Overcoming Psychological Resistance toward Using Recycled Water as a Solution to California's Climate Change Challenge[1]

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California's traditional hydrological system assumes a heavy, reliable snowpack and the timely release of surface water in the warmer months. However as a consequence of climate change and a prolonged drought, California must now consider alternative water supply sources such as recycled wastewater. But state officials fear that a proposal to expand direct or indirect potable use wastewater programs would trigger strong public resistance due to the 'yuck' factor, an instinctive aversion to many recycled wastewater uses. Here we use data from a representative sample of adult Californians (N=1500) to examine the relation between information and socio-demographic factors to the willingness to adopt recycled water in ten different applications. We find that direct consumption or skin contact with recycled water stirs the strongest resistance. We conducted a randomized experiment to test how respondents would react to learning that there is large, existing, indirect potable use program in Orange County and about the scientific reliability of purified wastewater. While both messages boost support for almost all uses of recycled water, respondents still resist drinking, bathing and cooking with it. Contrary to some previous findings, the response to both information cues generally does not appear to depend upon level of education.

California's water supply system is particularly vulnerable to climate change. While the state has experienced periodic droughts over its history, global warming presents a chronic challenge to a water supply system that depends on building up a heavy winter Sierra Nevada snowpack that can melt and provide fresh water during the dry months. The dual occurrence of multiyear drought and rising temperatures has resulted in a 2015 snowpack that is only 5% of the historical normal. A recent tree ring analysis concludes that this is anomalous within the context of the past 500 years.[1] Given the challenge of rising temperatures and smaller average snowpack, California will need to develop alternative means of water supply.

Public attitudes will ultimately determine the feasibility of different water infrastructure options the state faces in the near future.[2] California voters passed Proposition 1 in 2014 authorizing $7.12 billion in general obligation bonds for state water supply infrastructure projects, including water recycling and advanced water treatment technology. The public's attitude towards recycled wastewater has important implications for California's future infrastructure. If a majority of Californians cannot accept bodily contact with recycled wastewater, it will force local communities to deploy new, expensive "purple pipe" systems rather than replenishing aquifers that are pumped for potable use with recycled water.

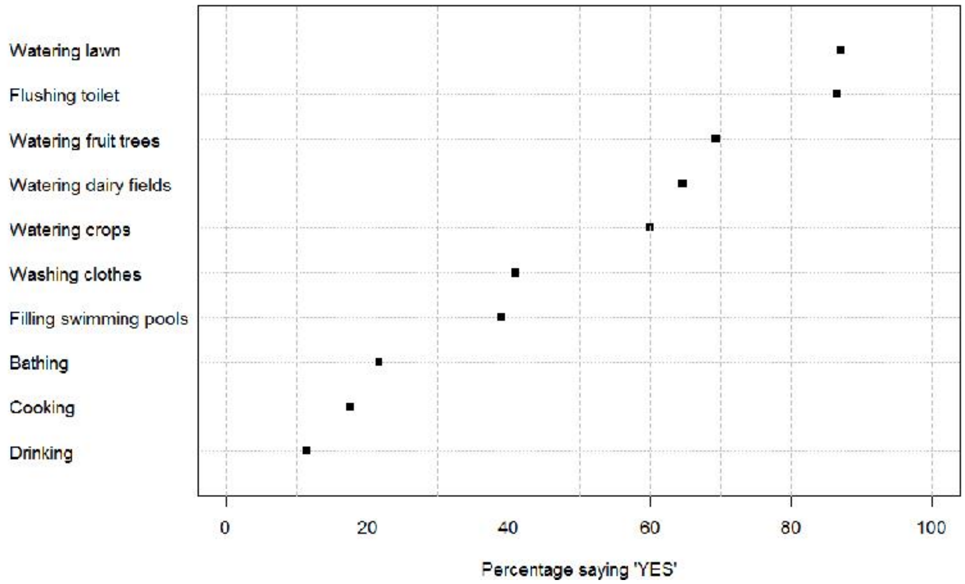
Previous research has documented a wide variation in public reaction to different possible recycled water uses. Information about recycled water characteristics[3], credibility of the information, perception of health risk,[4] level of public trust of the agency[5] that administers the program, awareness of water scarcity,[6] stakeholder communications,[7] consideration of costs[8] can affect the willingness to use recycled water. Education correlated positively with acceptance.[9] Those with higher education were found to be more receptive to scientific facts about the safety of recycled water.

The strongest resistance, however, is psychological in nature, particularly when political opponents highlight public fears.[10] The phrase "toilet to tap" invokes an image associated with revulsion combined with a fear that some pathogens might survive the cleansing process. Curiously, there is more suspicion about recycled wastewater than desalination.[11] This can cause many people to reject recycled water even if reputable scientists claim that it is purer than tap or bottled water.[12] The public's deep-rooted psychological resistance is often not evidence-based or derived from first-person unpleasant experience from exposure to contaminated wastewater.

Social communication seems to be more important with friends and relatives being the most influential in preventing people from drinking recycled water.[13]

Using a randomized experiment, we explore the extent to which such psychological resistance can be overcome by providing two types of knowledge: first that Orange county already has an indirect potable use program in operation, and second, the scientific claim that wastewater can be safely purified though a multi-stage process. As a baseline, we first determine the willingness of a control group to use recycled water across ten different applications without either information treatment. As expected, drinking, cooking and bathing—i.e. the three applications where recycled water is either directly digested or has skin contact--encounter the strongest resistance (Fig 1). Only 11% of respondents are willing to drink recycled water. About 40% of respondents are willing to use recycled to fill swimming pools or for washing laundry, two applications that mix recycled water with chemicals and detergents. There is strong support for using recycled water for crops, fields and trees, and almost unanimous support for using recycled water for crops, lawns, and toilet.

