Reducing Drinking Water Consumption by Dutch Households: A Comparison of Different Behavioral Interventions

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Abstract

The increasing worldwide water scarcity is a threat to humanity. This threat is also visible in the Netherlands, which is currently dealing with increasingly dry summers. To relieve pressure from drinking water sources in the short term, this study was conducted to identify the most effective (combination of) behavioral intervention method(s) to reduce drinking water consumption by Dutch households (n = 280). Knowledge, subjective norms and habits were addressed through letters and a “reminder sticker”; water conservation behavior and related psychological and behavioral constructs were measured at two time points by means of digital questionnaires. No significant differences were found between conditions, over time and between demographic characteristics. Recommendations are made for follow-up research based on the combined analysis of water usage data and questionnaire responses, in a larger, nationwide sample.

Keywords: household water conservation, behavior change, knowledge transfer, social norm, habits

The global demand for water has been on the rise. During the period from 1916 to 2016, there was an increase of nearly 600% in worldwide freshwater use (Wada et al., 2016). Specifically, the combination of worldwide industrial, municipal and agricultural demand has grown disproportionally, relative to the growth of the world's population (United Nations Development Programme, 2006). This is a problematic development, as merely 0,5% of the earth's water is available freshwater (Bureau of Reclamation California-Great Basin, 2020). A number of factors are responsible for this development, including population growth and the extension of irrigated agriculture (Ercin & Hoekstra, 2014). The main contributor to this increasing demand, however, is climate change (Wang et al., 2014). Droughts, disruptions in monsoon patterns and food production systems, and freshwater source depletion are among the consequences of climate change (United Nations Development Programme, 2006). This combination of reduced water availability and rapidly increasing demand poses a great danger to mankind.

Drinking water is primarily extracted from available freshwater. Even though technologies for extracting drinking water from other sources like salt water have been developed (e.g., Ou et al., 2020; Van Vliet et al., 2021), these technologies often have downsides like high economic costs, high energy consumption and detrimental effects on the environment produced by their by-product, brine (Van Vliet et al.). Therefore, to reduce the consumption of drinking water in the short term, a behavioral approach may be more promising instead. Behavioral interventions that foster water conservation behavior can be inexpensive, relatively easy to implement and have proven successful on numerous occasions (see Koop, Van Dorssen & Brouwer, 2019).

The situation in the Netherlands

In contrast to the global trend, drinking water demand in the Netherlands actually decreased during the period from 2000 to 2016 (Drinkwaterplatform, 2021b; Centraal Bureau

voor de Statistiek, 2020). However, after this period, the demand started to increase again. The dry summers of 2018 and 2019 have played an important role in this (Projectteam Beleidstafel Droogte, 2019). The COVID-19 pandemic that started in 2020 has also contributed to the increase in drinking water consumption (Drinkwaterplatform, 2021b). During the summer of 2020, many people went on holiday within the Netherlands or stayed at home, resulting in an increased water demand; for this reason, water companies and the minister of Infrastructure and Water Management had to issue a warning to use less tap water in nine of the 12 Dutch provinces (Kerstens, 2020).

Drinking water in the Netherlands is extracted from three types of water sources: groundwater, surface water and bank groundwater, which is a mix of the former two (Drinkwaterplatform, 2019; Van Driezum et al., 2020). In the west of the country, water extracted from beneath the dunes also makes up a significant source of drinking water; this "dune water" is also freshwater, unlike other groundwater sources along the coast (Dunea, n.d.). Due to climate change, several factors complicate the extraction of drinking water. Among factors in the case of groundwater extraction are salinization and increased 'pressure' on the soil due to geothermal energy extraction and CO2-storage. For surface water extraction, examples include lower river water levels due to longer drought periods and overloading of the sewer systems due to heavy rainfall, causing excess waste water to end up in the surface water (Drinkwaterplatform, 2020).

Two thirds of all tap water in the Netherlands is consumed by households (Drinkwaterplatform, 2021b). Dutch households consume the most water by showering, followed by using the toilet, washing machine and sink, respectively (Baggelaar & Geudens, 2017). Since households constitute the vast majority of Dutch tap water consumers, reducing their consumption by promoting conservation could relieve a considerable amount of pressure from drinking water sources.

Factors underlying drinking water consumption

In order to effectively address the water consumption behavior of Dutch households, it is necessary to identify the factors that influence it. In previous research, the theory of planned behavior has been used extensively to explain household water consumption and conservation behavior (Fielding, Russell, Spinks & Mankad, 2012; Hurlimann, Dolnicar & Meyer, 2009; Jorgensen, Graymore & O'Toole, 2009; Russell & Knoeri, 2020). According to the theory of planned behavior, any behavior is preceded by the intention to carry it out (Ajzen, 1991). In this study, the intention preceding household drinking water consumption behavior is considered from a conservation perspective, i.e., the intention to conserve drinking water. The factors that collectively predict tap water consumption of Dutch households and the preceding intention to conserve water are shown in Figure 1.

