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Implicit and Explicit Biases for Recycled Water and Tap Water

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Key Points:

- Consumers have negative implicit and explicit attitudes toward food grown with recycled water
- Consumers have negative implicit, but not explicit, attitude toward tap water compared to bottled water
- Tap water and food grown with recycled water are believed to be more sustainable options, but also less healthy and tasty

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Abstract Increasing use of recycled water to irrigate agricultural products and decreasing consumption of bottled water are important components of sustainable water management practices and consumer-driven efforts to improve water security and quality. However, consumers frequently discount agricultural products irrigated with recycled water relative to products irrigated with conventional water and place a premium on bottled water relative to tap water. This study measures consumer attitudes regarding recycled water and bottled water to understand more fully the reasons behind these preferences. We conduct two studies involving 2,616 adult consumers in the United States designed to measure consumer attitudes and preferences: the use of recycled water versus conventional water to irrigate food products and tap water versus bottled water for drinking. In each study, implicit attitudes are measured using an Implicit Association Test as well as explicit attitudes. We find that respondents have negative implicit attitudes regarding recycled water compared to conventional water and tap water compared to bottled water, and a negative explicit attitude toward recycled water. Tap water and food grown with recycled water were believed to be less healthy to consume and less tasty, although these are believed to be more sustainable options. Beliefs about water attributes (i.e., healthfulness, taste, and sustainability) are associated with attitudes, and both beliefs about attributes and attitudes are associated with preferences for products. Further, we find that respondents' stated preferences are consistent with their implicit and explicit attitudes.

1. Introduction

In 2019, the World Economic Forum (2019) listed water crises as the fourth greatest global risk. Securing useable water sources for humanity is a daunting challenge in both scope and scale. Solving these challenges will require comprehensive management of water resources and concerted effort to reduce consumption by agricultural producers, industries, and consumers. Advancements, like the use of recycled water, increase the scope of possible sources for useable water.

Recycling converts millions of gallons of wastewater such as storm run-off and sewer effluent into water that meets standards for drinking and is as safe as other drinking water supplies (Asano & Levine, 2004). The water is comprehensively treated using both filters and disinfectants to remove impurities. Use of tap water instead of bottled water addresses issues of pollution by plastics that wind up in water bodies and negatively affect water quality.

Use of recycled water addresses issues of supply, particularly for agricultural production which, in the United States, is responsible for 80% of all water consumption (U.S. Department of Agriculture Economic Research Service 2019). However, many consumers are averse to buying both fresh and processed foods that use recycled water (Li et al., 2018; Savchenko, Kecinski, et al., 2019). Numerous studies have shown that individuals develop cognitive biases toward certain foods (McFadden & Lusk, 2015), which can result in aversion to food technology (Lusk et al., 2015; McFadden & Smyth, 2019; Pakseresht et al., 2017). Though recycled water presents no known negative health risk, consumer bias has been exhibited by reductions in willingness-to-pay for agricultural products that use recycled irrigation water compared to identical products that used conventional is a term commonly used to refer to agricultural practices and commodities produced by processes used by the majority of farms (see Lusk, 2010; Messer et al., 2017; Williams & Hammitt, 2001) water (Ellis, Savchenko, & Messer, 2021; Li et al., 2018; Savchenko et al., 2018, 2019b; Whiting et al., 2019).

Consumer aversion to some sources of water have also caused increased demand for bottled water. In the US, bottled water surpassed soft drinks as the most consumed beverage by volume in 2016 (Rodwan, 2016), and annual global consumption of bottled water exceeds 99.5 billion gallons (Rodwan, 2018). Between 2012 and

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2017, annual global consumption increased by an average of 6.4% (Rodwan, 2018) and has continued to rise since, creating vast amounts of plastic pollution (Arnold & Larsen, 2006) and carbon emissions (Botto, 2009). Consumers' strong preference for bottled water is demonstrated by the value placed on it relative to tap water. Many brands of bottled water (roughly 40%) are just selling filtered tap water and at prices as much as 10 thousand times higher than the cost of household tap water, even though their products are less stringently regulated than municipal water supplies (Doria, 2006).

Consumer trends are constraining efforts to improve the quality of water in marine ecosystems, and create reluctance across the food system to undertake projects targeted at providing an alternative to groundwater withdrawals. Two efforts aimed at changing consumer behavior involve increasing demand for agricultural products produced using recycled irrigation water and decreasing demand for bottled drinking water. However, the concept of recycled water can be confusing to consumers, especially since recycled water is often the victim of the yuck factor, where words like "toilet-to-tap" are used by opponents of recycled water (Schmidt, 2008). These misunderstandings can trigger feelings of disgust and an aversion to produce irrigated with recycled water (Kecinski et al., 2016, 2018; Menegaki et al., 2009; Rozin et al., 2015; Savchenko, Kecinski, et al., 2019; Wester et al., 2016).

Individuals' behaviors are influenced by explicit and implicit attitudes. An explicit attitude occurs when an individual is consciously aware of an attitude's influence on behavior, while implicit attitudes are not consciously formed or behaviorally applied (Greenwald & Banaji, 1995). Although, implicit attitudes can influence explicit attitudes and decisions (Maison et al., 2001, 2004; Richetin et al., 2007). Unlike implicit attitudes, which are difficult to measure, explicit attitudes are relatively easy for people to self-identify and report. Consequently, consumer behavior research has tended to focus solely on explicit attitudes, producing an incomplete and sometimes misleading picture. For example, respondents often overstate or understate (and perhaps overestimate or underestimate) their explicit attitudes, especially when social values and morals are invoked (Fisher, 1993). Thus, self-reported measures of explicit attitudes about sensitive topics have low predictive power; however, this can be improved by concurrently measuring implicit attitudes (Greenwald et al., 2009).

The objective of this study is to better understand consumer perceptions of water by measuring implicit and explicit attitudes, stated beliefs about attributes of water (e.g., healthfulness), and stated preferences for water. Data were collected using an online survey distributed to adults in the US, and respondents were randomly assigned to one of two studies. One study examined consumer perceptions between recycled water and conventional water, and the other study examined consumer perceptions between tap water and bottled water.

