EXAMINING BIAS ASSOCIATED WITH RECYCLED WATER AND TAP WATER

by

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ABSTRACT

Increasing the use of recycled water and decreasing the consumption of bottled water are examples of water management and consumer-driven practices to improve water security and quality. However, consumers place a discount on goods irrigated with recycled water compared to conventional water, and a premium on bottled water compared to tap water. The goal of this study is to measure the biases associated with recycled water and tap water to better understand aversions associated with these sources of water that improve water security and quality. We conducted two similar studies: Conventional Water vs. Recycled Water and Bottled Water vs. Tap Water. For each study, we compared implicit bias measured through an Implicit Association Test to explicit bias. Bias measures were correlated with health, taste, and sustainability measures, and willingness-to-pay (WTP) and willingness-to-accept (WTA) values were collected for each type of water. WTP and WTA values were collected four different way to study the effect of elicitation method. Implicit and explicit biases were found to exist against recycled water and tap water. Respondents viewed conventional water and bottled water as healthier and tastier than recycled water and tap water. Additionally, the preferences for conventional water and bottled water were reinforced by larger WTP values, while elicitation method did significantly affect values. Lastly, despite implicit and explicit biases existing against recycled water and tap water, explicit bias had higher correlations with the attributes and a larger effect on the WTP and WTA values than implicit bias, suggesting explicit bias is a more predictive measure of consumer preferences.

Chapter 1

INTRODUCTION

In 2019, the World Economic Forum listed “water crises” as the fourth biggest risk in terms of global impact (World Economic Forum 2019). Nearly 70% of the global population are victims of water scarcity at least one month annually (Mekonnen and Hoekstra 2016) and 30% do not have access to safe drinking water (United Nations 2019). In 2018, due to severe droughts and high demand, Cape Town, South Africa came within ninety days of turning off the taps to four-million people (Welch 2018; Edmond 2019). Cape Town’s water security issues along with the ongoing water quality tragedy in Flint, MI reveal that water crises are more than a concern. The daunting challenges of water security and quality for current and future societies require water management and consumer-driven practices.

Shifting demand outward for recycled water and inward for bottled water are water management and consumer-driven practices to improve water security and quality. Using recycled water in agricultural production can increase water security while improving yields and reducing the negative externalities associated with nutrient runoff (Anderson 2003; Toze 2006; Chen et al. 2013). Additionally, decreasing the consumption of bottled water can slow down the rate of plastic pollution in water sources, and in turn, mitigate the presence of microplastics and improve water quality (Andrady 2011; Free et al. 2014). However, consumer preferences exist for goods irrigated with conventional water compared to recycled water (Li, McCluskey and Messer 2018; Savchenko et al. 2018; Savchenko, Li, et al. 2019) and bottled water compared to tap water (Doria 2006). These preferences may arise from implicit and explicit biases, such as inherent aversions to recycled water (Po et al. 2005; Menegaki, Hanley and Tsagarakis 2007; Rozin et al. 2015; Wester et al. 2016) and tap water (Doria 2006).

Consumer attitudes and decision-making may be influenced by implicit biases (Maison, Greenwald and Bruin 2001; Maison, Greenwald and Bruin 2004; Richetin et al. 2007). While explicit bias occurs knowingly on a conscious level, implicit bias occurs on a subconscious level. These biases relate to the two types of mental processing systems defined by Stanovich and West: System 1 and System 2 (2000). System 1 mental processes occur automatically and subconsciously, such as feeling disgust when viewing a graphic image; while System 2 mental processes are deliberate and require conscious effort, such as comparing the price and quality of two items (Kahneman 2011). Implicit bias is an example of a System 1 mental process. For example, a person may immediately associate recycled water with "toilet-to-tap", causing the person to feel disgust towards the product. On the other hand, explicit bias is more of a System 2 mental process. For example, when at a restaurant, a consumer deliberately decides between drinking bottled water and tap water. In this example, the consumer is aware of their bias, or in this case, their preference, towards either bottled water or tap water. Consequently, implicit and explicit biases may be sources of aversion towards recycled water and tap water. Our goal is to see how indicative each type of bias is of consumer preferences.

Implicit bias is rarely studied in the consumer industry because it requires complicated measuring methods. The most common method to measure implicit bias is the Implicit Association Test (IAT), which is a computerized task that measures the mental association between two targets (e.g., bottled water vs. tap water) and two attributes (e.g., good and bad). (Greenwald, McGhee and Schwartz 1998). An IAT takes about ten to fifteen minutes to complete, so it cannot just be added into a short survey. Explicit bias, which can be measured by simply having a respondent rate two products out of ten and then comparing the difference, is more commonly measured. However, the issue with just looking at explicit bias is that respondents can overstate or understate their answers. For example, sensitive questions may not be answered with complete honesty, leading to skewed results. However, by also measuring implicit bias, the accuracy of the data can be improved. In fact, a meta-analysis of IATs found that the predictive validities of an IAT and explicit bias measures generally provided a gain in predictive validity relative to using the other alone, highlighting the benefits of studying both implicit and explicit bias (Greenwald et al. 2009).

The objective of this study is to measure implicit and explicit biases towards recycled water (versus conventional water) and tap water (versus bottled water). Comparing implicit and explicit biases provides a better understanding about the source of aversion to available options that increase water security and quality. Additionally, we examine the effect of implicit and explicit bias on willingness-to-pay (WTP) and willingness-to-accept (WTA) to determine if either influences actual choices.

We researched these objectives by distributing an online survey to over 2,600 respondents. Respondents were randomized to one of two studies: Conventional Water vs. Recycled Water or Bottled Water vs. Tap Water. Implicit bias and explicit bias measures were collected, along with WTP or WTA measures and demographic data.

Chapter 2

BACKGROUND

Implicit Bias

Implicit biases occur on a subconscious level and manifest without awareness of the causation (Greenwald and Banaji 1995). Implicit bias has been heavily studied in the consumer industry and has been found to influence consumer decisions. Example IAT studies in the consumer industry involve studying brand preferences (Maison et al. 2004), attitudes towards organic food (Richetin, Mattavelli and Perugini 2016), and attitudes towards sustainable food shopping (Panzone et al. 2016). We use the IAT to measure implicit bias against recycled water and tap water.

The halo effect (Thorndike 1920) and horn effect are examples of implicit biases. These terms were first used in the field of psychology to describe attitudes towards individuals and occur when someone allows an observed positive or negative trait to influence the evaluation of other traits in a positive (halo) or negative (horn) manner (Nisbett and Wilson 1977; Forgas and Laham 2016). However, these terms have also been researched and documented in the consumer industry and some products have been found to have a "health halo." For example: fair trade chocolate is perceived as having fewer calories than chocolate that is not fair trade (Schuldt, Muller and Schawrz 2012); cheese labeled "traditional" is viewed as healthier and tastier than cheese labeled "industrial" (Richetin et al. 2019); and products with an organic label are regarded as healthier than food not labeled organic (Schuldt and Schawrz 2010; Ellison et al. 2016). A health halo may also explain the fondness for bottled water, at the expense of tap water, while the horn effect may explain the aversion to goods irrigated with recycled water. For example, a study found that a gap between science and public opinion leads to uncertainty about the safety of genetically modified foods (McFadden 2016). This also applies to recycled water and tap water because despite those products being safe to consume, they are still met with consumer skepticism due to the implicit attitudes towards the products.

Water Security and Quality

Using recycled water for irrigation is an efficient water management practice to improve water security. Recycled water is highly treated wastewater that has been filtered and disinfected in a water treatment plant to remove impurities (USGA 2014). It is just as safe to drink as water from other sources (Asano and Levine 2004), and can especially be used for agriculture (Pedrero et al. 2010), which consists of 80 percent of the consumptive water use in the United States (USDA ERS 2019). Irrigated land covers 275 million hectares globally (UNESCO WWAP 2017), yet only 35.9 million hectares are irrigated using recycled water (Thebo et al. 2017). The result is that 70 percent of all global freshwater is used for irrigation (Khokhar 2017). Recycled water even has agronomic benefits, such as improving soil health through the addition of nitrogen, phosphorus, and other micronutrients, which also decreases the amount of fertilizer needed (Chen et al. 2013). Despite the many benefits, consumers are skeptical of using recycled water.