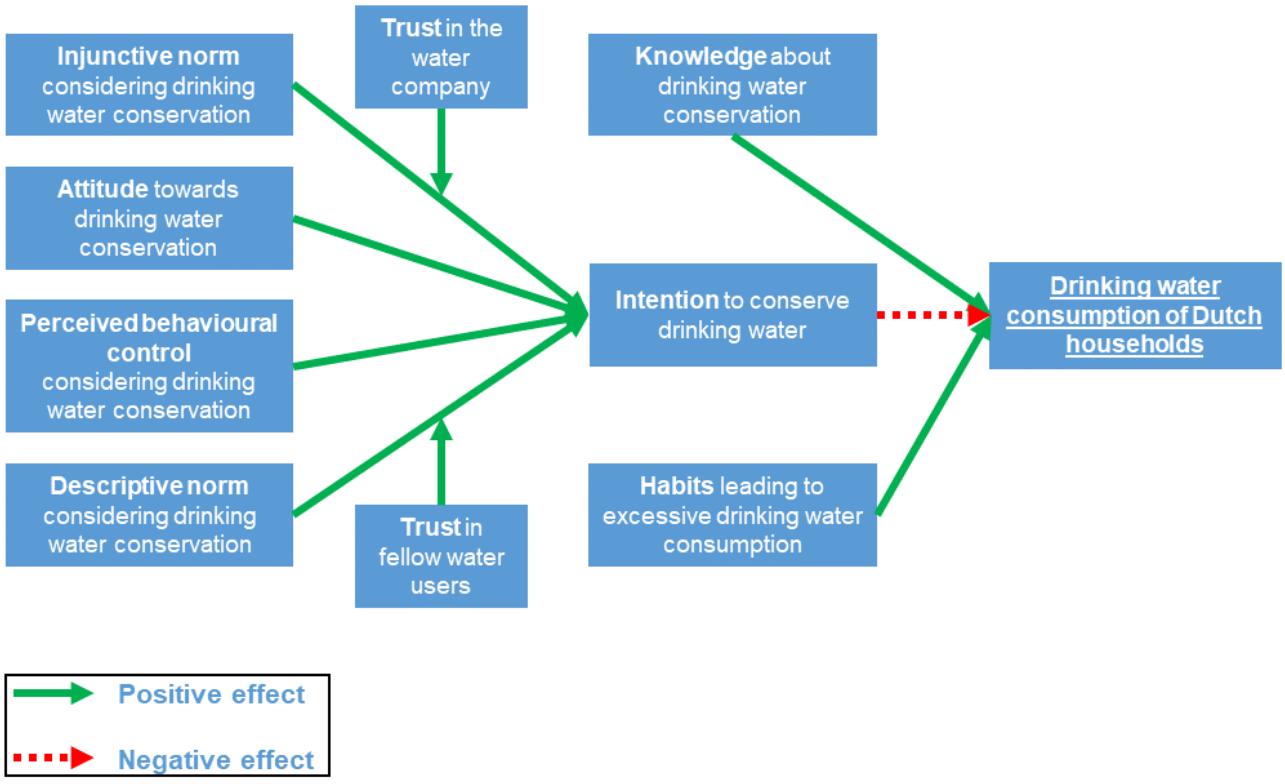

Figure 1. Process model depicting the process leading to tap water consumption of Dutch households.

Intention is predicted by attitude toward the behavior, subjective norms and perceived behavioral control (Ajzen, 1991). Attitude can be further divided into evaluative attitudes, which consist of beliefs and judgments of an object, and affective attitudes, which consist of feelings and emotional responses toward an object (Breckler & Wiggins, 1989). In the context of household water conservation, attitude toward water conservation was found to be a significant predictor of intention to conserve water (Gregory & Di Leo, 2003; Russell & Knoeri, 2020; Willis, Stewart, Panuwatwanich, Williams & Hollingsworth, 2011). Obviously, the more positive one's attitude toward water conservation, the higher their intention to actually do so.

Another key predictor of intention is the subjective norm. A subjective norm can be defined as experienced social pressure to (not) perform a specific behavior (Ajzen, 1991; Rhodes & Courneya, 2003). Subjective norms can be divided into two components. The first component is injunctive norm, which is one's perception of (dis)approval of a behavior by their social network (Rhodes & Courneya; Smith et al., 2012). An example of an injunctive norm with regard to water conservation is Vitens expressing their disapproval of excessive showering and watering gardens in the summer through a warning (see Vitens, 2019). Research has shown that the use of injunctive norms is effective in encouraging water conservation behavior (Bhanot, 2018; see also Han & Hyun, 2018; Schultz et al., 2014).

What could increase the effectiveness of injunctive norms even further is institutional trust; people have shown to be more likely to comply with an appeal if they are more trusting of the institution making it (e.g., Bargain & Aminjonov, 2020; Braithwaite & Makkai, 1994; Murphy, 2004). This also seems to be the case in respect of household water conservation (Jorgensen, Graymore & O'Toole, 2009). Hence, it could be hypothesized that trust in one's water company moderates the effect of injunctive norms on one's intention to conserve drinking water.

The second component of subjective norms is the descriptive norm, which refers to one's perception of actual engagement in a behavior by their social network (Ajzen & Fishbein, 2005); Rhodes & Courneya, 2003; Smith et al., 2012). An example of a descriptive norm regarding water conservation is whether one perceives others (from their neighborhood, town or country for example) to conserve water. Just as with injunctive norms, research has proven the use of descriptive norms to be effective in encouraging water conservation behavior (e.g., Bernedo, Ferraro & Price, 2014; Fielding et al., 2013; Han & Hyun, 2018).

Again, trust plays an important role, but in this case it is about trust in fellow water consumers. In other words, if one does not trust their neighbor to conserve water, they are less likely to do so themselves (Corral-Verdugo et al., 2002; Jorgensen, Graymore & O'Toole, 2009). Inter-personal trust could thus be hypothesized to moderate the effect of descriptive norms on one's intention to conserve drinking water.