1.1. Additional Information About the Types of Water Considered in This Study

Nearly 70% of the world's population suffer from water scarcity at least 1 month each year (Mekonnen & Hoekstra, 2016) and 30% do not have access to safe drinking water (United Nations, 2019). In 2018, because of severe droughts and high demand in South Africa, Cape Town came within 90 days of turning off the taps of 4 million people (Edmond, 2019; Welch, 2018). Crises involving water supplies and large-scale incidents of unsafe municipal tap water as occurred in Flint, Michigan, in the United States make clear that water crises are no longer only hypothetical threats.

In 2015, agricultural irrigation in the United States consumed 118 billion gallons of water per day (U.S. Geological Survey, 2015) and only 587 million of those gallons (less than 0.5%) were recycled water, used mostly in California and Florida (CONSERVE, 2020). Concerns about consumer responses have prevented agricultural producers from installing infrastructures needed to use recycled water. Israel, on the other hand, recycles 90% of its wastewater and uses 85% of that recycled water for irrigation, providing a strong case study that recycled water can be used cost-effectively on a large-scale (Ellis, Kecinski, et al., 2021). Furthermore, recycled water can offer agronomic benefits, such as improving soil health by adding nitrogen, phosphorus, and other micronutrients and decreasing the amount of fertilizer needed (Chen et al., 2013). Despite the many benefits of using recycled water, consumers in the United States and elsewhere remain skeptical.

Studies have shown that irrigating with recycled water can increase water security by reducing withdrawals of fresh water while improving yields and reducing the negative externalities associated with nutrient run-off (Anderson, 2003; Chen et al., 2013; Toze, 2006). Similarly, decreasing consumption of bottled water can reduce the presence of microplastics in water bodies, improving water quality. Microplastics originating from water bottles are found in most marine environments (Andrady, 2011), including remote lakes (Free et al., 2014). The average

shellfish consumer ingests 11,000 microplastics per year with meals (Van Cauwenberghe & Janssen, 2014), and it is estimated that plastic in the ocean will outweigh fish by 2050 (Ellen MacArthur Foundation, 2017). Furthermore, bottled water has a carbon footprint about 300 times larger than tap water (Botto, 2009). As a result, there are many benefits from reducing consumer demand for bottled water. In general, though, consumers strongly prefer products irrigated with conventional water to ones irrigated with recycled water (Ellis, Savchenko, & Messer, 2021; Li et al., 2018; Savchenko et al., 2018, 2019b) and bottled water to tap water (Doria, 2006). These preferences likely arise from implicit and explicit attitudes they have about recycled water (Menegaki et al., 2007; Po et al., 2005; Rozin et al., 2015; Wester et al., 2016) and tap water (Doria, 2006).

Studies have demonstrated that consumers' preferences for bottled water arise, in part, because they do not trust the quality and/or safety of municipally supplied tap water (Anadu & Harding, 2000; Hu et al., 2011; Jakus et al., 2009; McSpirt & Reid, 2011) and perceive bottled water as tasting better than tap water (Saylor et al., 2011). Marketing has played a role as well. Water, a nearly free public good when coming from a tap, has been turned into a branded commodity (Wilk, 2006) with brands such as Fiji Water, Voss Artesian Water, and Evian Natural Spring Water promoting their products as luxurious. However, most bottled waters are not healthier or safer than tap water, and blind taste tests comparing bottled water and tap water have often concluded that the tap water was equivalent and sometimes superior to bottled water (Shermer, 2003; Vann, 2004).

1.2. Background Information About the Implicit Association Test

The method most used to measure implicit attitudes is the Implicit Association Test (IAT) developed by Greenwald et al. (1998). The IAT measures a person's mental association between "targets" and "attributes" by requiring respondents to rapidly sort words or images into categories on the left and right side of the computer screen by pressing the "E" key if the word or image belongs to the category on the left and "I" if belonging to the category on the right (Project Implicit). The underpinning of the IAT is that respondents find it easier to make evaluations in rounds for which targets are implicitly associated with attributes, compared to rounds for which targets and attributes are not implicitly associated, and the speed of decisions are used as a measure of implicit attitudes.

The IAT has been used to examine implicit attitudes of consumers about brands (Maison et al., 2004), meat versus vegetables among vegetarians and nonvegetarians (Houwer & Bruycker, 2007), organic food (Richetin et al., 2016), and sustainable foods (Panzone et al., 2016). Further, the IAT has been used to study attitudes toward recycled water use. Fu and Liu (2017) studied implicit and explicit attitudes toward recycled water with a convenience sample of 101 residents of Xi'an, China. They concluded that explicit attitudes favored the use of water recycling technologies, but implicit attitudes were negative about personal use of recycled water. In this study, we use the IAT to measure implicit attitudes about food produced with recycled irrigation water relative to conventional irrigation water and tap water relative to bottled water.

There is some controversy about the IAT, mainly because of concerns related to low test-retest reliability and uncertainty about the mechanism behind implicit attitudes (Teige-Mocigemba et al., 2016). However, its validity has been repeatedly confirmed by a flowers-versus-insects version of the test that consistently found positive attitudes about flowers and negative attitudes about insects based on keystroke speed (Greenwald et al., 1998; Teige-Mocigemba et al., 2016). Furthermore, a meta-analysis of 184 IATs that had a mean sample size of 81 ($SD = 141.5$) found that the predictive validities of the IATs combined with measures of explicit attitudes generally increased models' predictive validity relative to using only the measure of explicit attitudes (Greenwald et al., 2009).

There are seven rounds in an IAT. The first two rounds are practice rounds to teach the respondent the mechanisms of the test. Round one is a practice round of 20 trial targets (bottled water and tap water images only), and round two is a practice round of 20 trial attributes (good and bad words only). Rounds three and four contain both targets and attributes. Round three consists of 20 practice trials and round four consists of 40 critical trials. Round five is a practice round of 40 trials of attributes, yet sides are switched to eliminate left-right associations learned in the previous rounds. Rounds six and seven are reverse combined rounds, which is like rounds three and four, but with attributes on opposite sides. Respondents are randomized to one of four versions of the IAT to ensure balance across options presented on the left and right side of a screen (Nosek et al., 2005). Table 1 uses an example from our study to show how the seven rounds and four versions of an IAT work in practice. Additional information about the IAT and the specific targets and attributes used in this study is provided in the Appendix A.