Consumers often deal with cognitive biases when purchasing goods (McFadden and Lusk 2015). For example, studies have found that consumers have aversion towards foods that have been genetically engineered (Lusk, McFadden and Rickard 2015; Pakseresht, McFadden and Lagerkvist 2017; McFadden and Smyth 2019). This aversion, often due to a lack of understanding of biotechnology, also applies to recycled water. Consumers may not fully understand recycled water and instead, associate it with “toilet to tap”. Thus, their System 1 mental processing conjures automatic feelings of disgust and a resistance to consume recycled water (Menegaki et al. 2009; Rozin et al. 2015; Kecinski et al. 2016; Wester et al. 2016; Kecinski et al. 2018; Savchenko, Kecinski, et al. 2019). Despite there being no health risks associated with consuming goods irrigated with recycled water, studies have found that consumers have a lower willingness-to-pay for products irrigated with recycled water compared to conventional water (Li et al. 2018; Savchenko et al. 2018; Savchenko, Li, et al. 2019). This irrational aversion towards recycled water may be an example of the horn effect as consumers are letting misperceptions about the safety of recycled water affect the perceived quality and value.

Drinking more tap water and less bottled water is a consumer-driven practice to improve water quality. Bottled water is a leading cause of plastic pollution and negatively affects water quality. However, in 2016, bottled water surpassed soft drinks as the most consumed beverage by volume in the U.S. (Rodwan Jr. 2016), and global consumption of bottled water is over 99.5 billion gallons (Rodwan Jr. 2018) with one-million plastic water bottles purchased every minute (Laville and Taylor 2017). This high amount of consumption has strained marine ecosystems and decreased water quality though the addition of microplastics. A literature search by Gall and Thompson found that at least 690 species have encountered marine debris; 92% of those encounters involved plastic and at least 10% of the species had ingested microplastics (2015). It is estimated that there will be more plastic than fish by weight in the ocean by 2050 (Ellen MacArthur Foundation 2017). This affects more than just marine life, as research shows that the average shellfish consumer consumes 11,000 microplastics per year (Van Cauwenberghe and Janssen 2014). As a result, consumer demand for disposable plastic bottles must be shifted inward by increasing demand for tap water. However, global bottled water consumption increased by an average of 6.4 percent per year from 2012 to 2017, and continues to increase (Rodwan Jr. 2018). This is despite bottled water being roughly forty percent from a tap, costing ten thousand times as much as tap water, having less health and safety regulations, and creating vast amounts of plastic pollution (Arnold and Larsen 2006).

The rise in bottled water consumption comes at the expense of tap water consumption and is due to two key reasons. First, the safety of tap water is often mistrusted, leading to the consumption of bottled water as a substitute (Anadu and harding 2000; Jakus et al. 2009; Hu, Morton and Mahler 2011; McSpirit and Reid 2011). Second, bottled water is perceived as tasting better than tap water (Saylor, Prokopy and Amberg 2011). However, bottled water is not healthier or safer than tap water, and blind taste tests between bottled water and tap water often find tap water as equivalent to bottled water, or even better (Shermer 2003; Vann 2004). This may exhibit the halo effect because these ingrained perceptions for bottled water overshadow the negative aspects of bottled water, like higher price and destructive environmental impact.

Chapter 3

METHODS

Respondents

This study was approved by the University of Delaware's Institutional Review Board. A preliminary version of this study was piloted in person and online, receiving 29 responses, in November 2018. After piloting the study, 2,616 responses were collected through Qualtrics between April 1, 2019 and April 8, 2019. The responses were collected from a demographically diverse sample, which was prescreened by Qualtrics based on age, gender, and income. The median age group of our sample was 45-54, 51.6 % were female, and the median income level was $50,000-$75,000. These results were consistent with the quota, which can be viewed in Appendix A. Additionally, 47 % had a bachelor's degree or higher.

Survey Overview

After consenting to take part in the study and answering some demographic questions so that the sample matched the quotas, respondents were randomly assigned to one of two studies: Conventional Water vs. Recycled Water or Bottled Water vs. Tap Water. Respondents then answered questions that measured implicit and explicit bias for the types of water in a given study (the measurement of implicit or explicit bias was randomized across respondents to decrease any order effects). Next, respondents answered willingness-to-pay (WTP) and willingness-to-accept (WTA) questions to determine preferences for the types of water in a given study. The survey flow can be seen in Appendix B.

Survey Responses

We received 2,616 responses. Based on the scoring algorithm developed by Greenwald et al. (2003), we excluded 263 responses from the analysis due to a response time on the IAT that was either too fast (i.e., more than 10 percent of decisions were made in less than 300 milliseconds) or too slow (i.e., a timeout pause of 10,000 milliseconds), leading to 2,353 valid responses. The Conventional Water vs. Recycled Water study had 1,233 responses, but 113 responses were dropped, leading to a sample size of 1,120 valid responses. The Bottled Water vs. Tap Water study had 1,383 responses and 41 were dropped, leading to a sample size of 1,342 valid responses. Responses may have been dropped at a higher rate in the Conventional Water vs. Recycled Water study because it used words for the targets (conventional water and recycled water), while the Bottled Water vs. Tap Water study used images.[1] The demographics were consistent with the quota for each survey.

Measuring Implicit and Explicit Bias

Implicit bias was measured using the Implicit Association Test (IAT) (Greenwald et al. 1998). The IAT measures the mental association between two targets (e.g., bottled water vs. tap water) and two attributes (e.g., good and bad). The theoretical underpinning of the IAT is that evaluations are easier to make for highly associated targets and attributes, leading to faster and more accurate decisions when they are grouped together. For example, someone that only drinks bottled water would more closely associate "bottled water" with "good" than with "bad" and would

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[1] See Appendix C for words and images used in each IAT

therefore be expected to make decisions faster when bottled water and good are grouped together.

The IAT works by tracking the speed that respondents press E or I on a keyboard based on the targets and attributes specified for the round. There are seven rounds in the IAT. The first two rounds are practice rounds to help the respondents learn how to take the IAT. Round one is a practice round of twenty trial targets (bottled water and tap water images only), while round two is a practice round of twenty trial attributes (good and bad words only). Rounds three and four contain both targets and attributes. Round three consists of twenty practice trials and round four consists of forty critical trials. Round five is a practice round of forty trials of attributes, yet sides are switched to eliminate left-right associations learned in the previous rounds. Rounds six and seven are the same as rounds three and four but with the attributes on opposite sides. This layout can be viewed in Appendix C.

The IAT is scored using data from the combined rounds (3+4 and 6+7). This information is used to create a standardized difference score, known as the D-score, which ranges from -2 to 2.[2] The D-score represents if respondents made decisions faster in the highly associated rounds. A D-score of 0 denotes no difference in decision-making speed, suggesting no implicit bias. A positive D-score shows faster responding in the highly associated rounds, suggesting implicit bias towards the positive target, such as bottled water or conventional water. A negative D-score represents faster responding in the incompatible rounds, suggesting implicit bias towards tap water or recycled water. Hence, the person that only drinks bottled water

[2] For more information about how a D-score is calculated, see Lane et al. (2007)."

would be expected to have a positive D-score, as they would make faster decisions in the rounds that have “bottled water” and “good” together.

The IAT has been met with controversy due to reliability, validity, and replicability issues (Teige-Mocigemba, Klauer and Sherman 2016). However, as previously stated, a meta-analysis of 184 studies with a mean sample size of 81 (SD = 141.5) found that the predictive validities of an IAT and explicit bias measures generally provided a gain in predictive validity relative to using the other alone (Greenwald et al. 2009). Furthermore, our studies had a large sample size (over 1,000 responses for each test), and reliability scores of $\alpha = 0.929$ and $\alpha = 0.907$[3], alleviating some concerns of using the IAT.

