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Psychological and social factors associated with wastewater reuse emotional discomfort

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ABSTRACT

Wastewater reuse (WWR) technology has improved greatly in recent decades and may be an important solution to global water challenges. Nevertheless, several psychological and social barriers to widespread adoption still exist. Negative emotional reactions to WWR, known as the "yuck factor," have been identified as central to public acceptance. The present study used a large, context-neutral, web-based, U.S. sample (N = 207), to examine factors underlying these negative emotions, here measured as discomfort felt toward WWR. We used a more nuanced measure to isolate what aspects of disgust sensitivity predict discomfort and then explored this relationship in the context of other individual and psychological differences. Being female, having less education, and being particularly sensitive to pathogen-related disgust stimuli, all were factors that were significantly and independently associated with reported discomfort. Mediation analysis showed that women felt greater discomfort because of higher levels of pathogen disgust sensitivity.

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1. Introduction

Wastewater reuse (WWR) is a key strategy for the conservation of finite water resources. It is increasingly important to consider and implement such approaches, given the mounting pressure on fresh water reserves from population growth, pollution, and climate change (see review in Jury & Vaux, 2007; Vorosmarty et al., 2010). Despite the advantages for the environment and public health, WWR is often only adopted in dire circumstances and as a last resort. Public acceptance has been found to be critical to the success of plans to reuse water (e.g., Chen, Ngo, & Guo, 2012; Rodriguez et al., 2009). In several cases, public opposition alone has overturned municipal plans even for indirect potable reuse (Lejano & Leong, 2012). A significant amount of research has addressed the issue of public acceptance through a variety of methods – extensive reviews of which can be found in Mankad and Tapsuwan (2011) and Po, Kaercher, and Nancarrow (2003). Within this body of work both qualitative and empirical studies have found that negative emotional reactions are important for acceptance at the individual and societal level (Marks, Cromar, Fallowfield, & Oemcke, 2003; Nancarrow, Leviston, Po, Porter, & Tucker, 2008). For example, public campaigns opposing WWR plans are often framed in terms of disgust (e.g., the "toilet to tap" framing in Los Angeles and Australia's "Citizens Against Drinking Sewage") (Hurlimann & Dolnicar, 2010; Lejano & Leong, 2012). Despite the acknowledged role that negative affect plays in determining attitudes toward WWR, the exact nature of these emotional reactions and how they relate to other psychological and individual differences is not well understood.

The broad concept of negative emotional reactions to water reuse is known in the literature as the "yuck factor" and has been identified in a number of studies. In a large-scale survey, structural equation modeling was used to identify important explanatory variables in determining intended behaviors around water reuse (including trust, subjective social norms, perceived control, and emotional aversion). In that study an individual's emotional reaction toward water reuse was one of the strongest predictors (Nancarrow et al., 2008; Nancarrow, Leviston, & Tucker, 2009; Po

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et al., 2005). The degree to which an association between WWR and disgust is made apparent on a semantic level also impacts acceptance. For example, the description "recycled water" elicits more acceptance than "treated waste water" (Menegakia, Mellonb, Vrentzoua, Koumakisa, & Tsagarakisc, 2009), and "purified water" is preferred to "recycled water" (Leovy, 1997). Some have argued that a focus on the "yuck factor" in the literature may be counterproductive as it ignores cultural strategies for increasing acceptance (Russell & Lux, 2009). However, others such as Mankad (2012) argue for the importance of better understanding aversive emotional reactions to decisions about decentralized water technology, such as WWR. Mankad also notes the role that psychological research can play in determining the mechanism of such emotions in order to further strategies for communication and broader public acceptance.

This approach is supported by research demonstrating the important role of emotions in decision making more broadly (see review in Weber & Johnson, 2009). Further, anticipated emotions have been found to be important to a variety of ecological behaviors ranging from choices about public transportation (Carrus, Passafaro, & Bonnes, 2008), views about climate change (Ferguson & Branscombe, 2010), and decisions about recycling (Smith, Haugtvedt, & Petty, 1994). Theoretical models of decision-making have been used to explore choices about other water-related environmental decisions such as conservation behaviors (Corral-Verdugo, Carrus, Bonnes, Moser, & Sinha, 2008). Some factors in these models, such as an individual's beliefs and attitudes, may be related to emotion (Seyranian, Sinatra, & Polikoff, 2014) and positive emotional reactions to communication strategies about water conservation have been related to the effectiveness of those strategies (Marandu, Moeti, & Haika, 2010). Often the anticipated emotions found in the relation to environmental behaviors take the form of anticipated regret or pride at the idea of violating or conforming to existing environmental and social norms. For a relatively more controversial environmental issue such as water recycling, anticipated emotions may be more complex and thus a more nuance understanding of what underlies them may be even more important for gaining insight into public attitudes and decisions.