Table 1
Seven Rounds and Four Randomized Versions Used in the Recycled v

Rounds	Trials	Task	Four randomized versions			
			Left side of screen		Right side of screen	
1	20	Target	Recycled	Bottled	Conventional	Tap
2	20	Attribute	Good	Good	Bad	Bad
3	20	Combined	Recycled/Good	Bottled/Good	Conventional/Bad	Tap or Bad
4	40	Combined	Recycled/Good	Bottled/Good	Conventional/Bad	Tap or Bad
5	40	Reversed target	Bad	Bad	Good	Good
6	20	Reversed combined	Recycled/Bad	Bottled/Bad	Conventional/Good	Tap or Good
7	40	Reversed combined	Recycled/Bad	Bottled/Bad	Conventional/Good	Tap or Good

Note. Conventional Water Implicit Association Test.

The IAT is scored using data from the combined rounds (3 + 4) and reversed combined rounds (6 + 7), creating a standardized difference score (D-score), which ranges from -2 to 2 . A D-score of 0 denotes no difference in the respondent's decision-making speed and, therefore, no negative or positive implicit attitudes toward one type of water relative to the other. A respondent who responds more rapidly in a compatible round than in an incompatible round has a positive D-score, which indicates that the respondent had an implicit attitude favoring the positive target (e.g., bottled water) over the negative target (e.g., tap water). A respondent who responds more rapidly in an incompatible round has a negative D-score, which indicates that the respondent had an implicit attitude favoring the negative target. To clarify, a D-score of 0 does not indicate a neutral attitude toward bottled water or tap water; it indicates a similar attitude toward both types of water.

2. Survey Questions and Details About Data Analysis

After consenting to take part in the study and completing questions about demographic characteristics, respondents were randomized to either the recycled v. conventional water study or the tap v. bottled water study. Respondents then completed an IAT, questions measuring explicit attitudes, beliefs about water attributes, preferences for water.

2.1. Beliefs About Water Attributes and Analysis

Although beliefs about water attributes were collected after attitudes, we are describing them here first because responses to these questions are included as independent variables when modeling heterogeneity in attitudes. The water attributes considered in this study were healthfulness, taste, and sustainability. Respondents were asked to select the type of water they thought performed better for the attributes, with an option to state that the waters performed similarly. For example, when asked “Which do you think is healthier?” in the recycled v. conventional water study, respondents could choose from the following response options: (a) Conventional Water, (b) Recycled Water, or (c) They are equally healthy.

Chi-square tests of independence were estimated to test the null hypotheses that beliefs about healthfulness, taste, and sustainability were constant across response options. If a null hypothesis was rejected, pairwise comparisons were then conducted between the response options using Bonferroni-corrected p -values and a 0.05 threshold. The results from these tests indicate the relative healthfulness, taste, and sustainability associated with the types of water considered.

2.2. Implicit Attitudes and Analysis

Respondents were randomized to one of the four versions of an IAT within a study (see Table 1). Specific wording and images used for attributes and targets used are shown in Table A1 for the recycled v. conventional water

study and in Table A2 for the tap v. bottled water study. The IATs used in this study were designed using the survey-software IATgen developed by Carpenter et al. (2019), and examples of IAT questions used in each study are illustrated in Figure A1.

IAT data were processed using the data cleaning and scoring algorithm (Greenwald et al., 2003; Lane et al., 2007) and a split-half procedure developed by Houwer and Bruycker (2007) to measure internal consistency and to exclude respondents whose response times on the IAT were too fast. D-scores were then estimated for the IATs using the IATgen Shiny Web Applet (Carpenter et al., 2019). Paired *t*-tests were estimated to test the null hypothesis that D-scores were different from 0 (two-tailed); recall that D-scores can range from -2 to 2 . Rejecting a null hypothesis indicates that there is implicit bias, and the direction of the difference indicates the type of water associated with an implicit bias. For example, a D-score significantly greater than 0 indicated a more favorable attitude toward conventional water or bottled water, while a D-score significantly less than 0 indicated a more favorable attitude toward recycled water or tap water.

2.3. Explicit Attitudes and Analysis

Explicit attitudes were measured by asking respondents to self-report ratings for the types of water considered in a study. Respondents were asked “Please rate how much you like recycled water” from a rating scale that ranged from 0 to 10. Thus, there were two explicit attitudes measured within a study (e.g., both recycled and conventional water).

Explicit ratings between two types of water considered within a study were combined into one variable by taking the difference in explicit ratings and then multiplying the difference by a factor of 0.2, which normalizes an explicit attitude to a scale that ranges from -2 to 2 like a D-score. And similar to the D-scores for implicit attitudes, a score greater than 0 indicated a favorable attitude about conventional water or bottled water and less than 0 indicated a favorable attitude about recycled water or tap water. Paired *t*-tests were also estimated to test the null hypothesis that scores for explicit attitudes were different from 0 (two-tailed).

2.4. Stated Preferences and Analysis

Preferences were measured by asking respondents to value two products. Respondents in the recycled v. conventional water study assigned values they were willing to pay for two 3-pound bags of clementines, one bag of clementines was irrigated with recycled water and the other irrigated with conventional water. In the tap v. bottled water study, respondents provided willingness to pay values for 16 ounces of tap and bottled water. Given that this contingent valuation method of eliciting willingness to pay is hypothetical, a cheap talk strategy was used to reduce hypothetical bias (Carson, 1997). Although, when valuing two products, as done in this study, the difference in valuation between two products is similar between hypothetical and non-hypothetical settings (Lusk & Schroeder, 2004).

Using the difference in values provided by a respondent, a relative preference variable was created. A relatively higher valuation indicated a preference for a product and products valued equally indicated indifference between two products. It was necessary to create a relative preference variable because respondents were randomized to one of four elicitation methods to relax assumptions about how individuals may value the products considered (see Bass et al., 2021 for more details about the elicitation methods). Creating the relative preference variable allows the valuation of products to be collapsed across elicitation methods.

Chi-square tests of independence were used to determine overall differences in relative preferences between products and thus types of water. Given the overall test is rejected, pairwise comparisons were conducted, using Bonferroni-corrected *p*-values with a threshold of 0.05, to determine which types of water were most preferred.