The third key predictor of intention is perceived behavioral control, which refers to one's perception of the ease or difficulty of performing a specific behavior (Ajzen, 1991). Examples in the context of water conservation are time and physical effort needed to conserve water (see Jorgensen, Martin, Pearce & Willis, 2013) and confidence in being able to do so (Perren & Yang, 2015). Perceived behavioral control has proven to be an accurate predictor of water conservation behavior (Jorgensen, Martin, Pearce & Willis; Perren & Yang; Jorgensen, Graymore & O'Toole, 2009).

In addition to the three main predictors of intention that are part of the theory of planned behavior, habits may be an even stronger predictor of water conservation behavior (Fielding, Russell, Spinks & Mankad, 2012; Russell and Knoeri, 2019). Habits are automatic and unintentional behavioral responses that are learned through repetition and are cued by the environment and context in which they are carried out (Neal, Wood & Quinn, 2006). Households that have a low water consumption are more likely to form water-conserving

habits (Gregory & Di Leo, 2003; Russell & Knoeri). Examples are taking shorter showers (Walton & Hume, 2011) and turning off the tap while brushing one's teeth (Russell & Knoeri). Hence, targeting one's water consumption habits if they are negative (e.g., taking long showers) should be an effective way to reduce their water consumption. One reason for the persistence of water-spilling habits might be the easy availability of drinking water; one simply has to turn on their tap or shower. The ease of both the availability of drinking water and the action that is performed to acquire it might be experienced as rewarding, which is a necessary condition for habits to be formed and to persist (e.g., Chen et al., 2020; Judah, Gardner, Kenward, DeStavola & Aunger, 2018; McCloskey & Johnson, 2019). Furthermore, one can leave the water running for a long time without directly evident negative consequences; water bills, sometimes partial or in the form of estimates, are sent only ten times a year at most (Vitens, n.d.-a). Also, since smart water meters (that show one's daily water consumption) are mostly still being tested in the Netherlands (Drinkwaterplatform, 2021a), the majority of Dutch households is not likely to have much insight into their water consumption. Even if one is aware of the aforementioned negative consequences, the habit is not affected because its direct consequences are rewarding (Jager, 2003).

Finally, in addition to intention and habits, knowledge about water conservation was found to influence water conservation behavior as well (Clark & Finley, 2007; Dean, Fielding & Newton, 2016; Salvaggio, Futrell, Batson & Brents, 2013). The more knowledge one possesses, the more likely they are to engage in water conservation behavior. Likewise, knowledge transfer can make people more receptive to water conservation in general (Stern, 1999; Syme, Nancarrow and Seligman, 2000). Knowledge transfer in itself is not enough to promote long-term changes in behavior; it is recommended to use it in conjunction with other behavioral intervention techniques (Koop, Van Dorssen & Brouwer, 2019).

The aim of the present study was to identify the most effective (combination of) behavioral intervention method(s) to reduce drinking water consumption by Dutch households, both between conditions and over time. The main factors addressed were knowledge, subjective norms and habits, respectively.

Method

Participants and design

A total of 10,823 households in Leeuwarden, Friesland, were invited to participate in the study. The first questionnaire was completed by 289 households; nine responses were incomplete and therefore had to be excluded from analysis. The number of valid responses per condition was 103, 37, 133 and 7, respectively (total: 280). The follow-up questionnaire was completed by 111 households; two incomplete responses were excluded. Here, the number of valid responses per condition was 34, 15, 56 and 4, respectively (total: 109). The study design consisted of a 2 (time: upon receipt of the intervention vs. 12 days later) × 4 (condition: control vs. interventions) mixed design with repeated measures on the first factor. The conditions were each assigned to a neighborhood as demarcated by Vitens, based on the presence of water consumption sensors in those areas.

Procedure

The households received the letters by post. To fill out the questionnaire, participants could retype its link or scan its QR code with a smart device. At the start of the questionnaire, a consent form was shown (see Appendix A). Along with two consent checkboxes, checks to see whether the participant had read the letter and whether they lived in Leeuwarden (to avoid responses from households that were not part of the research group) were included. In the next screen, an explanation was given about the terminology used in the questionnaire, along with a check to see whether the participant understood this. After this, participants completed the questions (see Appendix B for all items and their English translations). In the

last screen, participants could fill out their email address if they wanted to receive the follow-up questionnaire. Subsequently, participants were thanked for their participation. The follow-up questionnaire was emailed 12 days after the first (and most) responses were recorded.

Materials

The letters that were used for each condition, along with their English translations, are included in Appendix C.

Condition 1: Control

In the control condition, households received the letter that served as the basis for the letters in the other conditions. Some words that were relevant to the topic were printed in bold. The introductory paragraph of the letter is shown in Figure 2.

Dear customer,

Research has shown that the **drinking water consumption** of Dutch households has significantly **increased** over the last three years.[a] This has to do with **population growth** and increasingly **dry summers** due to climate change.[b]

We do our best to provide you with drinking water of the highest quality every day.[c] However, due to the above reasons, this is unfortunately becoming increasingly **difficult** for us. It is therefore important to use drinking water **sparingly**.[d] This way, it remains accessible to everyone.[e]

Figure 2. Introductory paragraph of the base letter. It contained a brief introduction to the topic[a], followed by an argument related to climate change[b], an appeal to invoke trust in the drinking water company[c], and a broad call to action (in which no specifics were mentioned, since that was done in the intervention conditions)[d]. The paragraph was ended with an argument related to the universal accessibility of drinking water[e]. Sentences [b], [c] and [e] were based on water conservation arguments cited by the Dutch "drinking water customer groups" that are willing to conserve drinking water (see Brouwer & Sjerps, 2018).

This paragraph was followed by a request to complete the questionnaire, accompanied by a link and QR code. The letter was concluded by thanking its reader.