Lastly, correlation coefficients were estimated to determine if implicit and explicit bias were correlated with health, taste, and sustainability to determine if the halo and horn effect were present. Depending on the study respondents were randomly assigned to, attribute preferences were measured by respondents selecting a type of water as healthier, tastier, and more sustainable. For example, when asked which type of water is healthier, a respondent could select bottled water, tap water, or equally healthy. This response was then coded into three indicator variables indicating which type of water was chosen as healthier: bottled water, tap water, or equally healthy. If bottled water was chosen, the variable indicating bottled water is healthier would be coded as 1, while the tap water and equally healthy variables would be coded as 0. The respondent would then answer similar questions for taste and sustainability.

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[3] Psychology literature considers $\alpha > 0.70$ as adequate (Cortina 1993).

Measuring Willingness-to-Pay and Willingness-to-Accept

WTP and WTA have historically been collected separately and defined as different concepts based on property rights. However, even though a consumer does not have the property right to a product prior to purchasing (WTP), a consumer does have property rights over individual characteristics (i.e., personal health and branding) that may require compensation (WTA) for certain products. For example, an environmentalist may be so opposed to bottled water that they would not accept a bottle for free. Typical WTP studies bound values at $0. However, $0 would not accurately represent the environmentalist's true value because they would need to be compensated to accept the bottle of water. As a result, only collecting WTP data could upwardly bias estimates by assuming no respondents would require compensation.

To examine this issue, respondents were randomized to one of four treatments to measure WTP or WTA: treatment 1) WTP Only – standard WTP questions, treatment 2) WTA Only – standard WTA questions, treatment 3) WTP/WTA Choice - respondents first select WTP Only or WTA Only and then give a positive value if selecting WTP Only or a negative value if selecting WTA Only, and treatment 4) WTP/WTA Scale – respondents answer combined WTP/WTA questions, where they can give a negative (WTA) or positive (WTP) value in the same question.

Depending on the study a respondent was randomly assigned to complete (i.e., Conventional Water vs. Recycled Water or Bottled Water vs. Tap Water), the products valued by respondents were either a 3-pound bag of clementines (irrigated with conventional water and recycled water) or 16-ounces of water (bottled and tap). For WTP Only, prices ranged from $0 to $8 for clementines and $0 to $2 for water. For WTA Only, prices ranged from -$8 to $0 for clementines and -$2 to $0 for water. For

WTP/WTA Choice, prices ranged from $0 to $8 for clementines and $0 to $2 for water if choosing WTP, and -$8 to $0 for clementines and -$2 to $0 for water if choosing WTA. Lastly, for WTP/WTA Scale, prices ranged from -$8 to $8 for clementines and -$2 to $2 for water.

Typically, a study would only elicit WTP to acquire a product. Thus, WTP only was used as a baseline. WTA only was a baseline for the respondents giving a negative number in the WTP/WTA Choice and WTP/WTA Scale treatments. We used WTP/WTA Choice to see if forcing a respondent to initially decide between WTP and WTA changes the resulting value and WTP/WTA Scale to study the effect of allowing respondents to see positive (WTP) and negative (WTA) numbers at the same time.

Statistical Methods

The IAT was designed using the software IATgen and D-scores were estimated using their "Shiny Web Applet" (Carpenter et al. 2019). IATgen uses the procedure developed by Greenwald, Nosek and Banaji (2003) to analyze the data and uses an odd-even split half procedure with Spearman-Brown correction developed by De Houwer and De Bruycker to measure internal consistency reliability (2007). Explicit bias was self-reported using a Likert scale ranging from 0-10, where a higher score represented a more favorable view for the type of water. We calculated the difference in rating between the two types of water and multiplied by 0.2 to normalize the explicit rating to the D-score, which ranges from -2 to 2. For example, if a respondent rated bottled water 8 and tap water 6, their explicit rating would be (8-6)*0.2 = 0.4. Two-tailed T-tests were used to determine if implicit and explicit bias were different than 0. Paired T-tests were used to determine if there was a difference in implicit and explicit bias. Correlation coefficients were measured to see if implicit and explicit bias were correlated with health, taste, and sustainability to determine a halo or horn effect.

A one-way ANOVA was used to test the null hypothesis that there was not a difference in mean values across the WTP/WTA treatments. If a null was rejected, pairwise comparisons between each treatment were conducted using T-tests with Bonferroni corrected P-values.

A linear regression model was estimated to determine the effect of implicit and explicit bias on WTP and WTA. Separate models were estimated for each type of water (Conventional Water, Recycled Water, Bottled Water, and Tap Water) and an estimated model can be mathematically represented by:

1. $$Y_{ij} = \alpha_0 + \beta_1 I_{2j} + \beta_2 I_{3j} + \beta_3 I_{4j} + \beta_4 X_j + \beta_5 Z_j + \varepsilon_{ij},$$

where Y_{ij} is the WTP or WTA amount given by the i^{th} respondent for the j^{th} type of water and ranges from -$8 to $8 for clementines and -$2 to $2 for water. I_2, I_3, and I_4 are indicator variables equal to one if the respondent was randomly assigned to the WTA Only, WTP/WTA Choice, or WTP/WTA Scale treatments, respectively, and zero otherwise. WTP Only was excluded to prevent collinearity and because it would be the typical elicitation format for measuring WTP. Implicit and explicit biases measures are represented by X_j and Z_j, respectively, β_1, β_2, β_3, β_4, and β_5 are all coefficients to be estimated and ε_{ij} is a normally distributed overall error term.

A tobit censored regression model was also estimated. This model had the same equation as the linear regression model but was censored at -8 and 8 for conventional water and recycled water, and -2 and 2 for bottled water and tap water.

Chapter 4

RESULTS

Implicit and Explicit Bias

The Conventional Water vs. Recycled Water study IAT and Bottled Water vs. Tap Water study IAT had estimated internal consistency reliability scores of $\alpha = 0.929$ and $\alpha = 0.907$.[4] The estimated mean D-score for the Conventional Water vs. Recycled Water study IAT was 0.764 [95% CI 0.734-0.794], with a median of 0.85, indicating an implicit bias against recycled water. For the Bottled Water vs. Tap Water study IAT, an implicit bias was associated with tap water as the estimated mean D-score was 0.202 [95% CI 0.171-0.233], with a median of 0.24. The results from the explicit bias measures were similar to the implicit bias measures, as there was also an explicit bias associated with recycled and tap water. The estimated mean explicit bias for the Conventional Water vs. Recycled Water study was 0.424 [95% CI 0.386-0.461], with a median of 0.40, and the mean explicit bias was 0.366 [95% CI 0.322- 0.409], with a median of 0.20, for the Bottled Water vs. Tap Water study. All measures, estimated D-scores and mean explicit bias, were significantly different from zero (P-values were all less than 0.01).

Additionally, there were significant differences between estimated D-scores and mean explicit bias for both studies (both P-values were less than 0.01). While there was implicit and explicit bias in both studies, there were differences in the relationship between the biases. Implicit bias was greater than explicit bias in the Conventional Water vs. Recycled Water study (T-value = 17.03); but implicit bias was

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[4] Psychology literature considers $\alpha > 0.70$ as adequate (Cortina 1993).

less than explicit bias for the Bottled Water vs. Tap Water study (T-value = -7.95). Additionally, there was lower correlation between implicit bias and explicit bias in the Conventional Water vs. Recycled Water study (r = 0.339) than in the Bottled Water vs. Tap Water study (r = 0.445). This may be because the gap between mean implicit and explicit bias was larger in the Conventional Water vs. Recycled Water study (0.340) than in the Bottled Water vs. Tap Water study (0.164). Furthermore, although the difference between median implicit and explicit bias in the Conventional Water vs. Recycled Water study is large (difference = 0.45), the same is not true for the Bottled Water vs. Tap Water study (difference = 0.04), suggesting the Bottled Water vs. Tap Water study was more sensitive to outliers.[5] This makes sense anecdotally, as there are many people who refuse to drink tap water and would only drink bottled water.