2.5. Models to Examine Heterogeneity in Attitudes and Preferences

Heterogeneity in implicit and explicit attitudes was explored using four linear regression models. These models examine the association between attitudes and respondent characteristics (including stated beliefs about attributes of water). The estimated linear regression models can be mathematically represented by:

$$Score_{ijn} = \alpha_{1ij} + X_n \beta_{1ij} + SB_n \gamma_{1ij} \quad (1)$$

where $Score_{ijn}$ is the attitude score in the i th study and j th attitude for the n th respondent, X_n are respondent characteristics (described and presented in Table 2 below), and SB_n are binary variables equal to one if a respondent had a stated belief about relative water performance for an attributes (e.g., Tap Healthier). The dependent variable in all models could range from -2 (more favorable toward recycled or tap water) to 2 (more favorable toward conventional or bottled water).

Models of heterogeneity in preferences were estimated using six logistic regressions; separate models were estimated for each product (type of water) and a separate model was estimated for respondents who were indifferent between products. These logit models included the independent variables defined in Equation 1, and the attitude variables were added to determine the association of attitudes and preferences. The estimated logistic regression models can be mathematically represented by:

$$\Pr(Preference_{ikn}) = \alpha_{2ik} + X_n \beta_{2ik} + SB_n \gamma_{2ik} + Att_n \delta_{ik} + EM_l \eta_{ik} \quad (2)$$

where $Preference_{ikn}$ is a binary variable equal to one if for the k th preference, Att_n are respondent attitudes, and EM_l are binary variables equal to one if a respondent was randomized to the l th elicitation method. As previously described, four methods were used to elicit values and there was heterogeneity in preferences across the methods (see Table A3). Thus, the binary variables EM_l were included to control for effects of an elicitation method on preferences, although these were not variables of interest in this study.

2.6. Respondents

This study was approved by the Institutional Review Board at <<masked for review>> and informed consent was secured from respondents prior to completing the survey. We piloted the survey. The protocols of this study were piloted and tested with adult subjects in November 2018, prior to the final launch, collecting 29 responses. The language used in the design also builds upon recent search on consumer responses to recycled water and foods grown with recycled irrigation water that involved approximately 8,000 adult consumers (see for instance, Ellis et al., 2022; Savchenko et al., 2019).

The survey was then fielded from 1 April through 8 April 2019 to an online panel of U.S. adults provided by Qualtrics. Qualtrics maintains an opt-in panel of respondents for market research, and a quota-based sampling method was used to recruit a sample representative of U.S. households across age, sex, and income. Qualtrics compensates respondents for their participation and compensation levels are proprietary to Qualtrics. A market research panel, also known as an online sample, is a group of people recruited to respond to a survey. They are typically chosen from a pre-arranged pool of respondents who've agreed to be contacted by a market research service in order to respond to surveys.

A total of 2,616 useable responses were collected after excluding respondents who finished the survey in less than six minutes (less than 1/3 of median duration); $n_1 = 1,233$ for the conventional v. recycled water study and $n_2 = 1,383$ for the tap v. bottled water study. However, 154 respondents were excluded by the IATgen Shiny Web Applet (Carpenter et al., 2019) because they sped through an IAT (more than 10% of decisions were made in less than 300 milliseconds). This resulted in a final total of 2,462 valid responses: $n_1 = 1,120$ and $n_2 = 1,342$. The larger number of responses that had to be dropped from the conventional v. recycled water study is potentially attributable to the difference in presentation between the two studies. The targets were described in words for the conventional v. recycled water study, while the targets were presented as images in the tap v. bottled water study.

The estimated mean age of the respondents was approximately 48 years, about 52% of respondents were women, and the mean estimated income was almost \$73,000. Table 2 presents a complete breakdown of the respondents' characteristics. Respondents were asked how much of their food was grown with recycled v. conventional water and how much of the water they consume is tap v. bottled water, and the mean responses to these questions are also reported in Table 2.

Table 2
Proportion of Respondent Characteristics by Study

Characteristic	Response options	Recycled v. conventional (<i>N</i> = 1,120)	Tap v. bottled (<i>N</i> = 1,342)
Age	18–24	12.14	12.52
	25–34	16.88	16.62
	35–44	15.89	16.39
	45–54	18.13	17.29
	55–64	16.79	17.59
	65+	20.18	19.60
Education	Less than high school degree	1.43	1.12
	High school graduate (including GED)	15.80	17.14
	Some college but no degree	22.86	24.14
	Associate degree in college (2-year)	10.27	12.30
	Bachelor's degree in college (4-year)	29.29	29.36
	Master's degree	16.52	12.67
	Doctoral degree	2.05	1.27
Sex	Professional degree (JD, MD)	1.79	2.01
	Male	48.39	47.91
Income	Female	51.61	52.09
	Less than \$25,000	17.32	17.44
	\$25,000 to \$50,000	21.43	23.40
	\$50,001 to \$75,000	20.00	18.63
	\$75,001 to \$100,000	13.39	14.46
	\$100,001 to \$150,000	15.00	15.13
	\$150,001 to \$200,000	6.25	5.59
Density	\$200,001+	6.61	5.37
	Urban	29.46	26.38
	Suburban	50.09	51.64
	Rural	20.45	21.98
Employment status	Unemployed	8.57	9.09
	Part time	10.18	10.13
	Full time	44.11	43.37
	Student	6.43	6.33
	Retired	24.20	23.99
	Not currently seeking employment	6.52	7.08
Race	White	81.70	81.74
	Black or African American	8.04	8.35
	Hispanic, Latino, or Spanish Origin	6.34	5.14
	American Indian or Alaskan Native	1.43	0.75
	Asian Indian	1.52	1.56
	Chinese	1.96	2.46
	Filipino	0.80	0.89
	Japanese	0.98	0.82
	Korean	0.27	0.60
	Vietnamese	0.36	0.45
	Native Hawaiian or Pacific Islander	0.36	0.15
Proportion of food irrigated with recycled water	Other	1.34	1.34
	Proportion of water consumed that is tap	37.81	45.90

Note. The proportions for Race sum to more than 100 because respondents could select more than one option.