Condition 2: Water Saving Tips

Households in condition 2 received the aforementioned letter with the addition of a paragraph that served to transfer knowledge, in the form of four water saving tips. These tips were based on the four "usage components" that consume the most water among Dutch households: shower, toilet, washing machine and sink (Baggelaar & Geudens, 2017). In summary, the tips communicated the following:

1. To shower two minutes less.
2. To only turn the washing machine on when full.
3. To use the small flush button.
4. To turn off the tap when brushing one's teeth.

Tips 1, 3 and 4 were selected from Vitens's website (see Vitens, n.d.-b) and slightly adapted. Each tip contained a description of the estimated amount of water savings when following the tip or spillage upon inaction.

Condition 3: Social Norm

The letter for condition 3 was identical to the letter for condition 2, with the addition of social norm manipulation in the form of a text in a frame. The text read as follows:

"Did you know that the average Dutch person saves 85 liters a week by showering just ***two minutes less*** *at a time? That way, you can also* ***enormously reduce*** *your water consumption ☺"*

The first sentence communicates a descriptive norm through explaining an action the average Dutchman can carry out to save water. The second sentence communicates an injunctive norm; the smiley face serves to express approval of the action described in this sentence. Such use of a smiley face has proven effective in the context of household energy

conservation (Schultz, Nolan, Cialdini, Goldstein & Griskevicius, 2007) and water conservation (Schultz et al., 2014).

Condition 4: Reminder Sticker

The households in condition 4 received the same letter as those in condition 3, with the addition of a "reminder sticker" (see Figure 3). The purpose of this sticker was to teach its viewer how and why they should take a shorter shower. The intervention technique that was used here is boosting, which is aimed at making one competent to execute certain decisions and behaviors (Hertwig & Grüne-Yanoff, 2017). Furthermore, an instruction to put the sticker on one's bathroom mirror was included, considering this location's (presumed) proximity to the shower. It was also assumed that the sticker would be clearly and frequently visible when placed there. This way, the sticker was expected to have a higher chance to disrupt and thereby influence the participants' showering habits, by serving as an environmental cue (see e.g., Eves & Puig-Ribera, 2019; Hackbart, LeCheminant, Smith & Lox, 2009).

Figure 3. Reminder sticker. “Eenvoudig drinkwater besparen” = “Easily save drinking water”; “-2 minuten per douchebeurt” = “-2 minutes per shower”; “85 liter besparing per week” = “85 liters savings per week”; “Plaats mij op uw badkamerspiegel” = “Put me on your bathroom mirror”.

The showering person was depicted as “neutral” (mostly free of distinguishable facial and bodily features) so that it would appeal to all participants. It held one arm up as a depiction of enjoyment despite the shorter shower. The time indication was further visualized by the triangle on the clock and the arrow above the clock, both aimed in a counter-clockwise direction. The backdrop of the sticker was teal and the text was dark blue, in line with Vitens’s corporate identity. The sticker was 8 cm wide and 6 cm high and made of static material, as to not leave glue residue on the mirrors. The use of reminder stickers to promote water conservation has proven effective in a variety of contexts (Hodges, Kuehl, Anderson, Ehret & Brick, 2020; Lede & Meleady, 2018; Nayar & Kanaka, 2017).

Questionnaire

Households in all conditions received the same questionnaire containing questions about the factors that influence drinking water consumption and conservation. The questionnaire consisted of two parts. The constructs that were measured in the first part, each accompanied by one example item, were as follows: one’s perception of their own drinking water consumption (three items, “I use drinking water sparingly”), attitude toward drinking water conservation (“I think drinking water conservation is important”), descriptive norm (two items, “I think it is important that others conserve drinking water”), injunctive norm (“People in my environment think drinking water conservation is important”), trust in other water consumers (“I trust that others conserve drinking water too”), perceived behavioral control (two items, “I can make a difference by conserving drinking water”), knowledge about drinking water conservation (“I know how I can conserve drinking water”), the influence of the easy availability of drinking water (“The fact that drinking water is easily available makes it difficult for me to save it.”), degree of insight into water consumption (“I have a clear picture of how much drinking water I use”) and trust in the water company (“I trust my drinking water company”). These constructs were measured on a 5-point Likert scale

ranging from 1 (strongly disagree) to 5 (strongly agree). In the second part, demographic data were requested. These data were number of persons per household (five categories; one person to five or more persons), property type (seven categories; “apartment”, “terraced house”, “student room with shared facilities”, “studio”, “semi-detached house”, “detached house” or “other”), garden ownership (“yes”/”no”), and if so, irrigation sprinkler ownership (“yes”/”no”). In total, the questionnaire consisted of 18 items.

Follow-Up Questionnaire

The follow-up questionnaire was identical to the first questionnaire, except that the items about demographic data were not included, and items about the sticker were added in condition 4. One item was about the location (whether participants put the sticker on the bathroom mirror or somewhere else, or did not use it) and two were about the experience of the sticker (“I found the sticker handy to use” and “I found the sticker helpful”). The questionnaire consisted of 14 items in total (condition 4: 17 items).

Both questionnaires were developed and administered in Qualtrics (2021).

