1, 267) = 0.42$, $p = .52$, $\eta^2 < .01$, 90% CI [0.00, 0.02]. To further probe these results, we conducted another 2 × 2 ANOVA substituting the rough median split knowledge groups for info condition, which yielded pattern similar to the confidence results obtained in previous experiments. Specifically, the effect of switching from the default on confidence was not significant, $F(1, 267) = 2.78$, $p = .10$, $\eta^2 = .01$, 90% CI [0.00, 0.04], while the effect of knowledge on confidence was significant, $F(1, 267) = 18.91$, $p < .001$, $\eta^2 = .06$, 90% CI [0.03, 0.12]. There was also a significant interaction, $F(1, 267) = 13.22$, $p < .001$, $\eta^2 = .04$, 90% CI [0.01, 0.09], such that those who stayed with their default reported almost equivalent levels of confidence regardless of knowledge level (low knowledge: $M = 3.86$, $SD = .70$; high knowledge: $M = 3.92$, $SD = .65$), while those who switched from the default had higher confidence when they were higher in knowledge ($M = 4.10$, $SD = .67$) than did those who were low in knowledge ($M = 3.37$, $SD = .94$; see Figure 6).

In sum, these results partially replicated the results obtained in prior experiments. Perhaps most importantly, results from Experiment 4 suggested that the stronger educational intervention used in an undergraduate sample from Experiment 3 was also effective among an MTurk sample. Unlike Experiment 3, however, the default was also effective at influencing recycled water choice in this experiment. This might suggest that even when effective educational interventions are used, using defaults may still be beneficial for some. Finally, confidence results did not replicate from the previous experiments. This result was surprising, especially given that the relationships between info condition and

Figure 6
Confidence Results From Experiment 4 With 95% Confidence Intervals



knowledge, and knowledge and confidence were similar to those observed in Experiment 3. One potential explanation is that average confidence ratings were higher in this sample ($M = 3.88$, $SD = .74$) than they were in the previous experiments. Average confidence ratings were moderately skewed (*skewness* = −.76), and more than 65% of the sample selected values of four or five (the maximum score) for each confidence rating. Thus, it is possible that the confidence measure used was not sensitive enough in this specific sample, and effects for confidence may have been muted. The interaction observed between knowledge and switching from the default may provide some indication that the same pattern of confidence results observed in Experiments 2 and 3 still applied in this experiment (i.e., those who were more knowledgeable and switched had higher confidence); however, this is a topic that deserves future attention.

General Discussion

Overall, our results suggest that both defaults and appropriate educational interventions may be effective at increasing recycled water acceptance for some people and under the right circumstances. Given the consistency with which the default nudges were successful in influencing some people to enroll in the hypothetical reuse programs in Experiments 1, 2, and 4, we can reasonably conclude that defaults could be used to help some individuals come to accept recycled water. Meanwhile, simple information conveyed using infographics did not influence recycled water acceptance in Experiment 2, but more detailed, complex information conveyed using videos increased acceptance in Experiments 3 and 4, indicating that the right kind of information conveyed in the right setting might also increase recycled water acceptance for some.

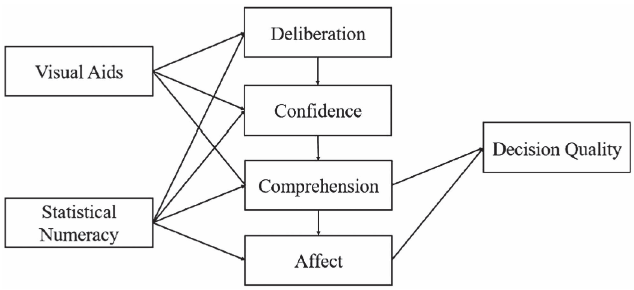
Theoretically, these results might be viewed as consistent with common dual-process accounts of the human mind (see Evans, 2008; see also elaboration likelihood model of persuasion; Petty & Cacioppo, 1986). The dual-process model conceptualizes two routes through which individuals process and use information to make decisions: a passive pathway (System I) which is quick, fairly automatic, and relies heavily on heuristics and other environmental cues, and an active pathway (System II), where individuals actively and effortfully process and deliberate upon information. Results from Experiments 1 and 2 could potentially be viewed as instances in which passive, System I processing was primarily used. It might be that participants either did not have access to relevant information, or the information was not strong enough to prompt more deliberate processes. Meanwhile, results from Experiment 3 might be viewed as instances where active, System II processes were more prevalent for many as a result of the stronger educational intervention. However, Experiment 4 suggests that alternate explanations might also be valid. For example, because both defaults and educational interventions were effective, it could be that all participants deliberately processed the scenario and information, and factors such as social desirability bias (see Nederhof, 1985) or inertia may have primarily influenced participants' choices. Future research should seek to further probe this relationship (e.g., by replicating Experiment 4, using reaction time data or process tracing methods).