Figure 1. Willingness to use recycled water in ten applications



Note: Without receiving any information about recycled water, respondents in the control group were asked if they would use it in ten applications. The applications are ranked in descending in term of public acceptance. Direct consumption of recycled water, including drinking and cooking, are met with highest resistance.

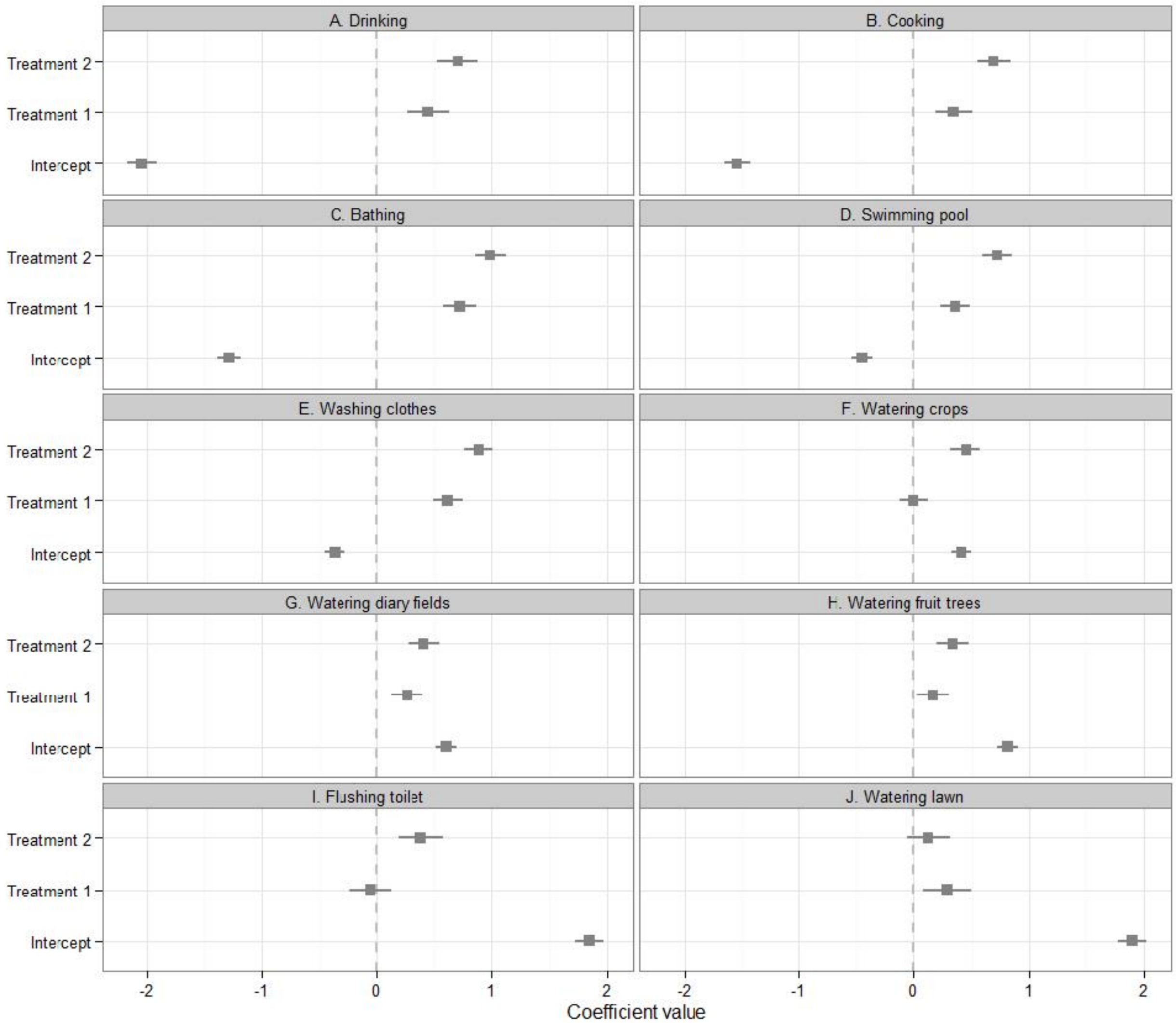
Across these ten different applications, three consistent patterns emerged. Males are generally more willing to use recycled water than females. Residents in the Central Valley, an agricultural area that has suffered severe drought and groundwater depletion, see a stronger urgency in putting recycled water to use, though they draw too the line at drinking and cooking. Self-identified Democrats are less resistant than Republicans or Independents (Supplementary Fig A1).

The disgust factor associated with the 'toilet to tap' seems to be partially offset by the reassurance of knowing that recycled water provides 70% of Orange County's water supply. The likelihood in Treatment 1 of using recycled water increased across all applications (Fig 2). It shifted the willingness to use recycled water for washing clothes and swimming pools to above

50%. It increased the willingness to drink recycled water by 6 from 11% to 17%, the willingness to cook with it from 18 to 23% and to bathe with it from 22 to 36% (Fig 3).