Based on the attribute preferences for each type of water, conventional water and bottled water were viewed as healthier and tastier, while recycled water and tap water were viewed as more sustainable.[6] Table 1 displays correlations between bias and attributes designed to test the hypothesis that there is a horn effect against recycled water and a health halo towards bottled water. A preference for conventional water and bottled water was found as implicit and explicit bias were positively correlated with health and taste when conventional water or bottled water were chosen, but negatively correlated when recycled water or tap water were chosen. Furthermore, the health and taste attributes had stronger correlations with explicit bias than implicit bias for each type of water. Additionally, correlations were stronger for

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[5] See Appendix D for bias summary statistics

[6] See Appendix F for attribute preference measures

bottled water and tap water than they were for conventional water and recycled water, perhaps suggesting the trade-off from conventional water to recycled water is not as big as the trade-off between bottled water and tap water. Although there was some evidence for a horn effect against recycled water and a halo effect towards bottled water, the results suggest that explicit bias is more predictive of water preference.

Table 1 Bias and Attributes Correlation Coefficients

	Conventional Water vs. Recycled Water Study			Bottled Water vs. Tap Water Study		
	Healthfulness					
	Conventional Water Healthier	Recycled Water Healthier	Equally Healthy	Bottled Water Healthier	Tap Water Healthier	Equally Healthy
Implicit Bias	0.116*	-0.261*	0.050	0.373*	-0.261*	-0.210*
Explicit Bias	0.395*	-0.344*	-0.189	0.529*	-0.350*	-0.317*
N	564	123	431	722	158	462
	Taste					
	Conventional Water Tastier	Recycled Water Tastier	Equally Tasty	Bottled Water Tastier	Tap Water Tastier	Equally Tasty
Implicit Bias	0.053	-0.250*	0.102*	0.374*	-0.289*	-0.194*
Explicit Bias	0.286*	-0.320*	-0.091*	0.580*	-0.423*	-0.323
N	542	118	460	890	187	256
	Sustainability					
	Conventional Water More Sustainable	Recycled Water More Sustainable	Equally Sustainable	Bottled Water More Sustainable	Tap Water More Sustainable	Equally Sustainable
Implicit Bias	-0.084*	0.003	0.080*	-0.221*	-0.286*	-0.074*
Explicit Bias	0.181*	-0.171*	0.010*	0.299*	-0.330*	0.074*
N	306	497	317	377	629	336

Note: * denotes significance level 0.05. Each question was answered by all 1,120 respondents in the Conventional Water vs. Recycled Water study and all 1,342 respondents in the Bottled Water vs. Tap Water study. N denotes how respondents answered each question (i.e., 564 respondents said conventional water is healthier, 123 said recycled water is healthier, and 431 said they are equally healthy).

Effect of Bias and Treatment on WTP and WTA

There was a premium associated with conventional water and bottled water. Participants were WTP, on average, \$1.68 for a 3lb bag of conventional water clementines and \$0.64 for a 16oz bottle of water, but just \$0.87 for a 3lb bag of recycled water clementines and there was a WTA of -\$0.22 for a 16oz glass of tap water.

There was a significant difference across WTP/WTA treatments for each type of water: conventional water [$F(3, 1{,}116) = 354.97$, P-value < .01], recycled water [$F(3, 1{,}116) = 247.94$, P-value < .01], bottled water [$F(3, 1{,}338) = 260.85$, P-value < .01], and tap water [$F(3, 1{,}338) = 88.86$, P-value < .01]. Furthermore, pairwise comparisons between each treatment using T-tests with Bonferroni corrected P-values found a significant difference in means across all treatments for recycled water and tap water (P-value < .01), and all treatments but WTP Only compared to WTP/WTA Scale for conventional water (P value = 0.069) and bottled water (P-value = 0.274). The means for each treatment can be viewed in Figures 1 and 2.[7]

[7] See Appendix F for WTP/WTA summary statistics

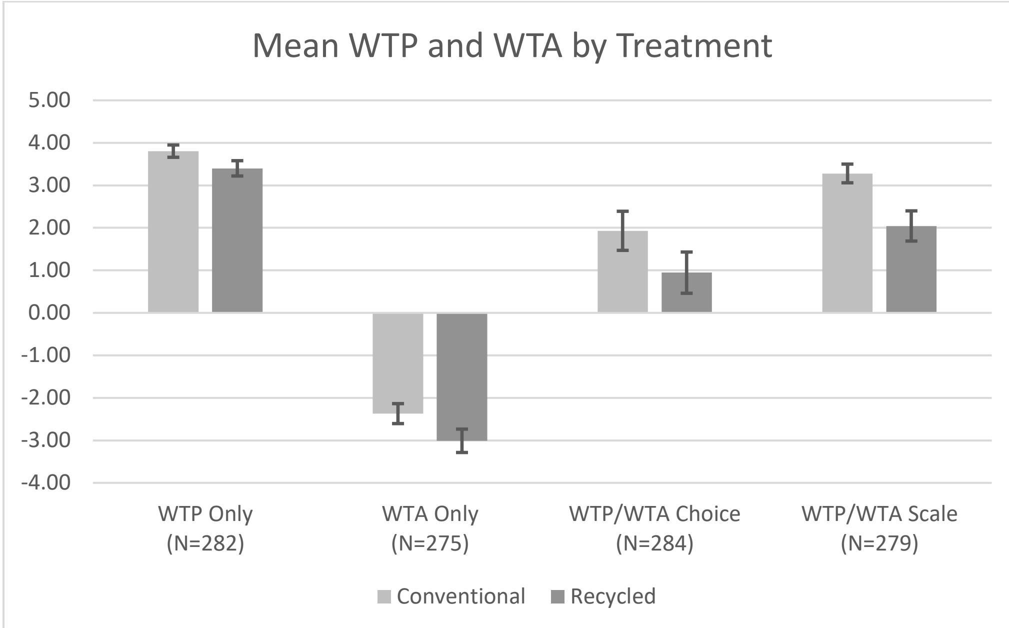

Figure 1 Means for Conventional Water and Recycled Water by Treatment with 95% Confidence Intervals

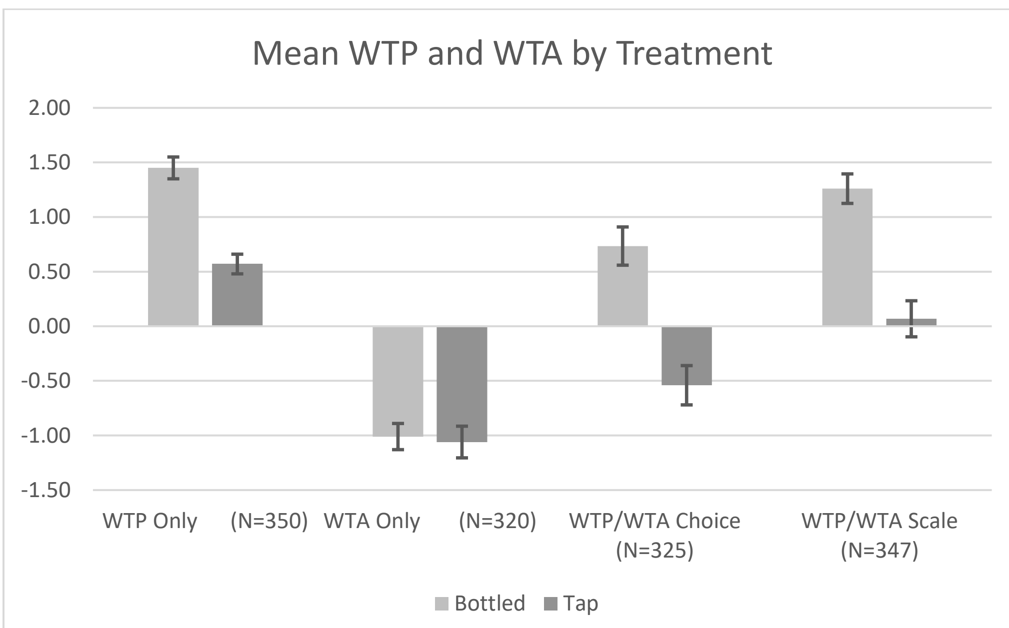

Figure 2 Means for Bottled Water and Tap Water by Treatment with 95% Confidence Intervals

The linear regression results in Table 2 highlight similar results. Treatment effects were found to be significant for each type of water, showing that WTP and WTA values were affected by elicitation method. Additionally, as each treatment coefficient was negative, there is evidence that WTP only was upwardly biased.