1.1. Emotion and decision-making

Relative to cognitive processes, which are comparatively slower and more deliberative, affective or "emotional" processes are fast and automatic, making them particularly important in the face of complex tasks that require rapid responses (Kahneman, 2003). Emotions act to focus attention, to motivate both cognitive and behavioral reactions, to provide information about the situation and potential consequences of actions, and to allow for easier evaluation of complex situations (Weber & Johnson, 2009). How emotion specifically impacts any particular decision will vary based on which emotion is elicited (Lerner & Keltner, 2000), whether the emotion is "immediate" (i.e., occurring at the moment of decision making) or "anticipated" (i.e., what one expects to feel about potential future consequences of a decision) (Mellers, 2001; Zeelenberg, van Dijk, & Manstead, 1998), and whether the emotion is perceived as being directly relevant to the situation or incidental (Lerner, Small, & Loewenstein, 2004). In particular, anticipated emotions, can direct and prioritize cognitive processes (Armony, Servan-Schreiber, Cohen, & Ledoux, 1997), impact behavioral intention and goal formation (Baumgartner, Pieters, & Bagozzi, 2008), and act to form heuristics for decision making (Baumgartner et al., 2008; Zeelenberg, Nelissen, Breugelmans, & Pieters, 2008).

Emotions are generally categorized as having either a positive or a negative valence, and can be characterized by the intensity (representing the degree of arousal) with which they are experienced. Specific emotions have been theorized to map onto two broad behavioral patterns, including approach or avoidance tendencies (Elster, 1998; Higgins, 1997). Considering specific emotions that fall within these overarching classifications, research has demonstrated that even emotions of the same valence can lead to significantly different patterns of attitudes, perceptions, and behavior. For example, sadness and disgust, two negative emotions, motivate opposing strategies in economic buying/selling scenarios. Sadness triggers behaviors that will increase one's holdings such as increased buying activities and lowered willingness to sell. In contrast, disgust prompts behaviors consistent with "purging" – less willingness to buy/acquire new things and increased willingness to sell (Lerner et al., 2004).

Disgust, the emotion most likely underlying the negative affective reactions to water reuse, could pose a unique challenge to WWR adoption due to the natural function this basic emotion performs (Haidt, Mccauley, & Rozin, 1994; Tybur, Lieberman, & Griskevicius, 2009). Researchers have found that there are three different "types" of disgust: disgust toward substances harboring disease-causing organisms (pathogen disgust); moral disgust toward inappropriate sexual partners or acts (sexual disgust); and disgust toward socio-moral violations (moral disgust). These different disgust systems are distinct both behaviorally and biologically (Borg, Lieberman, & Kiehl, 2008; Tybur, Bryan, Lieberman, Hooper, & Merriman, 2011). Although the assumption could be made that pathogen disgust underlies negative reactions to WWR, the exact nature of how these different disgust domains are related to WWR has not yet been examined in the literature. Gaining a greater understanding of the specific facet of disgust most strongly associated with affective responses, as well as how this factor may relate with other individual differences linked with WWR acceptance/refusal could inform how WWR campaigns tailor their messages to the public. The 'yuck factor' may be more easily overcome if messaging focuses on the most relevant aspects of disgust and if that messaging is targeted at the sectors of the public most discomforted by water reuse.

1.2. Other factors important to WWR acceptance

Another question that has not been answered in the extant literature, is whether the "yuck" factor (i.e., disgust) explains any variance in WWR acceptance above and beyond other demographic, experiential, and ideological variables. For example, past research has indicated that women, the elderly, and those with less education tend to view risks associated with WWR as greater than other demographic groups, though this finding is not entirely consistent across the literature (Mankad & Tapsuwan, 2011; Po et al., 2003; Robinson, Robinson, & Hawkins, 2005). Drinking tap water (as opposed to filtered or bottled water) was important for predicting a stated intention to drink recycled water but not for an intention to vote for recycled water scheme (Gibson & Burton, 2013). Current or future water shortage has also been found to be a factor in determining people's willingness to use recycled water, with acceptance being shown to correlate with water scarcity and experiences of water restrictions (Bakopoulou & Kungolos, 2009; Bakopoulou, Polyzos, & Kungolos, 2010; Dolnicar, Hurlimann, & Grun, 2011). Ideological variables implicated in WWR acceptance include moral beliefs about the fairness of a water reuse plan (Nancarrow et al., 2009; Wilson & Pfaff, 2008) or the religious purity of the practice (Alhumoud & Madzikanda, 2010; but see Wilson & Pfaff, 2008 for a study finding no religious objection).