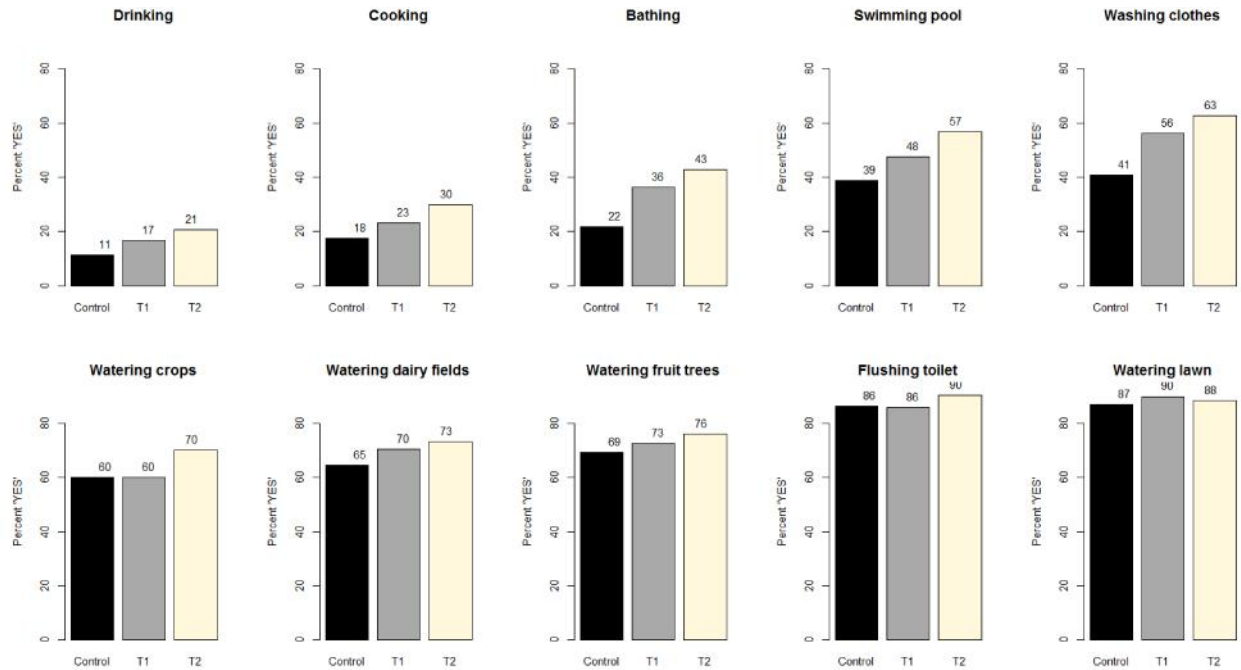
In treatment 2, we drop the “toilet to tap” description and provide additional information about the water purification process. This represents a likely upper bound of rational persuasion. Even so, treatment 2 only increases willingness to drink recycled water from 17% to 21%, to cook with it from 23 to 30% and to bathe with it from 36 to 43% (Fig 3). In short, adding scientific claims boosts support for using recycled water to some degree, but the public remains resistant to using water that involves ingestion or personal contact. At the same time, the prospects for recycling are quite high for a variety of uses that could be provided by a purple pipe and outdoor watering systems.

Figure 2. Treatment effects among control group, treatment group 1 and 2



Note: Logistic coefficients with 95% confidence intervals are presented. Control group received no information, treatment group 1 received a probe about ‘toilet to tap’ and a positive message, treatment group 2 received only positive message. Most of the coefficients are positive and statistically significant ($p \leq 0.05$). The latter group shows the biggest gain in public acceptance.

Figure 3. Group means of control, treatment group 1 (T1) and treatment group 2 (T2)



Note: Average treatment effects computed from Model 1 (Fig 2). The first bar represents support for an application among the control group, the second and third bar displays support in the Treatment 1 and 2. Treatment 2 has the strongest impact in applications that are the most resisted.

Finally we note that education does not seem to influence the control group's willingness to use recycled wastewater in the control group (Supplementary Fig A1). It also generally does not seem to alter the treatment effects (Supplementary Figure A3). Out of our ten applications, we find only one application (bathing) that has a noted educational effect. While this is at odds with some previous studies, we conjecture that this may be explained by the salience of California's drought. At the time of the survey, the Governor had declared a state of emergency, and California was aiming to reduce water consumption by 25%. We suspect that in less dire immediate circumstances, an appreciation of the need to find alternative water supplies given climate change might be greater among better educated people who follow the news regularly.

With a drought that directly affects the daily water usage of all Californians, there is a wider appreciation of the need to recycle water to replace dwindling surface and groundwater supplies.

In conclusion, we find that learning about existing potable use recycled wastewater programs and about the multistage scientific process of water purification can move the public towards greater acceptance of recycled wastewater. As others have concluded, a serious public outreach program is essential to winning public acceptance to recycled water.[14] But the psychological aversion to contact with and ingestion of recycled wastewater remains strong even when respondents are informed by our two experimental treatments. This suggests that there could be strong opposition to injecting recycled water into aquifers that are pumped for potable use. On the other hand, there is strong support for a purple pipe system that uses water for toilets, lawns, gardens and other outdoor functions. Our findings imply that as more communities adopt recycled water without harmful effects, the resistance to recycled water in other communities may break down over time. There is in effect a "reassurance" factor in knowing that other communities have used recycled water safely. This suggests that California might be able to build public confidence in recycled wastewater over time as its citizens see other communities have safely incorporated it into their water supply.

Methods

The Bill Lane Center for the American West and the Hoover Institution conducted an internet survey through Yougov in September 2015 with a representative sample of 1500 adult respondents in the state of California. Internet opt-in panel is found to produce estimates that are as accurate as a telephone survey.[15] Respondents were randomly assigned into three equal size groups. Respondents in the control group were asked, "would you be willing to use recycled wastewater for…" and were presented with ten items. The ten items include "drinking", "cooking", "bathing", "washing clothes", "toilet flushing", "filling swimming pools", "lawn watering", "watering grassy fields where dairy cows graze", "watering vegetable crops", "watering fruit trees".