Table 3
Sample Beliefs About Attributes of Recycled and Conventional Water

Healthier			Tastier			More sustainable		
Response	Proportion	Pairwise groupings	Response	Proportion	Pairwise groupings	Response	Proportion	Pairwise groupings
Conventional	50.36	A	Conventional	48.39	A	Recycled	44.38	A
Equal	38.48	B	Equal	41.07	B	Equal	28.30	B
Recycled	10.98	C	Recycled	10.54	C	Conventional	27.32	B

Note. $N = 1,120$. Healthfulness: Chi-square statistic = 412, p -value < 0.01. Taste: Chi-square statistic = 406, p -value < 0.01. Sustainability: Chi-square statistic = 92, p -value < 0.01. Bonferroni-corrected p -values with a threshold of 0.05 were used to determine pairwise comparison groupings.

3. Results

3.1. Beliefs About Water Attributes

Tables 3 and 4 display the proportions of stated beliefs about the healthfulness, taste, and sustainability of the types of water considered. Overall tests of independence indicate that beliefs about the attributes is dependent on the type of water. The pairwise comparisons show that respondents believed recycled water to be less healthy and the food irrigated with recycled water to be less tasty, but the use of recycled water is believed to be more sustainable (all Bonferroni-corrected p -values < 0.01). Similarly, tap water was believed to be less healthy and tasty, but more sustainable (all Bonferroni-corrected p -values < 0.01). These results point to the stigmatization of recycled water and tap water along the attributes of healthfulness and taste of products, and the need to reduce aversion if the desire is to increase acceptance and adoption.

3.2. Implicit and Explicit Attitudes

Table 5 displays the results of our analysis of respondents' implicit and explicit attitudes. All the estimated D-scores for the implicit and explicit attitude measures are significantly different from zero (all p -values < 0.01), confirming that respondents generally have formed attitudes toward the types of waters considered. The estimated mean D-scores are 0.764 for recycled v. conventional water and 0.202 for tap v. bottled water, with internal consistency scores of $\alpha = 0.929$ for recycled v. conventional water and $\alpha = 0.907$ for tap v. bottled water. The mean explicit attitude scores are 0.424 for recycled v. conventional water and 0.366 for tap v. bottled water. These results indicate that respondents, on average, had less favorable attitudes, both implicit and explicit, toward recycled and tap water.

Results from the four estimated linear regression models are shown in Table 6. Negative (positive) coefficient estimates indicate an association with more (less) favorable attitudes toward recycled or tap water. The Constant is greater than zero for both implicit attitude models and the explicit attitude for the tap v. bottled water study, which can be interpreted as the persistence attitudes after controlling for respondent characteristics and stated beliefs about water attributes. Thus, explicit attitudes about recycled v. conventional water are moderated by individual characteristics and attribute beliefs.

Table 4
Sample Beliefs About Attributes of Tap and Bottled Water

Healthier			Tastier			More sustainable		
Response	Proportion	Pairwise groupings	Response	Proportion	Pairwise groupings	Response	Proportion	Pairwise groupings
Bottled	53.20	A	Bottled	66.39	A	Tap	47.39	A
Equal	34.95	B	Equal	20.04	B	Bottled	27.05	B
Tap	11.85	C	Tap	13.56	C	Equal	25.56	B

Note. $N = 1,342$. Healthfulness: Chi-square statistic = 519, p -value < 0.01. Taste: Chi-square statistic = 1,003, p -value < 0.01. Sustainability: Chi-square statistic = 171, p -value < 0.01. Bonferroni-corrected p -values with a threshold of 0.05 were used to determine pairwise comparison groupings.

Table 5
Sample Attitude Scores

Attitude	Recycled v. conventional ($N = 1,120$)	Tap v. bottled ($N = 1,342$)
Implicit	0.764 ^a [0.734, 0.794]	0.202 ^a [0.171, 0.233]
Explicit	0.424 ^a [0.386, 0.461]	0.366 [0.322, 0.409]

Note. Positive scores indicate a more favorable attitude toward conventional or bottled water, and negative scores indicate a more favorable attitude toward recycled or tap water. *t*-tests were estimated to determine if attitudes differed from zero. Recycled v. Conventional: Implicit *t*-statistic = 50.5, Explicit *t*-statistic = 22.1. Tap v. Bottled: Implicit *t*-statistic = 12.8, Explicit *t*-statistic = 16.6.

^adenotes a significance level of <0.01 .

Favorable implicit and explicit attitudes toward recycled water were associated with younger respondents. Besides Age, only the coefficient estimates for Percent Recycled and variables for stated beliefs about water attributes were significant across both attitude models for the recycled v. conventional water study. Respondents had more favorable attitudes toward recycled water, in general, if they believed the food they consume was irrigated with recycled water or if they believed that food irrigated with recycled water is healthier or tastier. However, respondents who stated conventional water to be more sustainable generally had a more favorable implicit attitude toward recycled water compared to respondents who stated that recycled water was more sustainable. Being retired or residing in an urban area were associated with more favorable implicit attitudes. While higher income was associated with a more favorable explicit attitude toward recycled water and stating that conventional water is healthier was associated with a less favorable explicit attitude.

In the attitude models for the tap v. bottled water study, higher education was associated with more favorable attitudes toward tap water and identifying as female was associated with a less favorable explicit attitude. Respondents who consumed relatively more tap water, or believed tap water to be healthier or sustainable, had more favorable implicit and explicit attitudes toward tap water. While respondents who believed bottled water to be healthier or tastier had less favorable implicit and explicit attitudes toward tap water. A less favorable explicit attitude toward tap water was associated with the belief that bottled water tastes better.

3.3. Stated Preferences

Table 7 displays the proportion of the products preferred by respondents. Tests of independence and subsequent pairwise comparisons indicate that food irrigated with conventional water was preferred by more respondents than food irrigated with recycled water, and bottled water was preferred more than tap water. More than half of respondents (52%) preferred clementines irrigated with conventional water, while 28% of respondents preferred the clementines irrigated with recycled water, and the remaining 20% were indifferent. Almost 70% of respondents preferred bottled water, 21% preferred tap water, and 10% were indifferent.

Results from the six estimated logistic regression models are shown in Table 8. Coefficient estimates for implicit and explicit attitudes were significant across several of the logit models. The directional relationship of attitude coefficients and preferences make sense intuitively; more favorable attitudes toward a water are associated with increased likelihood of preferring that water. Not many respondent characteristics were significant across multiple models at an alpha less than 0.05. Respondents residing in urban areas were less likely to prefer bottled water and more likely to prefer tap water, and those who consume more tap water were more likely to be indifferent and less likely to prefer bottled water.