A related consideration is the manner in which the predictors of WWR acceptance might relate to one another. For example, research within social psychology has demonstrated that disgust

sensitivity and political conservatism are positively correlated (Inbar, Pizarro, Iyer, & Haidt, 2011). Disgust intuitions can shape moral views (Haidt, 2001). Because elicitors of disgust can be moralized (see DeScioli & Kurzban, 2009; Haidt, 2001), WWR technologies might also be opposed on normative grounds (Nancarrow et al., 2008). Indeed, according to the *Moral Foundations Theory*, one basic moral foundation, purity/sanctity, "is based on the emotion of disgust in response to biological contaminants (e.g., feces or rotten food), as well as to various social contaminants like spiritual corruption, or the inability to control one's base impulses" (Koleva, Graham, Iyer, Ditto, & Haidt, 2012, p. 185). To the extent that views regarding WWR activate disgust, they may also trigger normative views about such practices. The relationship between morality and disgust in context of WWR is not satisfactorily understood at this time.

1.3. Study overview and specific aims

The overarching aim of the present study was to further our understanding of negative emotional reactions toward water reuse, here operationalized as anticipated discomfort at the idea of using recycled water for a high-contact purpose such as drinking. Given the role that emotions play in decision making as reviewed above, we selected anticipated discomfort (i.e., "How distressed would you be to drink a glass of water, which has been scientifically treated, but was originally wastewater from showers and toilets?") as an important indicator of negative emotional aversion to WWR. 'Distress' is a general term used to refer to feelings of emotional discomfort in response to negative affect. Given the human tendency to avoid objects and situations that create displeasure (Elster, 1998; Higgins, 1997), measuring discomfort in relation to WWR may inform studies with respect to identifying barriers against widespread public acceptance. Aim 1 was to use a more nuanced measure of disgust sensitivity to isolate what specific facets of disgust are associated with emotional discomfort elicited by an anticipated interaction with reused wastewater. Our second aim was to examine the relationship between disgust and water reuse discomfort, within the context of other demographic, experiential, and ideological variables previously linked with WWR refusal. Importantly, and in contrast to the extant literature, we consider all of these variables within one model as simultaneous predictors of discomfort, to determine if disgust would explain any unique variance. A final aim was to examine three hypothesized mediation models to further clarify the relationship between disgust, individual difference factors, and water reuse discomfort. Specifically, we examine the connection between gender, education, and past exposure to water reuse, and water reuse discomfort as mediated by disgust.

2. Materials and methods

2.1. Participants

A sample of United States (U.S.) residents ($N = 218$), aged 18–68 years ($M = 34.12$, $SD = 11.41$), was recruited from an online participant pool (Amazon's Mechanical Turk, see below). Demographic characteristics of the sample are summarized in Table 1, along with comparison statistics of the general population from the 2010 U.S. Census. The questionnaires included in the current report were part of a larger survey, which was estimated to take between 40 and 60 min to complete. Initial data screening revealed that some individuals ($n = 11$) did not spend a sufficient amount of time (<30 min) answering the questions; we therefore excluded those individuals, resulting in a final sample of 207 participants.

Table 1
Demographic characteristics of the sample.

	N[a]	Percent	U.S. 2010 census statistics
Gender			
Female	109	53.20%	50.80%
Male	96	46.80%	49.20%
Age			
18–34	110	55.70%	21.30%
35–54	69	35.60%	18.10%
55–64	14	7.20%	11.60%
65+	1	0.50%	12.90%
Race			
White	164	80.00%	64.20%
Black	19	9.30%	12.20%
Hispanic	4	2.00%	16.10%
Asian	10	4.90%	4.70%
Other	8	3.90%	3.00%
Education			
Less than high school	5	2.40%	14.60%
High school degree	44	21.50%	28.60%
Some college	57	27.80%	21.00%
College degree	65	31.70%	25.30%
Advanced degree	34	16.60%	10.50%
Yearly income			
$0–20,000	25	12.40%	17.80%
$20K–40,000	66	32.70%	20.30%
$40K–60,000	46	22.80%	21.40%
$60K–80,000	23	11.40%	10.30%
$80K–100,000	16	7.90%	8.30%
Above $100,000	26	12.90%	21.90%

[a] Due to missing data the total N does not always add up to 207 for each variable.

2.2. Procedure

Mechanical Turk is a website that serves as a resource for marketing research and scientific investigations to recruit a large and diverse population of individuals willing to complete tasks in return for a small fee (Paolacci, Chandler, & Ipeirotis, 2010). Comparative analyses have demonstrated that Mechanical Turk provides as reliable data as that obtained by more traditional data collection methods (e.g., lab experiments, other internet studies). For example, test-retest reliability coefficients of various measures are within acceptable limits, and similar to those collected via paper and pencil questionnaires. One of the strongest benefits to using the Mechanical Turk system is that samples are more diverse than those included in investigations that recruit via e-mails or web pages, as well as college student samples (Buhrmester, Kwang, & Gosling, 2011).