Respondents in the Treatment Group 1 received a probe, "Orange County in Southern California currently has a toilet to tap wastewater recycling program for outdoor and indoor water use, including drinking and bathing. The Orange County Water District purifies wastewater and injects in into the local groundwater aquifer basin. The groundwater is then pumped back into the water system, providing 70% of Orange County's water supply."

Respondents in the Treatment Group 2 were shown, "Orange County in Southern California currently uses recycled wastewater for outdoor and indoor use, including drinking and bathing. The Orange County Water District puts wastewater through a multi-stage process that scientists claim removed all particles, chemicals, pharmaceuticals, bacteria, and viruses. The treated water is injected into the local groundwater aquifer basin. The groundwater is then pumped back into the water system, providing 70% of Orange County's water supply."

Both groups were given the same follow up question as respondents in the baseline group. The appearance of these ten items on the screen was randomized to ensure the ordering does not impact responses. Respondents were given three response categories, “yes”, “no” and “not sure”.

In our statistical analyses, we created a binary dependent variable (1 indicates “yes” and 0 otherwise). We also collected respondents’ socio-demographic characteristics. We conducted statistical tests to validate that treatment assignment was properly conducted and the background characteristics of respondents in our four groups were statistically indistinguishable (Supplementary Table A1). Random assignment into treatment conditions ensures that both the observed and unobserved characteristics of the respondents are independent from treatment received. Hence the treatment effect identified is attributable to the treatment condition received by the respondents and not caused by other factors.

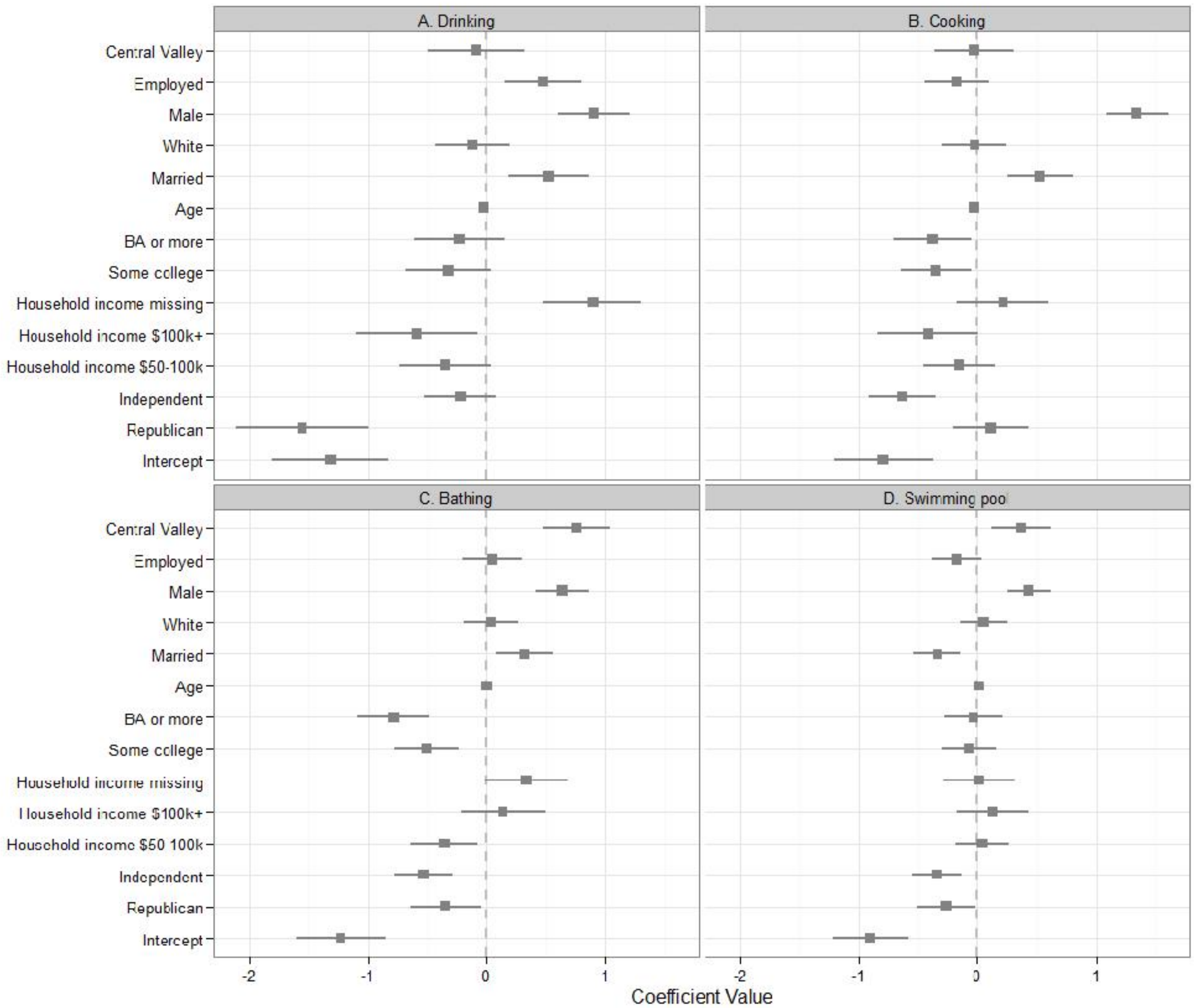
We ran logistic regression for each of the ten dependent variables in the baseline group to examine the correlation between demographic characteristics and their preferences (Supplementary Fig A1).