As for the effect of bias on WTP and WTA, implicit and explicit bias did not have a significant effect on conventional water. However, implicit and explicit bias both had significant negative effects on WTP and WTA for recycled water and tap water, and a significant positive effect on bottled water, reinforcing the aversion to recycled water and tap water. Similar to the attribute correlations, explicit bias had a larger effect than implicit bias for each type of water, both in terms of significance and magnitude, once again showing explicit bias is more predictive. Lastly, bias effects were largest towards recycled water and tap water, suggesting a negative bias affects price more than a positive bias.

The tobit censored regression models had similar results as the linear regression model. There were no changes in significance and just marginal changes in coefficients and standard errors. These model results can be viewed in Appendix G.

Table 2 Linear Regression Model: The Effects of Implicit and Explicit Bias on WTP and WTA

Variable	Conventional Water	Recycled Water	Bottled Water	Tap Water
Constant	3.784***	4.138***	1.330***	0.785***
	(0.183)	(0.209)	(0.068)	(0.072)
Implicit	-0.084	-0.424**	0.117*	-0.120*
	(0.156)	(0.178)	(0.065)	(0.069)
Explicit	0.199	-1.013***	0.271***	-0.515***
	(0.123)	(0.140)	(0.047)	(0.049)
WTP Only	(omitted)	(omitted)	(omitted)	(omitted)
WTA Only	-6.171***	-6.385***	-2.447***	-1.653***
	(0.210)	(0.239)	(0.068)	(0.101)
WTP/WTA Choice	-1.878***	-2.460***	-0.753*	-1.051***
	(0.209)	(0.237)	(0.095)	(0.101)
WTP/WTA Scale	-0.528**	-1.311***	-0.175**	-0.536***
	(0.209)	(0.238)	(0.093)	(0.099)
N	1,120	1,120	1,342	1,342
R^2	0.490	0.440	0.395	0.255

Note: Estimated coefficients from linear regression model. Standard errors are in parentheses. *, **, and *** denote significance level at 0.10, 0.05, and 0.01, respectively.

Chapter 5

CONCLUSIONS

Recent events have shown that water security and water quality are real issues (Welch 2018; Edmond 2019). Water-management practices such as increased usage of recycled water for irrigation can improve water security (Anderson 2003; Toze 2006; Chen et al. 2013), while shifting demand inward for bottled water is a consumer-driven practice that can improve water quality (Andrady 2011). Despite the benefits of using recycled water and the negative impact of bottled water, there has been a reluctance to adopt improved water-management practices. This study gives insight into the aversion consumers have towards recycled water and tap water.

We found significant implicit and explicit biases associated with recycled water and tap water. Although the implicit and explicit biases were significantly different for each type of water, recycled water had a larger implicit bias than explicit bias while tap water had a larger explicit bias. Additionally, recycled water and tap water were judged to be less healthy and less tasty than conventional water and bottled water, respectively. Furthermore, goods irrigated with recycled water had a lower WTP than goods irrigated with conventional water, consistent with findings in other studies (Li et al. 2018; Savchenko et al. 2018; Savchenko, Li, et al. 2019). Tap water also had a lower WTP than bottled water. The attribute preferences and WTP were impacted by bias, but explicit bias had larger correlations and effects in the linear regression and tobit regression models than implicit bias. These findings show that although there is an ingrained aversion to recycled water, possibly due to the horn effect, and an ingrained preference for bottled water, possibly due to the halo effect, explicit bias is still more predictive than those implicit cognitive biases. The fact that explicit bias had much larger indications of consumer preferences merits additional research needed for the practicality of studying implicit bias towards consumer goods.

Lastly, we found that elicitation method for WTP and WTA affect values, as all but two difference in means tests were significantly different. The difference in mean value for each treatment arises from respondents requiring compensation for certain goods due to personal reasons. As each treatment had a negative effect compared to the baseline WTP only questions, there is evidence that current WTP only studies may be overstating estimates. This may be especially important for measuring WTP values of more controversial goods, such as genetically engineered goods, as many consumers would likely require compensation to consume those goods. These results necessitate further research in this topic.

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Appendix A

DEMOGRAPHIC QUOTA

Table 3 Demographic quota compared to demographics for each test

Demographics	Quota Goal	Bottled vs. Tap	Conventional vs. Recycled
Age			
Under 18	0%	0.00%	0.27%
18-24	12.8%	12.74%	12.11%
25-34	17.7%	16.69%	16.83%
35-44	16.7%	16.77%	15.85%
45-54	17.7%	17.21%	18.08%
55-64	16.4%	17.36%	16.74%
65+	18.8%	19.23%	20.12%
Gender			
Female	50.8%	51.56%	51.61%
Male	49.2%	48.44%	48.39%
Income			
$0-<$25k	17.57%	17.36%	17.32%
$25K-<$50K	22.46%	23.55%	21.43%
$50K-<$75K	18.96%	18.41%	20.00%
$75K-<$100K	13.60%	14.38%	13.39%
$100K<$150K	15.15%	15.57%	15.00%
$150K<$200K	6.01%	5.37%	6.25%
$200K+	6.25%	5.37%	6.61%