The experiment was advertised on the Mechanical Turk website as an investigation of general decision making processes. The eligibility criteria consisted of non-minor status, English fluency, and U.S. residency. U.S. residency was used as a filter on the Mechanical Turk website. Residency was confirmed by the website, which has access to participants' addresses as they are required for compensation purposes. Interested and eligible parties were provided with a web link to an online data collection website, where they completed a battery of questionnaires. Upon completion of the survey, participants were directed to a separate webpage that provided more detailed information about the purpose of the study.

2.3. Measures

Participants first responded to a single item question measuring their anticipated *discomfort* in response to drinking certified safe recycled water ("How distressed would you be to drink a glass of water, which has been scientifically treated, but was originally wastewater from showers and toilets?"). Participants responded using a 5-point Likert scale from 1 (not at all) to 5 (extremely),

which captured their level of emotional discomfort in response to the outlined scenario. 'Distress' is a term routinely used to reflect negative affective response (Veit & Ware, 1983), and meets acceptability standards outlined for the use of single-item measures (Fuchs & Diamantopoulos, 2009) in business, social psychology, and medical research.

Demographic variables were collected to both characterize the sample and to be entered as predictor variables in the regression analysis. *Gender* (male = 0, female = 1), and *race/ethnicity* (census categories) were collected as categorical variables. Participants entered number values for the following variables: *age* (years), *income* (dollars earned annually), and *education* (total years of education, where 12 indicated high school graduation).

Information on prior exposure to WWR was measured by the following questions: (1; *Exposure-information*) "Had you heard about certified safe recycled waste water before participating in this study?", and (2; *Exposure-consumption*) "Have you ever knowingly drunk certified safe recycled waste water?" Participants responded either "yes" or "no" to these questions. Subjects also indicated their weekly drinking water use in *percentages amongst bottled*, *tap*, and *filtered tap* water.

Participants also completed the *Moral Foundations Questionnaire* (MFQ; Graham, Haidt, & Nosek, 2009), which is a 20-item self-report measure designed to evaluate the five belief foundations that individuals take into account when evaluating the degree to which something is moral. These moral pillars include *harm/care* (whether someone was harmed), *fairness/reciprocity* (whether everyone was treated equally), *ingroup/loyalty* (whether the good of the group was taken into account), *authority/respect* (whether authority was respected), and *purity/sanctity* (whether the situation violated purity). The first 10 items asked individuals to rate the extent to which they take the stated factors into consideration in judging whether something is right or wrong (e.g., "whether or not some people were treated differently than others"), and were measured on a 6-point Likert scale ranging from 0 (not at all relevant) to 5 (extremely relevant). The next 10 items inquired about the extent to which participants agree with statements concerning their values (e.g., "respect for authority is something that all children need to learn"). These items were also rated on a 6-point Likert scale ranging from 0 (strongly disagree) to 5 (strongly agree). Subscale scores represent the mean across items in each category.

Participants also provided information on their political ideology on social issues (*social ideology*), and their political ideology on economic issues (*economic ideology*). Each of these three variables was rated using a 7-point Likert scale ranging from 0 (very conservative) to 6 (very liberal).

Participants then completed the *Three Domain Disgust Scale* (Tybur et al., 2009), which consists of 21 items that measure the three domains of disgust sensitivity, including *pathogen, sexual and moral disgust* (e.g., pathogen disgust item: "accidentally touching a person's bloody cut"). Items were rated on a 7-point Likert scale ranging from 0 (not at all disgusting) to 6 (extremely disgusting). Subscale scores were computed by averaging ratings on each question of the respective subscale. The total score was computed by averaging all responses.

2.4. Analytic approach

Analyses were conducted using the SPSS 16.0 statistical software programs. A two-tailed significance level of 0.05 was chosen a priori for all analyses. Bivariate correlations (for continuous variables) and a t-test (for the categorical variable "gender") were used to identify factors associated with water reuse discomfort at a zero-order level. Simultaneous regression was used to examine the relationship between water reuse discomfort and all three subscales of disgust sensitivity simultaneously. Hierarchical, simultaneous regression was then used to explore predictors of water reuse discomfort that had correlated at a zero-order level: step 1 included demographic variables (gender and education), step 2 included exposure and water usage practices, step 3 include moral and political ideological factors, and finally step 4 included disgust sensitivity predicting water reuse discomfort in a stepwise fashion. Age, percentage of tap water used, economic ideology, and exposure-consumption were not associated with WWR discomfort and therefore were not included in this regression model. The only predictor not included in the complete model that was significantly associated with discomfort was percentage of filtered tap water used because it was redundant with percentage of bottled water used. Finally, regression equations, along with the PRODCLIN program (Tofighi & MacKinnon, 2011) were used to explore the three hypothesized mediation models. PRODCLIN assesses the product of the unstandardized path coefficients divided by the pooled standard error of the path coefficients ($\alpha\beta/\sigma_{\alpha\beta}$). A confidence interval is generated, whereby the inclusion of zero between the upper and lower limits suggests the absence of a statistically significant mediation effect. This method provides greater power for testing mediation, and is therefore recommended over more traditional approaches (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002).