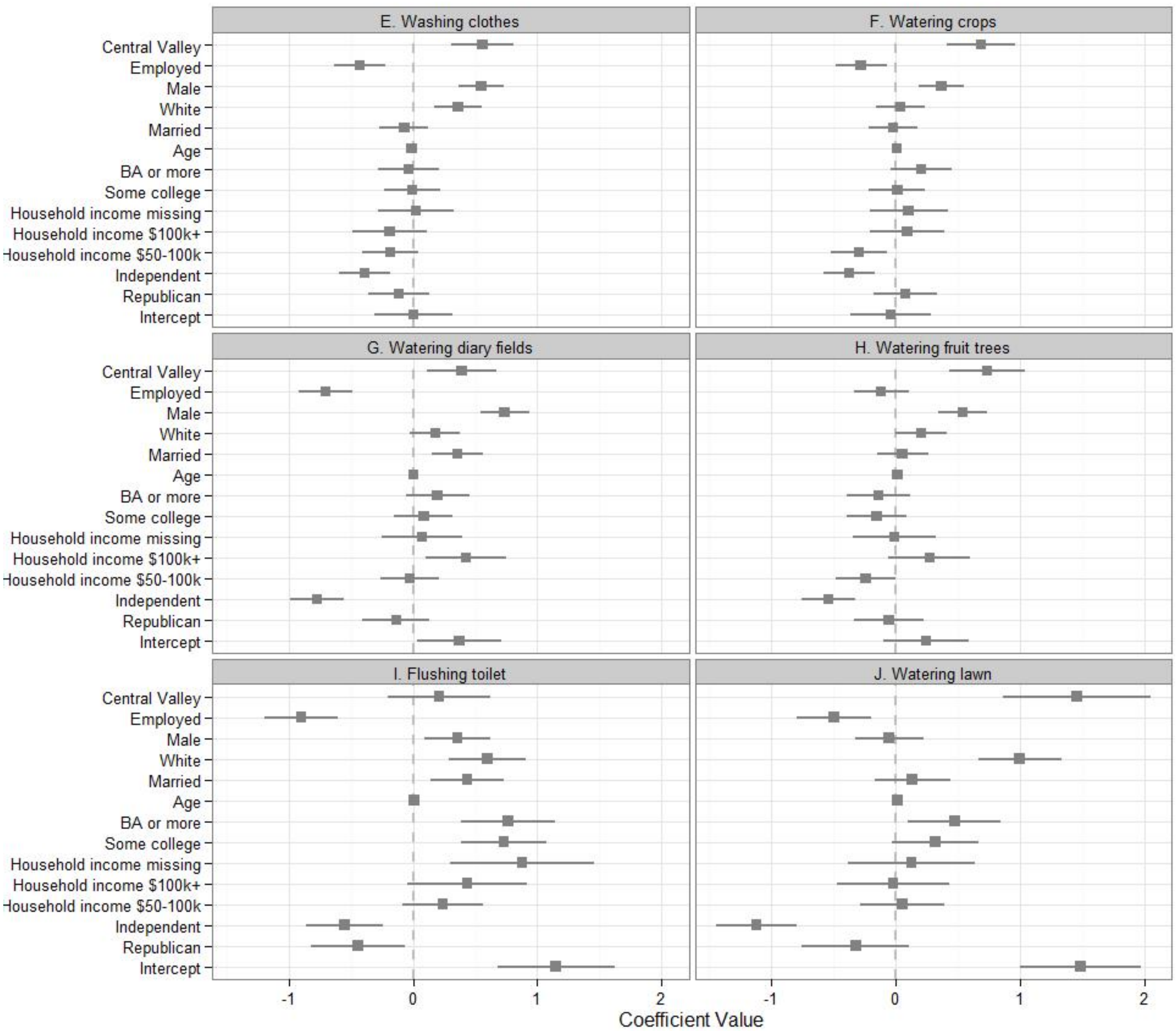
To estimate the treatment effect, we ran two different sets of logistic regression. The first set (Model 1), we used logistic regression and regressed each of the ten dependent variables on the treatment dummies ($\gamma = \alpha_0 + \alpha_1 Treatment1 + \alpha_2 Treatment2 + \varepsilon$).

The second set (Model 2) extends that with demographic covariates. We included the following covariates: self-reported partisanship, income, education, marital status, sex, employment status, race and region of residence. As respondents were randomly assigned into treatment conditions, their socio-demographic characteristics are uncorrelated with treatment assignment. Hence inclusion of the covariates does not change the substantive findings reported in Model 1 (Supplementary Fig A2 and Table A2).