Appendix B

SURVEY FLOW

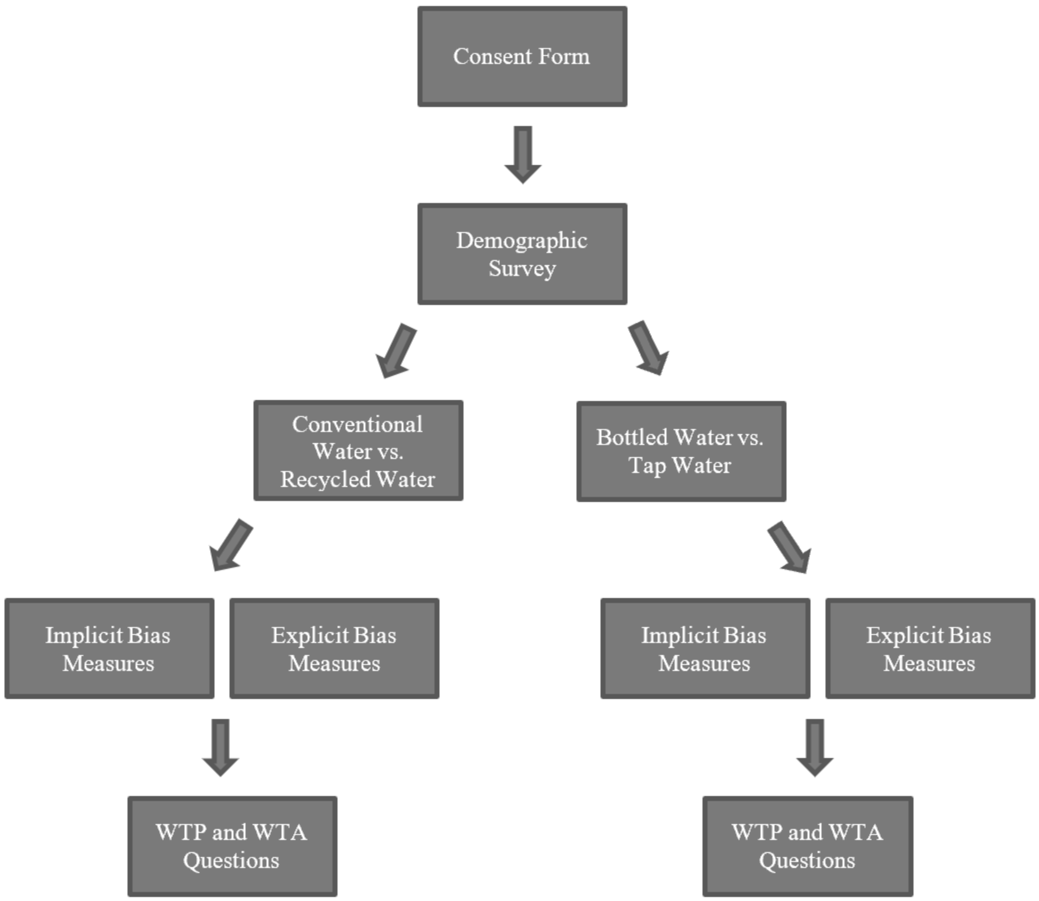

Figure 3 Graphic Representing the Survey Flow

Appendix C

IMPLICIT ASSOCIATION TEST

Table 4 IAT Format Example: Conventional Water vs. Recycled Water

Round	Number of Trials	Left side of screen "E"	Right side of screen "I"
1	20	Recycled	Conventional
2	20	Good	Bad
3	20	Recycled or Good	Conventional or Bad
4	40	Recycled or Good	Conventional or Bad
5	40	Bad	Good
6	20	Recycled or Bad	Conventional or Good
7	40	Recycled or Bad	Conventional or Good

Table 5 IAT Format Example: Bottled Water vs. Tap Water

Round	Number of Trials	Left side of screen "E"	Right side of screen "I"
1	20	Bottled	Tap
2	20	Good	Bad
3	20	Bottled or Good	Tap or Bad
4	40	Bottled or Good	Tap or Bad
5	40	Bad	Good
6	20	Bottled or Bad	Tap or Good
7	40	Bottled or Bad	Tap or Good

Table 6 Words used in Conventional Water vs. Recycled Water IAT

Category	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

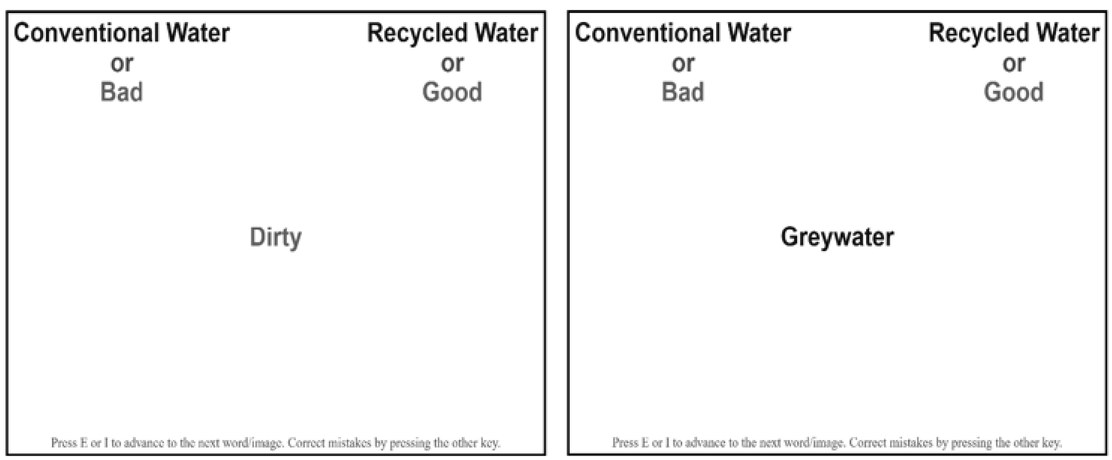

Figure 4 Example IAT Questions: Conventional Water vs. Recycle

Table 7 Words and images used in the Bottled Water vs. Tap Water IAT

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

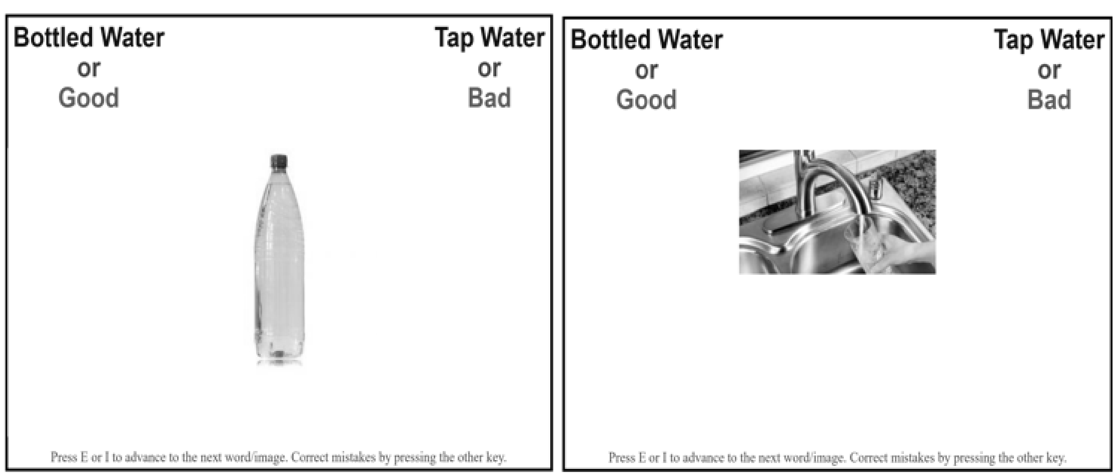

Figure 5 Example IAT Questions: Bottled Water vs. Tap Water

I

BIAS SUMMARY STATISTICS

Table 8 Conventional Water vs. Recycled Water Bias Summary Statistics

Variable	N	Mean	SD	Median	Min	Max	Std. Err.	95% CI
implicit	1,120	0.764	0.507	0.850	-1.136	1.713	0.015	[0.734, 0.794]
explicit	1,120	0.424	0.642	0.400	-2.000	2.000	0.019	[0.386, 0.461]

Table 9 Bottled Water vs. Tap Water Bias Summary Statistics

Variable	N	Mean	SD	Median	Min	Max	Std. Err.	95% CI
implicit	1,342	0.202	0.578	0.240	-1.157	1.575	0.016	[0.171, 0.233]
explicit	1,342	0.367	0.808	0.200	-2.000	2.000	0.022	[0.322, 0.409]

Table 10 Bias T-tests

	Conventional Water vs. Recycled Water		Bottled Water vs. Tap Water	
Variable	T	P-value	T	P-value
implicit bias ≠ 0	22.10	< .01	12.77	< .01
explicit bias ≠ 0	50.48	< .01	16.58	< .01
implicit bias ≠ explicit bias	17.03	< .01	-7.95	< .01