Several of the coefficients for attribute belief variables were significant across models and are generally in expected direction. For example, believing conventional water to be more healthy or tasty are both associated with preferring food irrigated with conventional water, and those respondents were less likely to be indifferent between products. Also, respondents who believed bottled water to be healthier were more likely to prefer bottled water and less likely to prefer tap water. The direction for some of the sustainability variable coefficients are counterintuitive; for example, believing that recycled water to be more sustainable was associated with a lower likelihood of preferring a food product irrigated with recycled water, and believing bottled water to be more sustainable was associated with a higher likelihood of preferring tap water.

4. Conclusions

Recent events have shown that water security and water quality are no longer hypothetical problems (Edmond, 2019; Welch, 2018). Water-management practices such as increased use of recycled water for irrigation can improve water security (Anderson, 2003; Chen et al., 2013; Toze, 2006) and reducing demand for bottled drinking water

Table 6
Heterogeneity in Attitudes Across Respondent Characteristics

Independent variables	Recycled v. conventional (<i>N</i> = 1,120)		Tap v. bottled (<i>N</i> = 1,342)	
	Implicit attitude	Explicit attitude	Implicit attitude	Explicit attitude
Constant	0.343 ^c (0.080)	0.089 (0.102)	0.405 ^c (0.094)	0.573 ^c (0.010)
Age	0.124 ^c (0.010)	0.072 ^c (0.013)	−0.003 (0.011)	0.020 (0.012)
Education	−0.006 (0.010)	0.005 (0.012)	−0.012 (0.011)	−0.027 ^b (0.012)
Income	−0.009 (0.009)	−0.036 ^c (0.011)	−0.003 (0.010)	−0.006 (0.011)
Female	0.007 (0.026)	−0.001 (0.034)	−0.021 (0.029)	0.105 ^c (0.032)
White	0.048 (0.046)	0.081 (0.59)	−0.084 ^a (0.050)	−0.034 (0.054)
Black	−0.022 (0.061)	−0.049 (0.078)	−0.074 (0.066)	0.028 (0.072)
Latinx	−0.050 (0.061)	0.019 (0.077)	−0.042 (0.071)	0.123 (0.078)
Working	−0.092 ^a (0.036)	−0.038 (0.045)	−0.030 (0.039)	−0.038 (0.042)
Retired	−0.102 ^b (0.048)	−0.048 (0.062)	−0.030 (0.053)	0.018 (0.057)
Urban	−0.084 ^c (0.031)	−0.048 (0.040)	0.052 (0.035)	−0.023 (0.038)
Rural	0.024 (0.035)	0.084 ^a (0.044)	0.021 (0.037)	−0.007 (0.040)
Percent Recycled	−0.001 ^b (0.001)	−0.002 ^c (0.001)		
Conventional Healthier	0.085 (0.036)	0.362 ^c (0.046)		
Recycled Healthier	−0.186 ^c (0.054)	−0.208 ^c (0.068)		
Conventional Tastier	−0.002 (0.037)	0.028 (0.047)		
Recycled Tastier	−0.197 ^c (0.055)	−0.302 ^c (0.070)		
Conventional more Sustainable	−0.140 ^c (0.040)	−0.003 (0.050)		
Recycled more Sustainable	0.066 ^b (0.032)	−0.007 (0.041)		
Percent Tap			−0.003 ^c (0.001)	−0.009 ^c (0.001)
Bottled Healthier			0.173 ^c (0.040)	0.275 ^c (0.043)

Table 6
Continued

Independent variables	Recycled v. conventional ($N = 1,120$)		Tap v. bottled ($N = 1,342$)	
	Implicit attitude	Explicit attitude	Implicit attitude	Explicit attitude
Tap Healthier			−0.112 ^b (0.054)	−0.125 ^b (0.059)
Bottled Tastier			0.153 ^c (0.045)	0.323 ^c (0.049)
Tap Tastier			−0.092 (0.056)	−0.173 ^c (0.061)
Bottled more Sustainable			−0.072 ^a (0.042)	−0.089 (0.045)
Tap more Sustainable			−0.160 ^c (0.036)	−0.116 ^c (0.039)
R^2	0.297	0.292	0.232	0.537

Note. Estimated coefficients are from linear regression models. Standard errors are in parentheses.

^asignificance level at 0.10. ^bsignificance level at 0.05. ^csignificance level at 0.01.

is a consumer-driven goal that can improve water quality by reducing microplastic pollution (Andrady, 2011). This study provides insight into negative attitudes consumers have regarding agricultural products irrigated with recycled water and replacing bottled water with tap water. Like Fu and Liu (2017), we find that respondents had a negative implicit attitude toward recycled water, and we find that consumers have a negative explicit attitude. Respondents also had a negative implicit attitude toward tap water.

Previous research found associations between individual characteristics and perceptions about the safety of water sources (Javidi & Pierce, 2018), and there is rich literature examining the factors like individual characteristics and risk perception associated with concerns about tap water (de França Doria, 2010). While we also find some significant associations between respondent characteristics and attitudes about water (e.g., age) as well as preferences for water (e.g., living in an urban area), results from estimated models indicate strong associations between beliefs about attributes of water (e.g., taste) attitudes and preferences.

Coefficient estimates for both implicit and explicit attitudes were significant in three of the six preference models, which demonstrates the connection of attitudes to potential consumption decisions. However, the direction and strength of associations between beliefs about attributes and attitudes or preferences were mixed. For example, beliefs about attributes of recycled water, but not conventional water, were associated with attitudes in multiple estimated models, and the opposite was noticed in the preference models. Also, the coefficient estimates for sustainability attributes were counterintuitive, but may hint that consumers can believe a product to be more sustainable yet have an implicitly negative attitude and be less likely to prefer that product. Thus, while providing

Table 7
Sample Preferences

Preference	Recycled v. conventional ($N = 1,120$)		Response	Tap v. bottled ($N = 1,342$)	
	Proportion	Pairwise groupings		Proportion	Pairwise groupings
Conventional	52.23	A	Bottled	69.52	A
Recycled	28.04	B	Tap	20.86	B
Indifferent	19.73	C	Indifferent	9.61	C

Note. Recycled v. Conventional Water: Chi-Square test statistic = 287, p -value < 0.01. Tap v. Bottled Water: Chi-Square test statistic = 1,225 p -value < 0.01; all comparisons were significantly different (p -value < 0.01). Bonferroni-corrected p -values with a threshold of 0.05 were used to determine pairwise comparison groupings.