Results

Data Processing

First, the data were retrieved from Qualtrics in .xlsx format. Unnecessary data (e.g., timestamps, response duration) were removed in Microsoft Excel 2016. The remaining data were then transferred to two separate data sets (one for each measurement) in IBM SPSS Statistics 27. These data sets were then merged into one; the cases were matched based on the codes attributed to participants that participated in both questionnaires. The items “Perceived consumption compared to the average Dutch person”, “It is difficult for me to conserve drinking water”, “Influence of the easy availability of drinking water” and “Shower frequency” were reverse coded, in accordance with the aforementioned conservation perspective adopted in this study. Subsequently, reliability analyses were conducted for the

scales containing multiple items. The internal consistencies of "perception of own drinking water consumption" (α = .30), "descriptive norm" (α = .39) and "perceived behavioral control" (α = .25) were all found to be unacceptable. Therefore, "I use drinking water sparingly", "If people in my environment conserve drinking water, I do the same" and "It is difficult for me…" were chosen to represent the respective constructs for further analysis, based on their direct formulation of the constructs they were meant to measure. The statistical analyses described below were carried out in SPSS.

Data analysis

The primary objective of the analysis was to test for effects of condition and/or time, and/or for differences based on demographic characteristics, on water conservation behavior as measured by "I use drinking water sparingly". The secondary objective was to test for effects on the constructs measured by the other 13 questionnaire items. Kolmogorov-Smirnov tests indicated that the questionnaire responses of all 14 items did not follow a normal distribution ($p < .050$). Levene's tests showed that the variances for all questionnaire responses were equal ($p > .050$), except for "I think drinking water conservation is important" ($F(12,96) = 2.865$, $p = .004$)) at measurement 1. Thereafter, a bivariate correlation test for all 14 questionnaire items was carried out, which showed that the majority of the items were significantly correlated (lowest significant $r = .103$). Subsequently, a mixed multivariate analysis of covariance (mixed MANCOVA) was carried out; this test was chosen because of its robustness against violations of the assumptions of normality and homogeneity of variance. The dependent variables were the 14 items, the within-subjects factors were time (measurement 1 and 2) and the between-subjects factors were condition/neighborhood (one to four) and property type. The latter was included as a between-subjects factor rather than as a covariate, because its categories were not ordered and could not be considered to be of equal psychological distance. Number of persons per household, garden ownership and irrigation

sprinkler ownership were included as covariates. Since there were two levels of repeated measurements, the assumption of sphericity was met.

Multivariate tests revealed neither significant differences between conditions/neighborhoods (p = .221), nor significant differences in effects based on demographic characteristics (all *p's* > .050, lowest p = .360). Furthermore, neither significant effects of time (within subjects; p = .966), nor significant interaction effects between time and condition (p = .641) or the demographic characteristics were found (all *p's* > .050, lowest p = .286). Responses to the additional items about the reminder sticker were not further analyzed, since only one household reported to have used the sticker.

To verify whether the low number of participants in condition 4 (n = 7) significantly affected the results, a mixed MANCOVA excluding condition 4 was carried out. This test also yielded no significant results, both between (all *p's* > .050, lowest p = .138) and within conditions (all *p's* > .050, lowest p = .284).

Thereafter, it was investigated whether demographic characteristics were independent of (and thus evenly distributed across) the conditions/neighborhoods. Chi-square tests of independence showed significant relationships between condition/neighborhood and number of persons per household (X^2 (12, N = 280) = 36.609, p < .005), property type (X^2 (15, N = 280) = 129.756, p < .005), garden ownership (X^2 (3, N = 280) = 67.013, p < .005) and irrigation sprinkler ownership (X^2 (3, N = 280) = 13.331, p = .004). This indicated no even distribution of demographic characteristics across the conditions/neighborhoods.

Next, since no significant differences were found between the questionnaire responses, their mean scores at measurement 1 were calculated to inspect their overall trend. A t-test was then performed to verify whether these mean scores deviated from the middle of the scale; all items except "I shower…" (4 as scale middle; insignificant nevertheless) and "I

have a clear picture…" (which was not directly related to water conservation) were significantly higher. These results are shown in Table 1.

Questionnaire item	Mean response score
1. "Compared to the average Dutch person, I think that I consume:"*	3,78**
2. "I think drinking water conservation is important."	4,13**
3. "I use drinking water sparingly."	3,88**
4. "I think it is important that others conserve drinking water."	4,07**
5. "People in my environment (family, friends, neighbours, acquaintances) think drinking water conservation is important."	3,29**
6. "If people in my environment (family, friends, neighbors, acquaintances) conserve drinking water, I do the same."	3,23**
7. "I trust that others conserve drinking water too."	3,19**
8. "I can make a difference by conserving drinking water."	3,90**
9. "I know how I can conserve drinking water."	4,07**
10. "It is difficult for me to conserve drinking water."*	3,64**
11. "The fact that drinking water is easily available (for example by opening the tap) makes it difficult for me to conserve it."*	3,72**
12. "I have a clear picture of how much drinking water I use (for example, the number of liters per day or per week)."	2,94
13. "I trust my drinking water company."	4,09**
14. "I shower (approx.):"*	3,87

Table 1. Mean response scores on the questionnaire items.

*Recoded questionnaire item. **Significantly higher than the middle of the scale ($p < .050$).

Discussion and conclusion

The present study sought to determine which (combination of) behavioral intervention method(s) is most effective in reducing drinking water consumption by Dutch households, and if so, whether these methods remain effective over time. Effects on the other psychological constructs preceding the intention to conserve water and differences in effect based on demographic characteristics were also examined. No significant results were found. The same analysis excluding condition 4, due to its low number of participants, yielded no significant results either.