Appendix E

ATTRIBUTE PREFERENCES

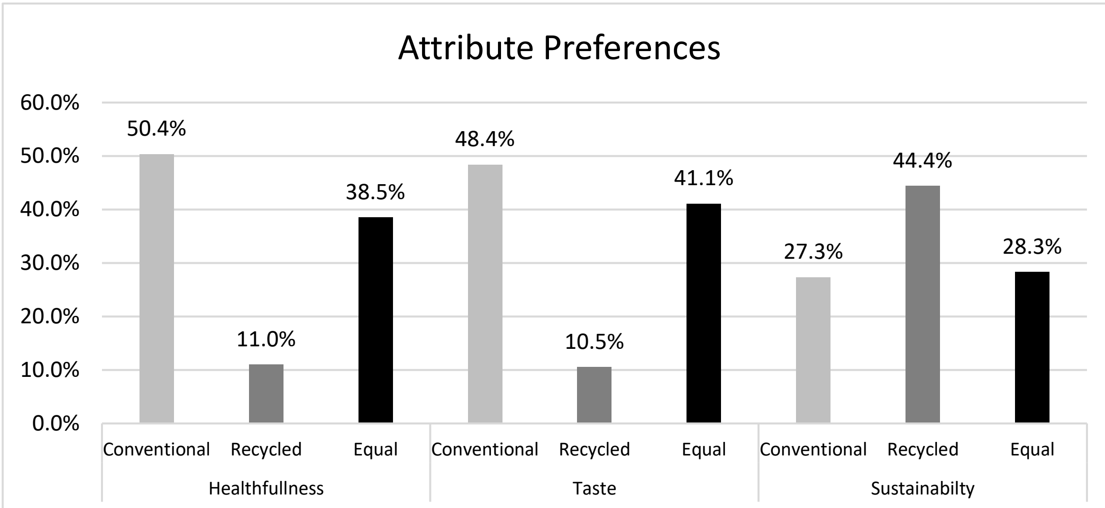

Figure 6 Attribute preference measures for Conventional Water and Recycled Water

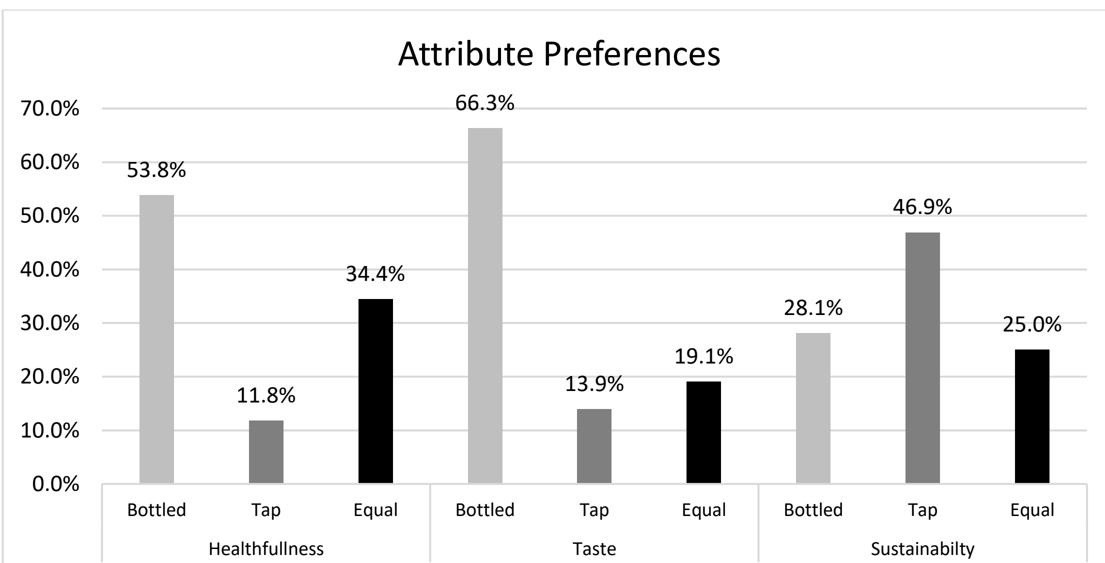

Figure 7 Attribute preference measures for Bottled Water and Tap Water

Appendix F

WILLINGNESS-TO-PAY AND WILLINGNESS-TO-ACCEPT SUMMARY STATISTICS

Table 11 Mean WTP and WTA by Treatment for Conventional Water

Variable	N	Mean	SD	Min	Max	95% CI
All treatments	1,120	1.68	3.45	-8	8	[1.48, 1.88]
WTP Only	282	3.81	1.27	0	8	[3.66, 3.95]
WTA Only	275	-2.37	1.97	-8	0	[-2.61, -2.14]
WTP/WTA Choice	284	1.93	3.92	-8	8	[1.47, 2.39]
WTP/WTA Scale	279	3.28	1.87	-8	8	[3.06, 3.50]

Table 12 Mean WTP and WTA by Treatment for Recycled Water

Variable	N	Mean	SD	Min	Max	95% CI
All treatments	1,120	0.87	3.76	-8	8	[0.65, 1.09]
WTP Only	282	3.40	1.50	0	8	[3.22, 3.58]
WTA Only	275	-3.01	2.30	-8	0	[-3.28, -2.73]
WTP/WTA Choice	284	0.95	4.16	-8	8	[0.46, 1.43]
WTP/WTA Scale	279	2.04	2.99	-8	8	[1.69, 2.40]

Table 13 Difference between WTP and WTA Elicitation Methods for Conventional Water and Recycled Water

	Conventional Water		Recycled Water	
Treatment	Diff.	P-value	Diff.	P-value
WTP Only | WTA Only	-6.18	< .01	-6.41	< .01
WTP Only | WTP/WTA Choice	1.88	< .01	2.45	< .01
WTP Only | WTP/WTA Scale	0.53	0.069	1.36	< .01
WTA Only | WTP/WTA Choice	-4.30	< .01	-3.95	< .01
WTA Only | WTP/WTA Scale	-5.65	< .01	-5.05	< .01
WTP/WTA Choice | WTP/WTA Scale	1.35	< .01	1.10	< .01

Table 14 Mean WTP and WTA by Treatment for Bottled Water

Variable	N	Mean	SD	Min	Max	95% CI
All treatments	1,342	0.64	1.58	-4	4	[0.56, 0.73]
WTP Only	350	1.45	0.92	0	4	[1.35, 1.55]
WTA Only	320	-1.01	1.07	-4	0	[-1.13, -0.89]
WTP/WTA Choice	325	0.73	1.63	-4	4	[0.56, 0.91]
WTP/WTA Scale	347	1.26	1.31	-4	4	[1.12, 1.39]

Table 15 Mean WTP and WTA by Treatment for Tap Water

Variable	N	Mean	SD	Min	Max	95% CI
All treatments	1,342	-0.22	1.51	-4	4	[-0.30, -0.13]
WTP Only	350	0.57	0.86	0	4	[0.48, 0.66]
WTA Only	320	-1.06	1.33	-4	0	[-1.20, -0.91]
WTP/WTA Choice	325	-0.54	1.66	-4	4	[-0.72, -0.36]
WTP/WTA Scale	347	0.07	1.55	-4	4	[-0.10, 0.23]

Table 16 Difference between WTP and WTA Elicitation Methods for Bottled Water and Tap Water

	Bottled Water		Tap Water	
Treatment	Diff.	P-value	Diff.	P-value
WTP Only | WTA Only	-2.46	< .01	-1.63	< .01
WTP Only | WTP/WTA Choice	0.72	< .01	1.11	< .01
WTP Only | WTP/WTA Scale	0.19	0.274	0.51	< .01
WTA Only | WTP/WTA Choice	-1.74	< .01	-0.52	< .01
WTA Only | WTP/WTA Scale	-2.27	< .01	-1.12	< .01
WTP/WTA Choice | WTP/WTA Scale	0.53	< .01	0.61	< .01

Appendix G

TOBIT MODEL

Table 17 Tobit Regression Model: The Effects of Implicit and Explicit Bias on WTP and WTA

Variable	Conventional Water	Recycled Water	Bottled Water	Tap Water
Constant	3.807***	4.168***	1.343***	0.801***
	(0.187)	(0.215)	(0.070)	(0.076)
Implicit	-0.105	-0.442**	0.116*	-0.116*
	(0.159)	(0.183)	(0.068)	(0.073)
Explicit	0.200	-1.040***	0.280***	-0.554***
	(0.125)	(0.144)	(0.048)	(0.052)
WTP Only	(omitted)	(omitted)	(omitted)	(omitted)
WTA Only	-6.187***	-6.452***	-2.476***	-1.705***
	(0.214)	(0.246)	(0.099)	(0.107)
WTP/WTA Choice	-1.882***	-2.489***	-0.766*	-1.08***
	(0.212)	(0.244)	(0.099)	(0.106)
WTP/WTA Scale	-0.526**	-1.314***	-0.177**	-0.549***
	(0.213)	(0.245)	(0.097)	(0.104)
N	1,120	1,120	1,342	1,342
Uncensored	1,096	1,083	1.286	1,266
Left-censored	12	30	21	64
Right-censored	12	7	35	12
Log-likelihood function	-2,605.699	-2,743.280	-2,226.685	-2,307.555

Note: Estimated coefficients from tobit censored regression model. Conventional water and recycled water were censored at -8 and 8, while bottled water and tap water were censored at -2 and 2. Standard errors are in parentheses. *, **, and *** denote significance level at 0.10, 0.05, and 0.01, respectively.