3. Results

Descriptive statistics of all variables and associations between each factor and water reuse discomfort are presented in Table 2.

3.1. Disgust sensitivity subscales and water reuse discomfort

When all three disgust sensitivity subscales were entered simultaneously as predictors of water reuse discomfort, only pathogen ($\beta = 0.322$, $t(206) = 4.133$, $p < .001$) and sexual disgust ($\beta = 1.68$, $t(206) = 2.167$, $p < .05$) remained significant. Pathogen and sexual disgust were therefore selected as the disgust factors to include in the larger regression model described below.

Table 2
Pearson correlations, means, and standard deviations between water reuse discomfort and primary variables of interest.

	Water reuse discomfort	Mean (SD) or %
Discomfort	–	3.37 (1.39)
Gender (mean difference reported here rather than Pearson correlation)	−0.68**	53.20% female
Education	−0.14*	14.82 (2.37)
Age	−0.01	34.13 (11.41)
Exposure: heard of recycled water	−0.21**	31.7% yes
Exposure: has consumed recycled water	−0.06	6.3% yes
% bottled water/week	0.22**	32.04 (37.34)
% tap water/week	−0.08	40.69 (39.07)
% filtered tap water/week	−0.15*	28.10 (36.92)
MFQ harm/care	0.12*	3.82 (0.78)
MFQ fairness/reciprocity	0.20**	3.81 (0.88)
MFQ ingroup/loyalty	0.33**	2.90 (0.94)
MFQ authority/respect	0.32**	2.61 (0.99)
MFQ purity/sanctity	0.38**	2.56 (1.13)
Social ideology	−0.20**	3.51 (1.04)
Economic ideology	0.04	2.99 (1.01)
TDDS pathogen disgust	0.39**	24.52 (8.57)
TDDS sexual disgust	0.33**	16.73 (10.99)
TDDS moral disgust	0.04	22.43 (11.50)

*$p < .05$; **$p < .01$.

3.2. Stepwise analysis of factors associated with water reuse discomfort

Table 3 provides a summary of the full model regression analysis; only those variables that were significantly associated with discomfort at the zero-order level were included in the larger regression model. Demographic predictors were included in Step 1 of the regression analysis. Gender and years of education were entered simultaneously and each predicted unique variance in discomfort. Female gender predicted greater levels of water reuse discomfort ($\beta = 0.26$, $t(202) = 3.835$, $p < .001$) while more years of education predicted lower levels of water reuse discomfort ($\beta = -0.16$, $t(202) = -2.308$, $p < .05$).

Exposure and water practice variables were included in Step 2 of the regression analysis. Having heard of recycled water ("exposure-information") and percentage of bottled water usage each predicted unique variance in discomfort. Exposure-information predicted lower levels of water reuse discomfort ($\beta = -0.16$, $t(200) = -2.453$, $p < .05$) while high percentage per week usage of bottled water predicted greater levels of water reuse discomfort ($\beta = 0.16$, $t(200) = -2.282$, $p < .05$). At this step, gender remained a significant predictor ($p < .001$), while education only marginally ($p = .08$) predicted discomfort.

All five moral foundations were entered simultaneously in Step 3 of the regression analysis, along with the social ideology variable. Only MFQ purity/sanctity "moral purity" and MFQ fairness/reciprocity "moral fairness" subscales predicted unique variance. Placing an emphasis on moral purity ($\beta = 0.23$, $t(194) = 2.649$, $p < .01$) or moral fairness ($\beta = 0.16$, $t(194) = 2.048$, $p < .05$) predicted greater levels of water reuse discomfort. At this step, gender ($p < .05$) and education ($p < .05$) remained significant predictors of discomfort, while exposure-information ($p = .07$) and percent bottled water usage ($p = .05$) were on-significant trends.

In the final step of the regression analysis, TDDS pathogen and sexual disgust sensitivity were entered. After controlling for all other variables in the model, only pathogen disgust sensitivity remained significant. Specifically, greater pathogen disgust sensitivity predicted greater water reuse discomfort ($\beta = 0.17$, $t(192) = 2.152$, $p < .03$). At this step only gender ($p < .01$) and education ($p < .05$) remained significant. Exposure-information was trending towards significance ($p = .08$).

Table 3
Stepwise regression model predicting water reuse discomfort.