Supplementary Information

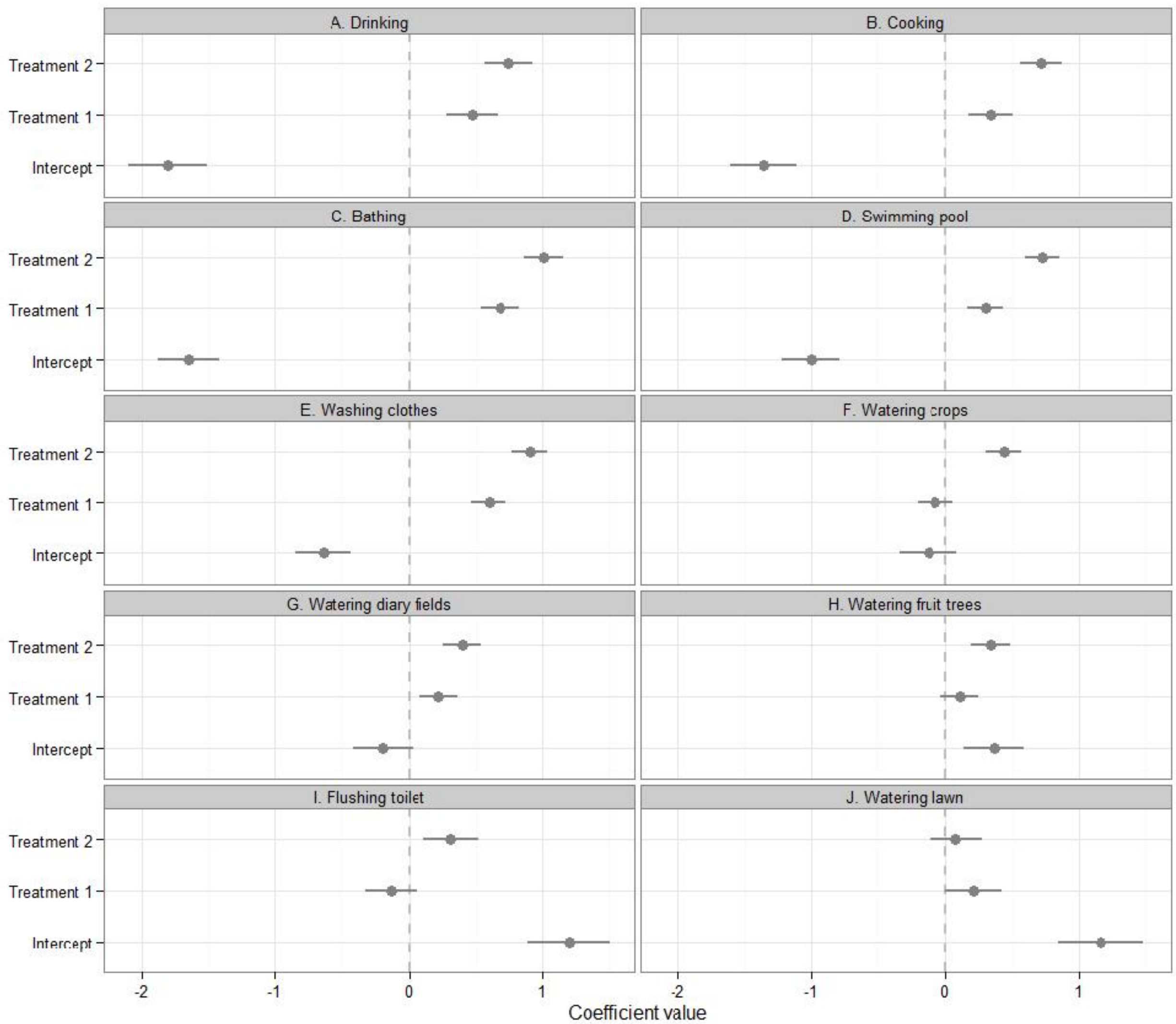
Figure A1. Relationship between socio-demographics and acceptance of recycled water in ten applications in baseline group





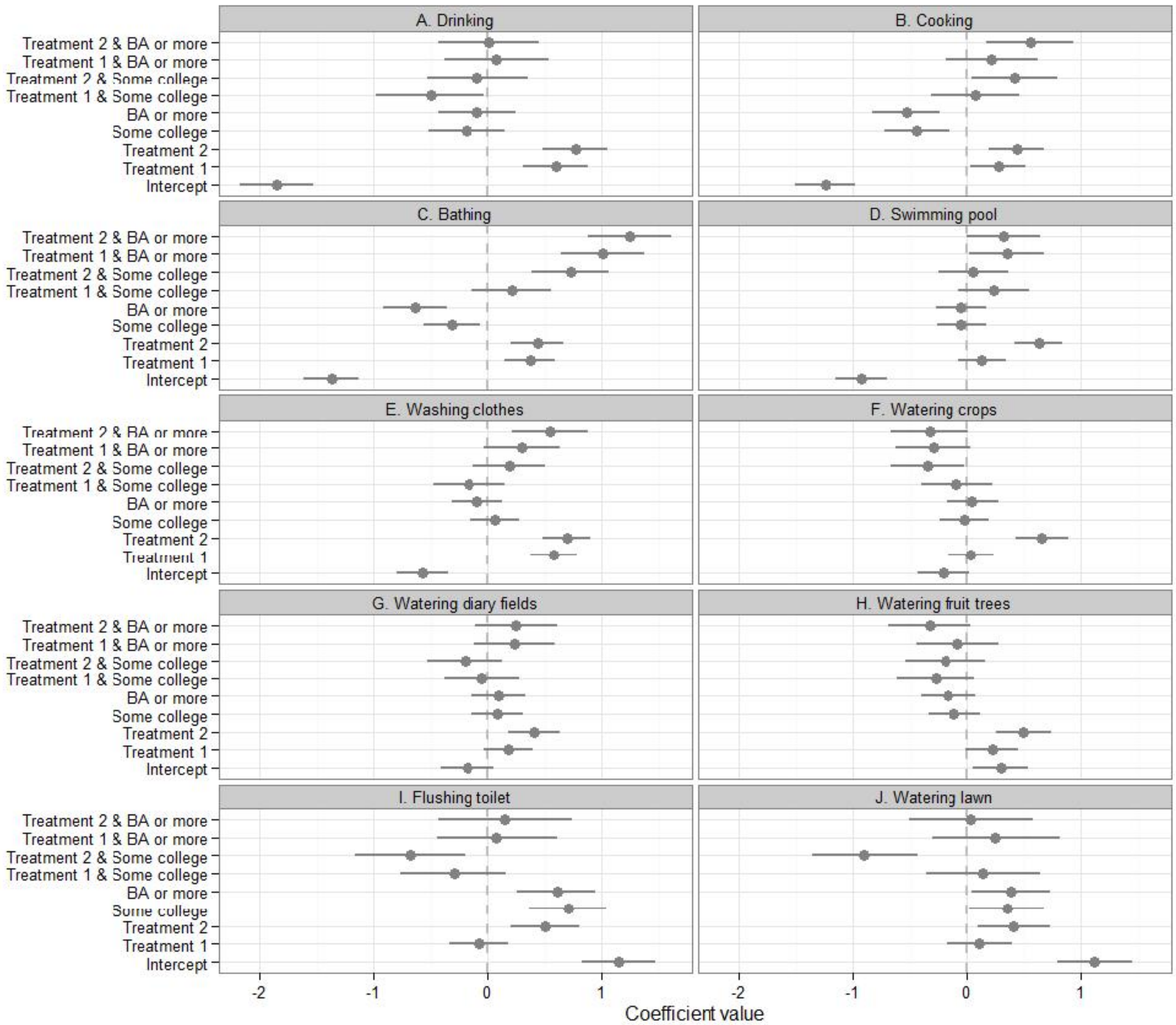
Note: Logistic coefficients with 95% confidence interval presented. Men tend to be less resistant than women in using recycled water. Central Valley residents tend to be more receptive than residents in other parts of the state, except for drinking and cooking. Party identification is also a strong predictor. Self-identified Democrats are more willing to use recycled water.