Table 8
Heterogeneity in Preferences Across Respondent Characteristics

Independent variables	Recycled v. conventional ($N = 1,120$)			Tap v. bottled ($N = 1,342$)		
	Prefer conventional	Prefer recycled	Indifferent	Prefer bottled	Prefer tap	Indifferent
Constant	−0.130 (0.422)	−0.567 (0.450)	−1.73 ^c (0.523)	1.699 ^c (0.531)	−1.597 ^c (0.557)	−3.914 ^c (0.777)
Implicit Attitude	0.103 (0.155)	−0.322 ^b (0.163)	0.282 ^a (0.199)	0.373 ^b (0.146)	−0.350 ^b (0.152)	−0.033 (0.196)
Explicit Attitude	0.662 ^c (0.129)	−0.588 ^c (0.141)	−0.311 (0.165)	0.625 ^c (0.144)	−0.570 ^c (0.147)	−0.245 (0.191)
Age	−0.023 (0.057)	−0.056 (0.061)	0.114 (0.072)	−0.099 (0.061)	0.123 ^a (0.064)	−0.003 (0.085)
Education	−0.033 (0.049)	−0.032 (0.053)	0.086 (0.060)	0.090 (0.061)	−0.111 ^a (0.064)	0.003 (0.081)
Income	0.025 (0.043)	−0.012 (0.047)	−0.026 (0.053)	−0.024 (0.053)	−0.014 (0.055)	0.059 (0.068)
Female	0.037 (0.133)	0.179 (0.145)	−0.294 ^a (0.166)	0.130 (0.158)	−0.324 ^b (0.165)	0.214 (0.214)
White	−0.535 ^b (0.238)	0.227 (0.252)	0.495 (0.303)	0.188 (0.270)	−0.404 (0.274)	0.177 (0.402)
Black	−0.305 (0.314)	0.065 (0.327)	0.320 (0.403)	−0.292 (0.360)	0.157 (0.360)	0.121 (0.545)
Latinx	−0.429 (0.313)	−0.064 (0.327)	0.648 ^a (0.369)	−0.443 (0.397)	0.297 (0.405)	0.120 (0.611)
Working	0.199 (0.181)	0.023 (0.195)	−0.369 ^a (0.224)	0.376 ^a (0.206)	−0.639 ^c (0.214)	0.406 (0.303)
Retired	0.149 (0.246)	0.012 (0.273)	−0.314 (0.296)	0.422 (0.279)	−0.812 ^c (0.291)	0.420 (0.392)
Urban	−0.088 (0.159)	0.166 (0.169)	−0.106 (0.205)	−0.458 ^b (0.187)	0.582 ^c (0.192)	−0.223 (0.273)
Rural	−0.111 (0.176)	0.005 (0.197)	0.150 (0.211)	−0.320 (0.197)	0.148 (0.207)	0.324 (0.247)
Percent Recycled	−0.004 (0.003)	0.003 (0.003)	0.003 (0.004)			
Conventional Healthier	0.567 ^c (0.182)	−0.030 (0.209)	−0.858 ^c (0.228)			
Recycled Healthier	0.146 (0.269)	0.251 (0.271)	−0.502 (0.343)			
Conventional Tastier	0.767 ^c (0.182)	−0.401 ^a (0.211)	−0.605 ^c (0.225)			
Recycled Tastier	0.054 (0.277)	0.663 (0.276)	−1.221 ^c (0.381)			
Conventional more Sustainable	−0.191 (0.206)	0.363 (0.226)	−0.397 (0.293)			
Recycled more Sustainable	0.128 (0.165)	−0.357 ^b (0.183)	0.235 (0.188)			

Table 8
Continued

Independent variables	Recycled v. conventional ($N = 1,120$)			Tap v. bottled ($N = 1,342$)		
	Prefer conventional	Prefer recycled	Indifferent	Prefer bottled	Prefer tap	Indifferent
Percent Tap				−0.009 ^c (0.003)	0.003 (0.003)	0.011 ^c (0.004)
Bottled Healthier				0.926 ^c (0.218)	−0.840 ^c (0.239)	−0.394 (0.283)
Tap Healthier				−0.278 (0.263)	0.353 (0.260)	−0.266 (0.355)
Bottled Tastier				0.426 ^a (0.227)	−0.440 ^a (0.239)	0.005 (0.282)
Tap Tastier				0.342 (0.271)	0.224 (0.266)	−0.948 ^b (0.374)
Bottled more Sustainable				−0.340 (0.239)	0.917 ^c (0.258)	−1.134 ^c (0.396)
Tap more Sustainable				0.281 (0.194)	−0.104 (0.210)	−0.340 (0.236)
Elicitation Method 1	−0.042 (0.184)	0.310 (0.201)	−0.353 (0.235)	−1.349 ^c (0.234)	1.414 ^c (0.261)	0.486 (0.369)
Elicitation Method 2	0.029 (0.184)	0.022 (0.207)	−0.065 (0.227)	−0.563 ^b (0.237)	0.575 (0.272)	0.329 (0.369)
Elicitation Method 3	−0.042 (0.184)	0.310 (0.201)	−0.353 (0.235)	−1.349 ^c (0.234)	1.414 ^c (0.261)	0.486 (0.369)
Log-Likelihood	−689	−606	−487	−554	−517	−344

Note. Estimated coefficients are from logistic regression models. Standard errors are in parentheses.

^asignificance level at 0.10. ^bsignificance level at 0.05. ^csignificance level at 0.01.

more information or education about the benefits of recycled or tap water may seem like an obvious policy approach, many consumers may already know these alternatives are better for the environment and still not want to increase their relative consumption.

Strategies for promoting the use of alternative sources of water may be more effective by emphasizing private benefits. These results suggest that public information campaigns should promote the relatively equivalent healthfulness and tastiness of foods irrigated with conventional water and recycled water and emphasize the additional benefit of the sustainability of recycling water. This type of combined messaging should be most effective in influencing consumers' attitudes, beliefs, and preferences and, therefore, in affecting their choices. The same is likely true for efforts to increase demand for tap water. Even though tap water is far less expensive than bottled water, many consumers still prefer bottled water. Information campaigns can highlight the equivalence of many brands of bottled water with tap water and the significant private and environmental costs of drinking water that is not safer or cleaner than tap water.