Step Predictor variable	F	ΔR^2	Unstandardized coefficients B (SE)	Standardized coefficients B	t
Step 1	9.45**	0.09**			
Gender			0.71 (0.19)	0.26	3.84**
Education			−0.09 (0.04)	−0.16	−2.31*
Step 2	8.37**	0.06**			
Gender			0.66 (0.18)	0.24	3.66**
Education			−0.07 (0.04)	−0.12	−1.76
Exposure			−0.48 (0.20)	−0.16	−2.45*
% bottled water/week			0.01 (0.00)	0.16	2.28*
Step 3	8.15**	0.15**			
Gender			0.58 (0.17)	0.21	3.36**
Education			−0.08 (0.04)	−0.13	−2.11*
Exposure			−0.34 (0.19)	−0.11	−1.82
% bottled/week			0.01 (0.00)	0.12	1.97
MFQ harm/care			−0.17 (0.15)	−0.10	−1.16
MFQ fairness/ reciprocity			0.25 (0.12)	0.16	2.05*
MFQ ingroup/loyalty			0.17 (0.14)	0.11	1.18
MFQ authority/respect			0.12 (0.13)	0.08	0.90
MFQ purity/sanctity			0.27 (0.10)	0.23	2.65*
Social ideology			0.02 (0.09)	0.02	0.22
Step 4	7.48**	0.02*			
Gender			0.51 (0.19)	0.19	2.75*
Education			−0.08 (0.04)	−0.13	−2.09*
Exposure			−0.33 (0.18)	−0.11	−1.79
% bottled water/week			0.004 (0.002)	0.10	1.54
MFQ harm/care			−0.14 (0.14)	−0.08	−0.96
MFQ fairness/ reciprocity			0.19 (0.13)	0.12	1.50
MFQ ingroup/loyalty			0.15 (0.14)	0.10	1.08
MFQ authority/respect			0.12 (0.13)	0.09	0.96
MFQ purity/sanctity			0.18 (0.11)	0.15	1.64
Social ideology			0.01 (0.09)	0.01	0.15
TDDS pathogen disgust			0.03 (0.01)	0.17	2.15*
TDDS sexual disgust			0.00 (0.01)	0.02	0.17

*$p < .05$; **$p < .01$.

3.3. Mediation models

First we assessed whether pathogen disgust might partially explain the noted relationship between gender and discomfort. Beta values from a series of regression analyses for this model are presented in Fig. 1. Gender was significantly associated with discomfort ($r_{pb} = -0.25$, $p < .001$, with men reporting less discomfort). As predicted, the path between the mediator (pathogen disgust sensitivity) and the outcome variable (discomfort) was also significant, even after controlling for gender. Finally, results from the PRODCLIN analysis revealed that pathogen disgust was indeed a significant mediator of discomfort. The program generated lower and upper 95% confidence limits of 0.029 and 0.327 for an estimated indirect effect of 0.17 (SE = 0.08).

A different pattern of results emerged when we examined a hypothesized model wherein pathogen disgust partially mediated the association between education and discomfort. Beta values from a series of regression analyses for this model are presented in Fig. 2. Education was significantly and negatively associated with discomfort. When controlling for education, the relationship between the mediator (pathogen disgust sensitivity) and the outcome variable (discomfort) was also significant. The PRODCLIN analysis revealed that pathogen disgust sensitivity was not a significant mediator of discomfort in this model. The program generated lower and upper 95% confidence limits of −0.33 and 0.32 for an estimated indirect effect of −0.01 (SE = 0.16).

Finally, we tested a third model, wherein pathogen disgust mediated the relationship between exposure-information and discomfort. As shown in Fig. 3, exposure-information was significantly associated with discomfort and the relationship between disgust and discomfort again remains significant when controlling for exposure. The PRODCLIN analysis revealed that pathogen disgust sensitivity was not a significant mediator of discomfort in this model. The program generated lower and upper 95% confidence limits of −0.30 and 0.02 for an estimated indirect effect of −0.13 (SE = 0.08).

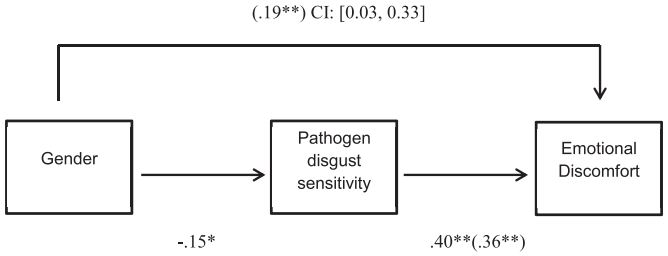

Fig. 1. Mediation model for associations between gender and discomfort as mediated by pathogen disgust sensitivity. Values on paths are path coefficients (standardized βs). Path coefficients outside parentheses are zero-order correlations. The confidence intervals (CI) were derived from the Prodclin mediation analysis statistic (Tofighi & MacKinnon, 2011).