Figure A2. Estimating treatment effects with covariates



Note: Logistic regression coefficients with 95% confidence interval. Only coefficients for the treatment effects are shown. Results are consistent with that from the model without covariates (Fig 2).Full regression results reported in Supplementary Information Table A2.

Figure A3. Interaction effect between treatment conditions and respondents' educational level



Note: Logistic regression coefficients with 95% confidence interval. Only coefficients for the interaction effects are shown. Contrary to previous studies, we find that responses to treatment conditions are generally uncorrelated with respondents' educational attainment. The interaction terms are usually statistically insignificant at 0.05 level. The only exception is the case for using recycled water for bathing. Respondents who have at least some college education are more willing to accept its use when given the positive information cues.

Table A1. Randomization tests

Covariate	Chi-square test p-value
Party identification (1=Democrat; 2=Republican; 3=Independent)	0.67
Household Income (1=Less than $50k; 2= $50-100k; 3=over $100k; 4=income missing	0.44
Education (1=High school education or less; 2=Some college; 3=College or more)	0.14
Age (Age 19 – 88)	0.24
Married (1=Married; 0=otherwise)	0.25
Sex (1=Male; 0=female)	0.38
White (1=White; 0=otherwise)	0.72
Employment (1=Employed; 0=otherwise)	0.18
Region (1=Central Valley; 0=otherwise)	0.91

Note: Chi-square tests verify that treatment randomization was properly conducted as the observed covariates are independent from the treatment assignment.

Table A2. Estimating treatment effects with covariates (full logistic regression outputs)

	Drinking	Cooking	Bathing	Swimming Pool	Washing clothes	Watering crops	Watering dairy fields	Watering fruit trees	Flushing toilet	Watering lawn
Intercept	-1.805***	-1.359***	-1.650***	-1.005***	-0.640**	-0.125	-0.195	0.369	1.201***	1.166***
	(0.294)	(0.250)	(0.233)	(0.211)	(0.210)	(0.214)	(0.222)	(0.228)	(0.311)	(0.316)
Treatment 1	0.477*	0.343*	0.685***	0.302*	0.600***	-0.074	0.222	0.109	-0.134	0.215
	(0.192)	(0.163)	(0.146)	(0.131)	(0.131)	(0.133)	(0.141)	(0.144)	(0.193)	(0.209)
Treatment 2	0.749***	0.718***	1.009***	0.728***	0.907***	0.441**	0.399**	0.336*	0.315	0.080
	(0.182)	(0.154)	(0.142)	(0.129)	(0.131)	(0.136)	(0.141)	(0.144)	(0.206)	(0.198)
Republican	-0.724**	-0.196	-0.080	-0.061	-0.203	-0.022	-0.189	-0.119	-1.080***	-0.533*
	(0.229)	(0.176)	(0.158)	(0.148)	(0.149)	(0.155)	(0.163)	(0.166)	(0.226)	(0.233)
Independent	-0.099	-0.237	-0.323*	-0.252*	-0.294*	-0.133	-0.303*	-0.155	-0.574**	-0.383*
	(0.160)	(0.143)	(0.131)	(0.121)	(0.121)	(0.125)	(0.131)	(0.134)	(0.197)	(0.192)
Household income $50-100k	-0.249	-0.201	-0.391**	-0.324*	-0.313*	-0.381**	-0.003	-0.228	-0.085	-0.123
	(0.193)	(0.165)	(0.150)	(0.138)	(0.139)	(0.141)	(0.148)	(0.150)	(0.199)	(0.207)
Household income $100k+	-0.365	-0.309	-0.387*	-0.283	-0.426*	0.022	0.190	0.205	0.668*	0.351
	(0.247)	(0.213)	(0.191)	(0.177)	(0.179)	(0.187)	(0.200)	(0.203)	(0.337)	(0.316)
Household income missing	-0.071	0.042	-0.138	-0.259	-0.291	-0.143	-0.122	-0.108	0.250	-0.101
	(0.232)	(0.196)	(0.181)	(0.171)	(0.172)	(0.177)	(0.181)	(0.188)	(0.267)	(0.258)
Some college	-0.379*	-0.267	0.006	0.038	0.063	-0.155	-0.003	-0.253	0.381*	0.058
	(0.185)	(0.155)	(0.141)	(0.130)	(0.131)	(0.135)	(0.139)	(0.145)	(0.193)	(0.195)
BA or more	-0.078	-0.254	0.149	0.152	0.162	-0.142	0.229	-0.293	0.651**	0.452
	(0.198)	(0.174)	(0.157)	(0.146)	(0.148)	(0.153)	(0.162)	(0.163)	(0.245)	(0.244)
Age	-0.015**	-0.009*	0.002	0.011**	0.004	0.007*	0.008*	0.007*	0.016**	0.018**
	(0.005)	(0.004)	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.005)	(0.006)
Married	0.179	0.115	0.075	0.073	0.192	0.069	0.370**	0.100	0.328	0.313
	(0.165)	(0.140)	(0.126)	(0.116)	(0.118)	(0.121)	(0.127)	(0.129)	(0.184)	(0.188)
White	0.164	0.402**	0.187	0.242*	0.191	0.439***	0.314*	0.340**	0.521**	0.741***