The main element of the interventions used in this study was a letter. To ensure that most participants would notice the letter in time, it was sent outside public and school

holidays. Two digital questionnaires served as measurement instruments. In order to access the first questionnaire, participants could retype a shortened link or scan a QR code included in the letter. By providing these two access options, the variety of digital devices used by participants was taken into account. Before completing the questionnaire, a mandatory check was included ("I have read and understood the letter that contains the link to this questionnaire."). This check served to prevent participants from completing the questionnaire without reading the letter first (i.e., being exposed to the interventions). Additionally, to avoid responses from outside the research sample, a check was included to verify whether participants really lived in Leeuwarden ("I confirm that I live in Leeuwarden."). Those who were interested in participating in the follow-up questionnaire could fill out their email address. A few days after sending out the follow-up questionnaire, a reminder was sent to maximize the number of respondents.

All conditions/neighborhoods received the same letter, with the only difference being the cumulatively added elements. To ensure that eventual effects could be attributed to these (differences between) elements, they were made as salient as possible; the social norm manipulation was displayed in a teal frame and the water saving tips were accompanied by illustrations (see Appendix C).

That no statistically significant effects were found nevertheless, might have been due to various reasons. First of all, the conditions were distributed over neighborhoods of one Dutch city. The less balanced distribution in demographic characteristics that resulted from this could have made attribution of eventual findings to the behavioral interventions, rather than to other factors, increasingly difficult (Hariton & Locascio, 2018).

Moreover, even though the intervention letters were sent out to more than 10,000 households, there was a response rate of merely 2.67%. The number of participants was especially low in condition 4; less than ten households participated and only one reported to

have used the sticker – thereby leaving its potential unexplored. A possible explanation for this is selection bias (Lavrakas, 2008); households could have participated out of personal interest in water conservation, leading to underrepresentation of those who are uninterested. Analysis of the questionnaire responses indeed showed that, except for one item, the households scored above average on the items related to drinking water conservation. An implication of this bias for the apparent ineffectiveness of the interventions could be that those who chose to fill out the questionnaires were already conserving drinking water, and therefore did not do this (to a greater extent) as a result of the interventions.

Also, the present study was conducted over a period of three weeks, which may have been too short to achieve and detect long-term effects. Likewise, participants were exposed to the (messages conveyed by the) interventions only once. A longer research period could have allowed for repetition of these messages; this has proven effective in fostering water conservation behavior, both in the cases of knowledge transfer (Borisova & Useche, 2013; Chang, 2013) and social norm (Landon, Woodward, Kyle & Kaiser, 2018).

Additionally, this study relied on self-report measures, some of which could have been inflated due to social desirability bias (Krumpal, 2011). For example, participants could have stated to consume much less water than they actually do, to appear more “favorable”. The use of household-level water consumption data measured by water meters could have controlled for this bias; however, this was beyond the methodological possibilities of this study. Nevertheless, self-report was the most efficient way to measure psychological constructs in the current research setup.

Another explanation might be related to the weather. During the period between the first and second measurement, the average temperature in Leeuwarden varied between 9,5 °C and 19,5 °C (see KNMI, 2021). During the warmer weather, the households’ intentions to conserve water might have been too strongly reduced to be influenced by the interventions.

The aforementioned limitations might have influenced the effectiveness of the interventions, and therefore the conclusions that can be drawn from the findings of this study. Further research should thus be undertaken to determine the effectiveness of the interventions. The conditions should be randomly and evenly distributed over a large, nationwide sample in order to obtain results that can be generalized to Dutch households. Conclusions should be drawn based on analysis of household water consumption data, in conjunction with self-report measures, to determine relations with and between the various psychological constructs in the context of water conservation. The weather should be included as a moderator variable. Also, the research should be conducted over a larger timeframe, which also facilitates repetitive presentation of the messages conveyed by the interventions. Investigating the influencing of habits through the reminder sticker is particularly interesting, given the low number of participating households in condition four and that only one household reported to have used the sticker. Another reason for studying this is the relatively small amount of research into influencing the "automatic" processes leading to water consumption behavior (Koop, Van Dorssen & Brouwer). In any case, despite its limitations, the present study has contributed to the existing body of knowledge about the application of behavioral insights to foster household drinking water conservation and provides a promising framework for future research.

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Appendix A

Consent form

Dutch

Beste lezer,

Deze vragenlijst is onderdeel van een onderzoek naar drinkwaterverbruik onder Nederlandse huishoudens op wijkniveau.

Het invullen van de vragenlijst duurt ongeveer 5 minuten. U kunt op ieder moment afzien van uw deelname.

Uw deelname is anoniem en de resultaten zullen anoniem verwerkt worden.

Tevens is uw deelname geheel vrijblijvend. Ik zou het erg waarderen als u wilt deelnemen, maar u bent tot niets verplicht.

Het is de bedoeling dat deze vragenlijst door één persoon per huishouden wordt ingevuld.

Voor vragen kunt u terecht bij Ramón Daci: ramon.daci@student.ru.nl

Alvast hartelijk dank voor uw deelname!

Ramón Daci

Masterstudent Psychologie: Gedragsverandering

Radboud Universiteit Nijmegen

Aan te vinken statements ter controle

1. Ik heb bovenstaande informatie gelezen en begrepen.
2. Ik heb de brief, waarin de link naar deze vragenlijst staat, gelezen en begrepen.
3. Ik bevestig dat ik in Leeuwarden woonachtig ben.
4. Ik begrijp dat ik op ieder moment van mijn deelname kan afzien, zonder dat dit negatieve gevolgen heeft.

English

Dear reader,

This questionnaire is part of a study into drinking water consumption by Dutch households at neighborhood level.

Filling in the questionnaire takes about 5 minutes. You can cancel your participation at any time.

Your participation is anonymous and the results will be processed anonymously.

Your participation is also completely without obligation. I would really appreciate it if you would like to participate, but you are not obliged to do so.

This questionnaire is intended to be completed by one person per household.