There are several limitations in this study that may necessitate further research. To start, unlike with bottled and tap water, there is no clear way to use images to differentiate between recycled and conventional irrigation water. As a result, we had to use words like greywater, municipal, blackwater, and reservoir for the Recycled v. Conventional IAT, which are more difficult to differentiate than comparing images of a glass of tap water and a bottle of water. To improve future recycled v. conventional studies, a focus group or survey can be used to determine which words are most associated with recycled and conventional water. This could help fix the issue of not being able to use easy-to-differentiate images. Furthermore, using attribute words like “good” and “bad” rather than

more divisive words that elicit stereotypes like “healthy” and “dangerous” could improve the pure measurements of recycled water to conventional water and tap water to bottled water.

Another potential limitation is that produce irrigated with conventional water and produce irrigated with recycled water are more direct substitutes than bottled water and tap water. A consumer would not be able to tell the difference between a clementine irrigated with conventional water compared to one irrigated with recycled water, but they can easily tell the difference between a bottle of water and a glass of tap water. This makes it harder to make a direct comparison between the gap in perception between the two sets of products. A future field experiment can be run where respondents answer the same set of attribute questions asked in this survey, but they actually have the products in front of them.

Another limitation is that the sample is exclusively within the United States. As different countries and cultures may have varying opinions regarding types of water, these results may not be generalized to other parts of world. For example, the implicit attitudes toward recycled water relative to conventional water may be completely different with an Israeli sample, as Israel recycles 90% of its wastewater. Additionally, implicit attitudes toward tap water relative to bottled water may be more favorable from a sample composed of respondents from a country with access to high-quality tap water compared to a country that has poor quality tap water and thus frequently relies on bottled water for drinking.

Lastly, future work can improve on these studies by running field economic experiments where respondents bid on and consume the various types of waters, with the attitude measures randomly dispersed, to get a better understanding of behavioral measures. Moreover, a within measure, in which respondents complete both studies in this paper, could provide insight into heterogeneity across studies.

Appendix A

Table A1

Attributes/Targets and Items Used in the Recycled v. Conventional Water Implicit Association Test

Attributes/Targets	Items
Good	Safe, Fresh, Tasty, Refreshing, Wonderful, Clean, Healthy Delicious
Bad	Unsafe, Dirty, Hazardous, Dangerous, Disease, Unhealthy, Disgusting, Gross
Conventional Water	Municipal, Stream, Reservoir, Glacial, Spring, Tap
Recycled Water	Nontraditional, Greywater, Unconventional, Reclaimed, Reused, Blackwater

Table A2

Attributes/Targets and Items Used in the Tap v. Bottled Water Implicit Association Test

Attributes/Targets	Items
Good	Clean, Healthy, Fresh, Efficient, Tasty, Yummy, Safe, Refreshing
Bad	Unsafe, Dirty, Polluted, Wasteful, Unhealthy, Disgusting, Gross, Dangerous
Bottled Water	
Tap Water	

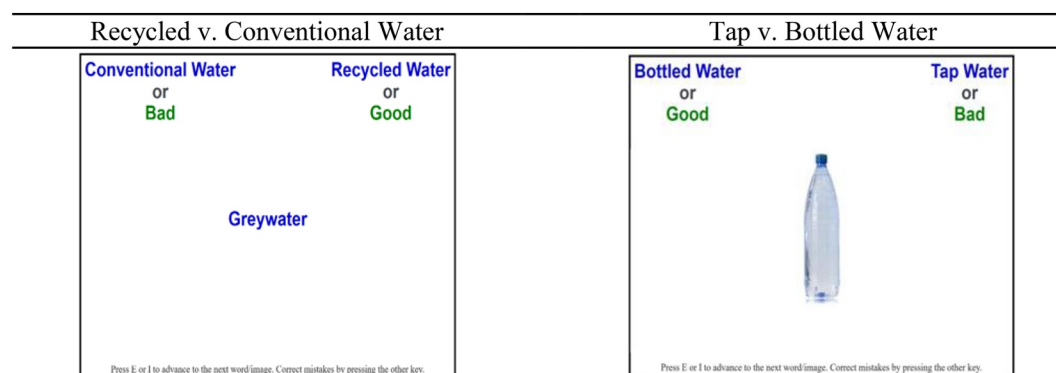


Figure A1. Example of Questions used in the Implicit Association Tests.

Table A3
Elicitation Method Effect on Preferences

Variable	Recycled v. conventional (N = 1,120)			Tap v. bottled (N = 1,342)		
	Prefer conventional	Prefer recycled	Indifferent	Prefer bottled	Prefer tap	Indifferent
Constant	0.171 (0.112)	−1.108 ^c (0.138)	−1.330 ^c (0.146)	1.966 ^c (0.163)	−2.404 ^c (0.194)	−3.178 ^c (0.273)
Elicitation Method 1	−0.001 (0.169)	0.291 (0.189)	−0.394 ^a (0.221)	−0.944 ^c (0.206)	1.056 ^c (0.238)	0.399 (0.361)
Elicitation Method 2	0.053 (0.170)	0.014 (0.195)	−0.098 (0.211)	−0.479 ^b (0.213)	0.500 ^b (0.251)	0.330 (0.361)
Elicitation Method 3	−0.382 ^b (0.170)	0.338 ^a (0.189)	0.157 (0.204)	−2.697 ^c (0.202)	2.140 ^c (0.224)	2.029 ^c (0.303)
Log-Likelihood	−771	−662	−553	−686	−618	−381

Note. Estimated coefficients are from logistic regression models. Standard errors are in parentheses.

^asignificance level at 0.10. ^bsignificance level at 0.05. ^csignificance level at 0.01.

Conflict of Interest

The authors declare no conflicts of interest relevant to this study.

Data Availability Statement

All analyses were estimated using Stata/SE 16, and the data and code for this paper can be retrieved from the anonymized link: https://osf.io/fp5wy/?view_only=ab7b1ca90e4f47cbb4bda06a57d034e8.

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