	(0.158)	(0.135)	(0.122)	(0.114)	(0.115)	(0.119)	(0.125)	(0.128)	(0.185)	(0.195)
Male	1.080***	0.801***	0.727***	0.333**	0.528***	0.551***	0.596***	0.566***	-0.028	-0.186
	(0.160)	(0.132)	(0.119)	(0.110)	(0.111)	(0.115)	(0.121)	(0.124)	(0.169)	(0.173)
Employed	0.330*	0.013	0.178	-0.001	-0.053	0.027	-0.239	-0.091	-0.379*	-0.510**
	(0.163)	(0.144)	(0.132)	(0.124)	(0.125)	(0.128)	(0.134)	(0.137)	(0.184)	(0.185)
Central Valley	-0.290	-0.359*	0.053	0.065	-0.147	0.104	0.367*	0.111	-0.129	0.468
	(0.209)	(0.181)	(0.155)	(0.145)	(0.146)	(0.151)	(0.165)	(0.164)	(0.211)	(0.250)
Log-likelihood	-606.709	-784.400	-912.409	-1024.431	-1005.564	-966.914	-901.256	-862.794	-513.100	-489.513
AIC	1245.418	1600.799	1856.818	2080.861	2043.127	1965.828	1834.512	1757.589	1058.201	1011.026
BIC	1330.311	1685.692	1941.710	2165.754	2128.020	2050.721	1919.405	1842.481	1143.094	1095.919
N	1488	1488	1488	1488	1488	1488	1488	1488	1488	1488

Note: Logistic regression results. Survey weight applied. $*p\leq0.05$; $**p\leq0.01$; $***p\leq0.001$

[1] Belmecheri, S., Babst, F., Wahl, E., Stahle, D. and Trouet,V. Multi-century evaluation of Sierra Nevada snowpack. *Nature Climate Change* **6**, 2-3 (2015).
[2] Marks, J. Taking the public seriously: the case of potable and non potable reuse. *Desalination* **187**, 137-147 (2006).
[3] Hurlimann, A. C., & McKay, J. What attributes of recycled water make it fit for residential purposes? The Mawson Lakes experience. *Desalination* **187**, 167-177 (2006).
[4] Nancarrow, B. E., Leviston, Z. & Tucker, D. I. Measuring the predictors of communities' behavioural decisions for potable reuse of wastewater. *Water Science and Technology* **60**, 3199 (2009).
[5] Hurlimann, A, Hemphill,E., McKay, J. & Geursen, G. Establishing components of community satisfaction with recycled water use through a structural equation model. *Journal of Environmental Management* **88**, 1221-1232 (2008).
[6] Dolnicar, S., & Hurlimann, A. Drinking water from alternative water sources: differences in beliefs, social norms and factors of perceived behavioural control across eight Australian locations. Water Science Technology **60**, 1433-1444 (2009).
[7] Khan, S. J., & Gerrard, L. E. Stakeholder communications for successful water reuse operations. *Desalination* **187**, 191-202 (2006).
[8] Anderson, J. M. Integrating recycled water into urban water supply solutions. *Desalination* **187**, 1-9 (2006).
[9] Rock, C., Solop, F. & Gerrity, D. Survey of statewide public perceptions regarding water reuse in Arizona. *Journal of Water Supply: Research and Technology—AQUA* **61**, 506-517 (2012).
[10] Po, M., Nancarrow, B. & Kaercher, J. Literature review of factors influencing public perceptions of water reuse. CSIRO Land and Water Technical Report **54 (**2003).
[11] Dolnicar, S. & Schäfer, A. Desalinated versus recycled water: public perceptions and profiles of the accepters. *Journal of Environmental Management* **90**, 888-900 (2009).
[12] Rozin, P., Haddad, B., Nemeroff, C. & Slovic, P. Psychological aspects of the rejection of recycled water: contamination, purification and disgust. *Judgment and Decision Making* **10**, 50-63 (2015).
[13] Dolnicar, S., & Hurlimann, A. Drinking water from alternative water sources: differences in beliefs, social norms and factors of perceived behavioural control across eight Australian locations. Water Science Technology **60**, 1433-1444 (2009).
[14] Bridgeman, J. Public perception towards water recycling in California. Water and Environment Journal **18**, 150-154 (2004).
[15] Ansolabehere S. & Schaffner, B. Does survey mode still matter? Findings from a 2010 multi-mode comparison. Political Analysis **22**, 285-303 (2004).