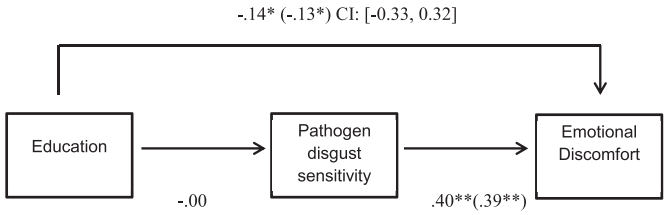

Fig. 2. Mediation model for associations between education and discomfort as mediated by pathogen disgust sensitivity. Values on paths are path coefficients (standardized βs). Path coefficients outside parentheses are zero-order correlations. The confidence intervals (CI) were derived from the Prodclin mediation analysis statistic (Tofighi & MacKinnon, 2011).

4. Discussion

Despite the prominence of the "yuck factor" in the water reuse literature and the acknowledged importance of emotion for decision making in general, previous research has not considered which individual or psychological differences might uniquely underlie negative emotional reactions to WWR. Our findings help move the literature toward a more fine-grained conceptualization of the "yuck factor" as an important predictor of negative reactions toward water reuse. Specifically, our results emphasize the important role of evolved, affective pathogen disgust sensitivity in accounting for discomfort related to WWR. Additionally, other important ideological and demographic characteristics were shown to independently relate to the strength of these feelings of discomfort. In particular, women, those with less education, and, to a lesser extent, those unfamiliar with WWR all reported greater WWR discomfort, when controlling for all other factors. Finally, our mediation models indicated that only the relationship between gender and WWR discomfort was mediated by pathogen disgust sensitivity, indicating that women felt more discomfort with water reuse because they are more sensitive to pathogen disgust.

We relied here on reported "distress" as a measure of negative emotional reactions to or "discomfort" with WWR rather than using reports of "acceptance". Distress is a nonspecific term that captures a variety of negative feelings ranging from discomfort to anxiety. Emotion research has repeatedly demonstrated that negative affect provides motivation to avoid its source. As such, negative affect may be a stronger indicator of future behavior (i.e., acceptance of WWR) than specific attitudes an individual may have regarding a given topic. Yet, considering the "yuck factor" as a negatively valenced emotional response gives an incomplete picture. Emotion research has emphasized that even different emotional domains of the same valence (i.e., negative emotions such as disgust and anger) may trigger different cognitive and behavioral responses. More recent research has suggested that the specific domain of disgust can be triggered by a variety of stimuli. Our findings indicate that the broad conceptualization of the "yuck factor" as negative emotion can be focused on disgust, particularly pathogen disgust. Concern over pathogens can be seen as the main driver of the emotional reactions to water reuse, which would then determine acceptance of water reuse along with other higher-order cognitive factors (such as cost, social demand, trust in provider, water scarcity, etc.).

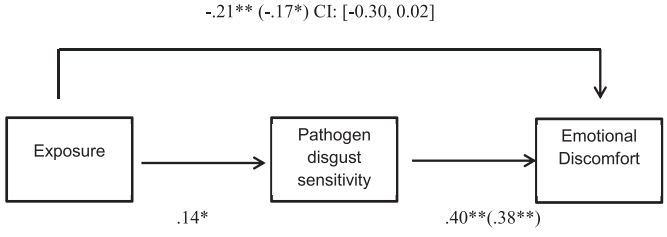

Fig. 3. Mediation model for associations between exposure and discomfort as mediated by pathogen disgust sensitivity. Values on paths are path coefficients (standardized βs). Path coefficients outside parentheses are zero-order correlations. The confidence intervals (CI) were derived from the Prodclin mediation analysis statistic (Tofighi & MacKinnon, 2011).

Other factors were related to water reuse discomfort at a zero-order level and at specific stages of our regression models. The demographic factors gender and education continued to predict unique variance when controlling for all other variables. This indicates that women and those with less education may experience greater levels of discomfort associated with water reuse over and above concern about pathogens. These groups could be particularly important interpretive communities when reaching out to the public about water reuse plans. Having heard of recycled water (exposure-information), also correlated negatively with discomfort and was trending toward significance in our final model. It is possible that those who had heard of WWR previously have a particular interest in water issues not captured by our survey which caused them to seek out information on water reuse in the past and which could also relate to lower reported discomfort. Only 12 individuals endorsed having knowingly consumed certified safe recycled water (exposure-consumption), compared to 182 who had never done so. Those who had never knowingly consumed recycled water reported greater discomfort, but the difference between groups was not significant. This may be attributable to low power and/or to limited definitions of wastewater reuse. The exact role of exposure is not clear from these results alone and future research may tease apart exactly what aspects of exposure and experience are most important. Differences in moral ideology were also predictive of discomfort levels at earlier steps in our model. An emphasis on the moral pillar "purity/sanctity" was associated with water reuse discomfort, though this relationship was only weakly trending toward significance in the final model. This pillar tends to be emphasized by those with conservative political ideological leanings. It has been hypothesized to relate to evolved disgust reactions (Rozin, Haidt, & McCauley, 2000) and is associated with values and rules that serve important social cohesion functions such as helping to identify members of one's cultural "in-group" (Graham et al., 2009). Interestingly, the moral pillar of "fairness/reciprocity," which tends to be emphasized by those with liberal political ideological leanings, was also positively correlated with discomfort. Other studies on WWR have reported that public acceptance of water recycling schemes has been damaged by the perception that plans were unfair to socioeconomically vulnerable communities (Nancarrow et al., 2009; Wilson & Pfaff, 2008).