Appendix H

SURVEY QUESTIONS

Table 18 Demographic Survey Questions and Results by Study

Question	Answer Choices	Conventional Water vs. Recycled Water	Bottled Water vs. Tap Water
Please select your age range below:		N = 1123	N = 1342
	Under 18	0.27%	0.00%
	18-24	12.11%	12.74%
	25-34	16.83%	16.69%
	45-54	15.85%	16.77%
	55-64	18.08%	17.21%
	65+	16.74%	17.36%
What is the highest level of education you have received?		N = 1120	N = 1342
	Less than high school degree	1.43%	1.19%
	High school graduate (high school diploma or equivalent including GED)	15.80%	17.21%
	Some college but no degree	22.86%	23.85%
	Associate degree in college (2-year)	10.27%	12.30%
	Bachelor's degree in college (4-year)	29.29%	29.21%
	Master's degree	16.52%	12.97%
	Doctoral degree	2.05%	1.27%
	Professional degree (JD, MD)	1.79%	2.01%
What is your sex?		N = 1120	N = 1342
	Male	48.39%	48.44%
	Female	51.61%	51.56%
Please indicate the answer that includes your entire household income in (previous year) before taxes.		N = 1120	N = 1342
	Less than $25,000	17.32%	17.36%
	$25,000 to $50,000	21.43%	23.55%
	$50,000 to $75,000	20.00%	18.41%
	$75,000 to $100,000	13.39%	14.38%
	$100,000 to $150,000	15.00%	15.57%
	$150,000 to $200,000	6.25%	5.37%
	$200,000+	6.61%	5.37%

What is your 5-digit ZIP code			
Which of the following best describes the area you live in?		N = 1120	N = 1342
	Urban	29.46%	27.27%
	Suburban	50.09%	51.04%
	Rural	20.45%	21.68%
What is your employment status?		N = 1120	N = 1342
	Unemployed	8.57%	9.09%
	Part time	10.18%	10.21%
	Full time	44.11%	44.04%
	Student	6.43%	6.33%
	Retired	24.20%	23.25%
	Not currently seeking employment	6.52%	7.08%
Have you ever worked on a farm?		N = 1120	N = 1342
	Yes	23.57%	21.39%
	No	76.43%	78.61%
What is your race?		N = 1120	N = 1342
	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%
	Other	1.34%	1.34%
Generally speaking, do you usually think of yourself as a Republican, a Democrat, an Independent, or something else?		N = 1120	N = 1342
	Republican	34.91%	33.90%
	Democrat	34.46%	36.14%
	Independent	25.27%	23.70%
	Other:	0.54%	1.19%
	No preference	4.82%	5.07%
		N = 1120	N = 1342
	Very Liberal	12.23%	12.22%

In general, how would you describe your political views?	Liberal	18.21%	18.41%
	Moderate	32.14%	31.82%
	Conservative	20.71%	21.09%
	Very Conservative	12.95%	11.48%
	Don't Know	3.75%	4.99%

Table 19 Explicit Measures: Conventional Water vs. Recycled Water

Question	Answer Choices	Results
Please rate how much you like conventional water.	N = 1120	Mean = 7.615/10 SD = 2.136
	0	1.43%
	1	0.71%
	2	1.52%
	3	1.34%
	4	1.96%
	5	7.32%
	6	10.71%
	7	15.00%
	8	22.32%
	9	15.36%
	10	22.32%
Please rate how much you like recycled water.	N = 1120	Mean = 5.497/10 SD = 2.887
	0	6.96%
	1	4.82%
	2	6.52%
	3	6.96%
	4	8.04%
	5	14.91%
	6	12.50%
	7	11.25%
	8	10.71%
	9	8.39%
	100	8.93%
Have you ever drank recycled water?	N = 1120	
	Yes	30.09%
	No	25.63%

	I don’t know	44.29%
What percent of the food you eat is grown with conventional water or recycled water?	N = 1120 Conventional Water Recycled Water	 62.19% 37.81%
Which do you think is healthier	N = 1120 Conventional water Recycled water They are equally healthy	 50.36% 10.98% 38.48%
Which type of water would produce better tasting food?	N = 1120 Conventional water Recycled water They would taste the same N = 1120	 48.39% 10.54% 41.07%
Which do you think is more sustainable?	Conventional water Recycled water They are equally sustainable	27.32% 44.38% 28.30%

Table 20 Explicit Measures: Bottled Water vs. Tap Water

Question	Answer Choices	Results
Please rate how much you like bottled water.	N = 1342	Mean = 7.743/10 SD = 2.459
	0	2.31%
	1	1.19%
	2	1.64%
	3	3.28%
	4	2.68%
	5	4.77%
	6	6.93%
	7	11.48%
	8	18.33%
	9	17.06%
	10	30.33%
Please rate how much you like tap water.	N = 1342	Mean = 5.956/10 SD = 2.879

	0	5.14%
	1	4.84%
	2	6.11%
	3	5.96%
	4	6.56%
	5	9.46%
	6	12.74%
	7	14.98%
	8	13.26%
	9	9.69%
	100	11.25%
Do you know where the water in your house comes from?	N = 1342	
	Yes	70.94%
	No	29.06%
Do you drink more bottled water or tap water?	N = 1342	
	Bottled	48.44%
	Tap	36.36%
	I drink them equally	15.20%
What percent of the water you drink is bottled or tap water?	N = 1342	
	Bottled Water	54.01%
	Tap Water	45.99%
Which do you think is healthier	N = 1342	
	Bottled water	53.80%
	Tap water	11.77%
	They are equally healthy	34.43%
Which type of water would produce better tasting food?	N = 1342	
	Bottled water	66.32%
	Tap water	13.93%
	They are equally healthy	19.75%
Which do you think is more sustainable?	N = 1342	
	Bottled water	28.09%
	Tap water	46.87%
	They are equally healthy	25.04%

Appendix I

IRB APPROVAL LETTER

RESEARCH OFFICE

210 Hullihen Hall
University of Delaware
Newark, Delaware 19716-1551
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DATE:	March 15, 2019
TO:	Daniel Bass
FROM:	University of Delaware IRB
STUDY TITLE:	[1379608-1] Implicit Association Test: Recycled Water and Tap Water
SUBMISSION TYPE:	New Project
ACTION:	DETERMINATION OF EXEMPT STATUS
DECISION DATE:	March 15, 2019
REVIEW CATEGORY:	Exemption category # *(2)*

Thank you for your submission of New Project materials for this research study. The University of Delaware IRB has determined this project is EXEMPT FROM IRB REVIEW according to federal regulations.

We will put a copy of this correspondence on file in our office. Please remember to notify us if you make any substantial changes to the project.

If you have any questions, please contact Renee Stewart at (302) 831-2137 or stewartr@udel.edu. Please include your study title and reference number in all correspondence with this office.