For questions, please contact Ramón Daci: ramon.daci@student.ru.nl

Thank you very much for your participation!

Ramón Daci

Student Psychology: Behavior Change

Radboud University Nijmegen

Mandatory checks (that could be confirmed by ticking boxes):

1. I have read and understood the information above.

2. I have read and understood the letter that contains the link to this questionnaire.

3. I confirm that I live in Leeuwarden.

4. I understand that I can cancel my participation at any time, without negative consequences.

Appendix B

Questionnaire items and item codes

Dutch

Alle vragen werden beantwoord aan de hand van een 5-punts-Likertschaal (zeer mee oneens – mee oneens – neutraal – eens – zeer mee eens), tenzij anders aangegeven. De itemcodes en gemeten constructen staan tussen haakjes aangegeven.

Drinkwaterbesparing

1. (TovGemNed, Perceptie eigen drinkwaterverbruik) Ik denk dat ik zelf, ten opzichte van de gemiddelde Nederlander:
    i. Veel minder water verbruik
    ii. Minder water verbruik
    iii. Evenveel water verbruik
    iv. Meer water verbruik
    v. Veel meer water verbruik
    vi. Ik weet het niet
2. (IkBelang, Attitude richting drinkwaterbesparing) Ik vind drinkwaterbesparing belangrijk.
3. (IkSpaarzaam, Perceptie eigen drinkwaterverbruik) Ik ga spaarzaam om met drinkwater.
4. (VindBelangAnd, Descriptieve norm) Ik vind het belangrijk dat anderen drinkwater besparen.
5. (OmgBelang, Injunctieve norm) Mensen in mijn omgeving (familie, vrienden, buren, kennissen) vinden drinkwaterbesparing belangrijk.
6. (AlsOmgIkOok, Descriptieve norm) Als mensen in mijn omgeving (familie, vrienden, buren, kennissen) drinkwater besparen, doe ik dat ook.

7. (VertrouwenAnd, Vertrouwen in medewatergebruikers) Ik vertrouw erop dat anderen ook drinkwater besparen.
8. (IkVerschMak, *Perceived behavioral control*) Ik kan een verschil maken door drinkwater te besparen.
9. (WeetHoeBesp, Kennis over drinkwaterbesparing) Ik weet hoe ik drinkwater kan besparen.
10. (KostMoeite, *Perceived behavioral control*) Het kost mij moeite om drinkwater te besparen.
11. (MakkVerkrg, Makkelijke verkrijgbaarheid van drinkwater) Dat drinkwater makkelijk verkrijgbaar is (bijvoorbeeld door de kraan open te zetten), maakt het voor mij moeilijk om het te besparen.
12. (HelderBeeld, Inzicht in eigen drinkwaterverbruik) Ik heb een helder beeld van hoeveel drinkwater ik verbruik (bijvoorbeeld het aantal liter per dag of per week).
13. (VertrouwenBedr, Vertrouwen in drinkwaterbedrijf) Ik vertrouw mijn drinkwaterbedrijf.
14. (DoucheFreq, Perceptie eigen drinkwaterverbruik) Ik douche (ongeveer):
    i. Een keer per week
    ii. Twee keer per week
    iii. Drie keer per week
    iv. Vier keer per week
    v. Vijf keer per week
    vi. Zes keer per week
    vii. Zeven keer per week of vaker

Demografische gegevens

15. (AantalPers) Mijn huishouden (mijzelf meegeteld) bestaat uit...

i. Eén persoon
ii. Twee personen
iii. Drie personen
iv. Vier personen
v. Vijf of meer personen

16. (TypeWoning) Ik woon in een...
    i. Appartement
    ii. Rijtjeshuis
    iii. Studentenkamer met gedeelde voorzieningen
    iv. Studio
    v. Twee-onder-een-kapwoning
    vi. Vrijstaand huis
    vii. Anders
17. (Tuin) Ik heb...
    i. Een eigen tuin
    ii. Geen eigen tuin
18. (Sproeiinst) Ik heb een sproei-installatie
    i. Ja
    ii. Nee
19. (StickerGeplaatst) Ik heb de herinneringssticker, die bij de brief zat:
    a. Op de badkamerspiegel geplaatst
    b. (StickerLocatie) Ergens anders geplaatst, namelijk: [Tekstveld]
    c. Niet gebruikt
20. (StickerBehulp) Ik vond de sticker behulpzaam.
21. (StickerHandig) Ik vond de sticker handig in gebruik.

English

All questions were answered on a 5-point Likert scale (strongly disagree – disagree – neutral – agree – strongly agree), unless otherwise noted. The item codes and measured constructs are indicated in brackets.

Drinking water conservation

1. (TovGemNed, Perception of own drinking water consumption) Compared to the average Dutch person, I think that I consume:
    i. Much less water
    ii. Less water
    iii. The same amount of water
    iv. More water
    v. Much more water
    vi. I don’t know
2. (IkBelang, Attitude toward drinking water conservation) I think drinking water conservation is important.
3. (IkSpaarzaam, Perception of own drinking water consumption) I use drinking water sparingly.
4. (VindBelangAnd, Descriptive norm) I think it is important that others conserve drinking water.
5. (OmgBelang, Injunctive norm) People in my environment (family, friends, neighbours, acquaintances) think drinking water conservation is important.
6. (AlsOmgIkOok, Descriptive norm) If people in my environment (family, friends, neighbors, acquaintances) conserve drinking water, I do the same.
7. (VertrouwenAnd, Trust in other water consumers) I trust that others conserve drinking water too.