The conclusions and results should be interpreted in light of several limitations. The sample was slightly biased toward female (53.2%), young, white, highly educated, and lower-income individuals. Some of these characteristics are associated with greater perception of risk and thus could potentially impact the results, as risk attitudes were not specifically addressed in this study. Future research may be needed to replicate the findings with a larger, more representative sample. The inclusion of our questionnaire in a larger survey necessitated a relatively long time to complete the overall task. Some studies have found that motivation to answer questions accurately decreases with survey length, though steps can be taken to reduce this effect (Galesic & Bosnjak, 2009; Herzog & Bachman, 1981). We attempted to reduce the impact of length on results by excluding participants that had completed the survey in exceptionally short period of time, by making the anticipated length of the survey clear prior to the beginning of the questionnaire, and by placing the dependent variable at the beginning of the

survey. The dependent variable directly addresses the emotional reactions toward WWR, but does not speak to whether a person would be willing or able to overcome this discomfort in order to drink recycled water. As such, these findings are applicable specifically to the nature of the "yuck" factor, but have more limited applicability to specific water reuse plans which will trigger higher-order factors relevant to water reuse acceptance (i.e., trust, cost, necessity). Further, the dependent variable was only measured with a single item. Although multi-item measures are generally preferred, there is a growing appreciation for the need to balance considerations of participant burden, construct measurement, and economy of assessment implementation, when conducting survey-based research. Specifically, Fuchs and Diamantopoulos (2009) have identified a number of advantages for single-item measures, including their brevity, the flexibility and ease with which they can be administered, and the potential that they reduce response bias by being less monotonous. Research has also demonstrated that single-item measures can have acceptable psychometric properties (Bergkvist & Rossiter, 2007; Drolet & Morrison, 2001; Wanous, Reichers, & Hudy, 1997). Nevertheless, the limit here remains and follow up studies should expand on this measure to increase variability and reliability.

5. Conclusions and future directions for research

The findings of this study indicate that the "yuck" factor, which has heretofore been described only generally as an emotional aversion, may be more complex. Our findings emphasize the importance of pathogen disgust in driving negative feelings about WWR. We also highlight segments of the population – women and those with less education – who may feel more discomfort when anticipating using WWR technology. At least for women, discomfort with WWR appears to be mediated by pathogen disgust sensitivity. These findings suggest that public outreach on WWR should keep in mind the importance of concerns over disease when trying to overcome the "yuck factor" and that segments of the population, such as women and those with less education, may be particularly averse to WWR plans on an emotional level. Women in particular often make key family household decisions on food and health choices, so arguably would be a group to target with appropriately framed information (Larson, Ibes, & White, 2011; Schahn & Holzer, 1990).

Our findings suggest several future avenues of research, particularly with regard to public outreach on water reuse. The trending significance of having heard about WWR indicates that disgust reactions to WWR could be affected by increasing discussion of the topic in the public forum. Increased exposure might remove some of the uncertainty and strangeness around these plans, allowing recycled water to become part of a broader public norm. Future research should empirically determine the mechanisms by which exposure decreases emotional discomfort. Particular aspects of WWR technology may be responsible for triggering certain emotional responses. What aspects of the technology relate to the concepts explored here could have implications for how this technology is packaged and marketed for the public, and would be particularly important for increasing acceptance of decentralized systems designed to be used in individual homes or businesses. Messaging could also be targeted to address concerns associated with certain moral pillars found on both the ideological "left" and "right" (i.e., through emphasizing "fairness/reciprocity" or "purity/sanctity" respectively). Other factors may also relate to the individual difference variables explored here, such as attitudes toward risk and science. Finally, the strength of pathogen disgust sensitivity as a predictor of discomfort indicates that future research into the "yuck factor" should focus on ways to reduce associations of WWR with pathogens. Kemp, Randle, Hurlimann, and Dolnicar (2012) attempted unsuccessfully to change attitudes toward WWR using inoculation theory. They concluded that the rational arguments preparing participants for potential "scare" campaigns characterized by disgust-laden images and language were not able to "inoculate" attitudes against disgust framing. Fabrigar and Petty (1999) found that if an attitude or belief is affectively based, then affectively framed persuasive messaging will be more effective than "rational" messaging. Future research on attitudes toward water reuse might draw on our findings of the nature of the emotional reactions toward water reuse to explore what types of message frames are most effective at overcoming pathogen disgust.

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