Our results are also consistent with what would be predicted by the Deficit Model (Sturgis & Allum, 2004)—to the extent that one becomes more knowledgeable, one makes decisions consistent with expert consensus on recycled water. The Deficit Model, however, provides little insight into the cognitive mechanisms that might explain the link between effective educational interventions and recycled water acceptance. To explore potential cognitive mechanisms, one promising framework that might be explored in future studies is the model of skilled decision-making (Cokely et al., 2018). Part of skilled decision theory posits that transparent decision aids (i.e., aids that are specifically designed to promote understanding of risks and information) support skilled decision-making both by directly influencing deliberation, confidence, and knowledge, which in turn affects the precision and calibration of affective reactions (see Figure 7). Our studies were not designed to test the framework for skilled decision-making. Future research (e.g., using validated educational interventions, measuring deliberation time, using a direct measure of confidence calibration) should be conducted to examine this possibility.

Practically, our results imply that multiple factors often need to be taken into account when deciding which type of intervention will be better suited for specific needs and individuals. For example, future researchers and policy makers contemplating educational-based approaches should carefully consider the types of information they will use (i.e., none vs. simple vs. complex), the mediums through which they will communicate information (e.g., static infographic vs. video), and other situational factors (e.g., if individuals will have time to process the information) before implementing interventions, as each these factors may play a role—and perhaps interact—in determining the effectiveness of the chosen intervention.

To illustrate why it can be important to take into account these multiple factors, one can look to potential costs and benefits associated with the Libertarian Paternalistic default nudges and informing decisions. Our results suggest one potential cost associated with default nudge interventions may be related to decreased decision confidence and knowledge compared to informing decisions for some people. Knowing more is often associated with higher quality decisions (e.g., expert decision-making, see Figure 7), and previous research has also suggested that appropriate levels of confidence are often indicative of higher quality normative decisions (Gigerenzer et al., 1991; Ybarra et al., 2018) while overconfidence may lead to poorer quality decisions (Bruine de Bruin et al., 2007; Stanovich, 1999; Stanovich & West, 2000). Given this link between

Figure 7
Structural Process Model From the Skilled Decision-Making Framework



knowledge, appropriate confidence, and decision quality, the positive association between knowledge and confidence observed in Experiments 2–4, as well as the interactions between education and defaults on confidence in at least Experiments 2 and 3, it could be argued that there is a potential cost involved for those who switched *without* relevant information. That is, to the extent that we can consider those who switched active decision makers (because in order to switch from the default, there was arguably at least some consideration as to how the choice fit in with their preferences, beliefs, and values), it is concerning that these participants seemed unable to achieve the level of confidence they could have reached simply because they were denied relevant information. Moreover, common conceptions of the widely shared value of autonomy suggest that autonomy involves the ability to make *self-determined*, *informed* decisions in accordance with one's own values (Buchanan & Brock, 1989; Dworkin, 1981; Mele, 2001). Thus, overall our confidence and knowledge results suggest that not providing relevant information might have partially infringed upon an individual's ability to truly make an informed, autonomous decision in some cases. To the extent, then, that libertarian paternalistic nudges often work precisely because they sometimes do not openly disclose this type of relevant information, ethical risks (e.g., costs in terms of autonomy) should be considered.

Even with a potential ethical cost, however, persuasion using default nudges has benefits that may make them desirable to use in some cases. For example, default nudges usually have low implementation costs. For example, it would likely cost significantly less to use some kind of creative default or other libertarian paternalistic strategy than it would develop effective educational materials, run ads on television, print and distribute informational pamphlets, etc. Furthermore, default nudges typically deliver more immediate results (Sunstein, 2014); thus, in more urgent situations (e.g., when a water shortage is imminent), one might have good reason to use defaults (or even nonlibertarian paternalistic policies) to persuade. Moreover, in some cases, as was illustrated in our experiments, defaults can be more effective than information-based approaches, because even after educational materials are distributed, there is no guarantee that individuals will take the time to examine or process the information. In sum, we recommend that future decisions between nudge-based persuasion and knowledge-based interventions in this domain be accompanied by cost–benefit analyses (Hertwig, 2017; Trout, 2005).

Of course, our studies have some notable limitations. Perhaps most notable is the hypothetical and somewhat unrealistic nature of our scenarios. The hypothetical scenarios might not have been highly representative of an actual choice environment or the type of recycled water decision one would typically be expected to make (i.e., individuals typically do not choose whether their house specifically will receive recycled water), meaning these results might not generalize to a real-world setting. However, it is likely that choosing to enroll in a hypothetical program to receive recycled water from a residential tap would predict similar actions (e.g., voting on a referendum about recycled water). Future studies should seek to replicate our findings using more realistic behavioral outcomes (e.g., by having participants choose between an actual bottle of recycled water vs. a normal water bottle they had received by default; see Leong & Lebel, 2020).

Furthermore, it is worth noting that none of the infographics, videos, and knowledge questions were tested or psychometrically validated in any way prior to use in our experiments. This could have affected the results (e.g., information in the relevant infographic may not have been as pertinent to the objective knowledge questions as the information in the relevant video, which may have caused discrepancies in both objective knowledge scores and confidence). Thus, future studies might wish to use or develop more sound, testable instruments, and decision aids (e.g., the objective knowledge of potable recycled water scale developed by Mahmoud-Elhaj et al., 2020).

To summarize, our research suggests there are multiple strategies and factors to consider when designing effective decision aids aimed at increasing potable recycled water acceptance. Many communities across the world are currently debating, planning, or implementing potable recycled water programs. In terms of recycled water acceptance, continued collaboration between water experts, policy makers, and decision scientists will therefore likely be essential to map out the key features that will help, in an ethical way, inform which strategies to use, when, and for whom.

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