8. (IkVerschMak, Perceived behavioral control) I can make a difference by conserving drinking water.
9. (WeetHoeBesp, Knowledge about drinking water conservation) I know how I can conserve drinking water.
10. (KostMoeite, Perceived behavioral control) It is difficult for me to conserve drinking water.
11. (MakkVerkrg, Easy availability of drinking water) The fact that drinking water is easily available (for example by opening the tap) makes it difficult for me to conserve it.
12. (HelderBeeld, Degree of insight into own water consumption) I have a clear picture of how much drinking water I use (for example, the number of liters per day or per week).
13. (VertrouwenBedrijf, Trust in the water company) I trust my drinking water company.
14. (DoucheFreq, Perception of own drinking water consumption) I shower (approx.):
    i. Once a week
    ii. Two times a week
    iii. Three times a week
    iv. Four times a week
    v. Five times a week
    vi. Six times a week
    vii. Seven times a week or more

Demographics

15. (AantalPers) My household (including myself) consists of...
    i. One person
    ii. Two persons

iii. Three persons

iv. Four persons

v. Five or more persons

16. (TypeWoning) I live in a(n)...

i. Apartment

ii. Terraced house

iii. Student room with shared facilities

iv. Studio

v. Semi-detached house

vi. Detached house

vii. Other

17. (Tuin) I have…

i. My own garden

ii. No own garden

18. (Sproeiinst) I have an irrigation sprinkler

i. Yes

ii. No

19. (StickerGeplaatst) I have put the reminder sticker, that came with the letter:

a. On my bathroom mirror

b. (StickerLocatie) Somewhere else: [Text field]

c. I haven't used the reminder sticker

20. (StickerBehulp) I found the sticker helpful.

21. (StickerHandig) I found the sticker convenient to use.

Appendix C

Intervention letters

Dutch

Vitens

Beste klant,

Uit onderzoek blijkt dat het **drinkwaterverbruik** van Nederlandse huishoudens de laatste drie jaar fors is **toegenomen**. Dit heeft onder andere te maken met de **bevolkingsgroei** en de steeds **drogere zomers** als gevolg van klimaatverandering.

Wij doen ons best om u elke dag drinkwater te leveren van de hoogste kwaliteit. Echter wordt dit, vanwege bovenstaande redenen, helaas steeds **moeilijker** voor ons.

Wist u dat de gemiddelde Nederlander 85 liter water per week bespaart door slechts twee minuutjes per keer korter te douchen? Zo kunt ook u uw waterverbruik enorm terugdringen ☺

Condition 3 and 4

Het is daarom belangrijk om **spaarzaam** om te gaan met drinkwater. Zo blijft het voor iedereen toegankelijk. Helpt u ook mee? Dit hoeft **niet moeilijk** te zijn. Hieronder ziet u 4 tips:

Condition 2, 3 and 4

1. Douche twee minuutjes per keer korter.
Hierdoor bespaart u al zo'n 85 liter per persoon per week. Dat is ruim 4.400 liter per jaar! **De bijgevoegde sticker kan helpen u te herinneren aan deze tip.**

2. Zet uw wasmachine pas aan als deze vol is.
Door minder vaak te wassen, bespaart een gemiddeld huishouden duizenden liters water per jaar.

Condition 4

3. Gebruik de kleine knop of spoel-onderbreker op uw toilet, in plaats van de grote knop.
Zo kunt u de helft van het toiletwater besparen.

4. Draai de kraan dicht tijdens het tandenpoetsen.
Indien u de kraan open laat staan bij het tandenpoetsen, spoelt u meer dan 40 liter water per keer door de gootsteen.

In samenwerking met de Radboud Universiteit doet Vitens onderzoek naar drinkwaterverbruik op wijkniveau. Wilt u meedoen? Dit kost u slechts 5 minuten en kan via deze link: [Link] of scan de QR-code hieronder. Alvast bedankt voor uw hulp!

Met vriendelijke groet,

Team Gedragsonderzoek
Vitens

[QR-code]

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Deze brief is onderdeel van een onderzoek naar drinkwaterverbruik op wijkniveau.

English (text only)

Dear Customer,

Research shows that the **drinking water consumption** of Dutch households has significantly **increased** over the last three years increased. This has to do with **population growth** and increasingly **dry summers** due to climate change.

We do our best to provide you with drinking water of the highest quality every day. However, due to the above reasons, this is unfortunately becoming increasingly difficult for us. It is therefore important to use drinking water **sparingly**. This way, it remains accessible to everyone

Did you know that the average Dutch person saves 85 liters a week by showering just **two minutes less** at a time? That way, you can also **enormously reduce** your water consumption ☺*

Will you help too? This doesn't have to be difficult. Below are 4 tips:**

1. Shower for two minutes shorter each time.

This saves you about 85 liters per person per week. That is more than 4,400 liters per year! **The attached sticker can help you remember this tip.***

2. Turn on your washing machine only when it is full.

By washing less often, an average household saves thousands of liters of water per year.

3. Use the small button or flush breaker on your toilet, instead of the large button.
This way, you can save half of the toilet water.

4. Turn off the tap while brushing your teeth.
If you leave the tap open while brushing your teeth, you flush more than 40 liters of water through the sink at a time.

Vitens is conducting research into drinking water consumption at neighborhood level in collaboration with Radboud University. Would you like to participate? This only takes 5 minutes and can be done via this link: [link] or you can scan the QR code below. Thanks in advance for your help!

Sincerely,

Behavioral Research Team
Vitens

*This paragraph (social norms manipulation) was only included in condition 3 and 4

**The tips were only included in condition 2, 3 and 4

***This sentence was only included in condition 4