

Can a simple plan change a complex behavior? Implementation intentions in the context of water drinking

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ABSTRACT

Underhydration has significant adverse physical and mental health effects, yet many people drink too little water. Implementation intentions have been found to effectively promote many health behaviors, but little is known about the processes underlying their effects in naturalistic settings, and whether they could improve water drinking. This mixed-methods study assessed the impact and potential underlying processes of using implementation intentions to increase self-reported water intake over a five-day follow-up. Ninety-five participants ($M_{age} = 39$, $SD = 12$) received an educational quiz to increase their water drinking motivation before being randomly assigned to the control or intervention group. Participants also completed a qualitative survey that assessed the processes underlying their attempts to increase water intake. Quantitative results suggested that most participants increased their average daily water intake regardless of group. Qualitative results indicated that implementation intention participants struggled with remembering and the perceived effort of preparation and drinking behaviors, which reduced the effect of planning on behavior. This study provides essential theoretical and methodological considerations for researchers studying implementation intentions, as the effects and mechanisms of implementation intentions in real-life situations may be more complex than previously assumed. For example, the results suggest that implementation intentions did not automatize remembering and performing the behavior in ways the current literature theorizes. Other kinds of interventions may be needed to improve the complex daily-life behaviour of water drinking.

1. Introduction

Water drinking is an important health behavior because underhydration is linked to health issues such as chronic kidney disease, metabolic disorders (Armstrong & Johnson, 2018; Perrier et al., 2020), and cognitive deficits (Benton & Young, 2015; Liska et al., 2019). However, large proportions of industrialized nations' populations do not meet water intake guidelines (Drewnowski, Rehm, & Constant, 2013; Ferreira-Pêgo et al., 2015), and many people seem to lack hydration knowledge (Drake, Ferragud, & Andrés, 2014; Rodger, Wehbe, & Papies, 2021; Veilleux et al., 2020). Effective intervention efforts to increase people's water intake and improve their hydration status could address issues associated with underhydration (Perrier et al., 2020). However, current water drinking interventions do not seem to meaningfully increase people's water intake (Franse et al., 2020; Moghadam, Krieger, & Loudon, 2020; Vargas-Garcia et al., 2017). In the current study, we examined the effectiveness of implementation intentions in a water drinking intervention informed by recent research on water drinking

motivations, and evaluated how participants experienced this intervention for use in complex, daily-life settings.

1.1. Water drinking research

Previous research suggests that factors such as availability, perceptions of taste and health beliefs are associated with water intake (Block, Gillman, Linakis, & Goldman, 2013; Hess, Lilo, Cruz, & Davis, 2019). Recent research (Rodger et al., 2021; Rodger & Papies, 2021) expanded on this and showed that people have highly situated water drinking habits. Participants reported drinking water effortlessly when a specific set of contextual features (i.e., internal and external cues, concurrent goals, cognitive capacity) were present but effortfully when this set of contextual features was absent (Rodger et al., 2021). Additionally, associating water drinking with valued, rewarding outcomes, such as feeling less fatigued, was associated with high, subjectively effortless water intake (Rodger & Papies, 2021). Finally, participants with low water intake either lacked intentions to drink water due to a lack of

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knowledge of the importance and benefits of hydration, or they did not act on their intentions because they did not know how to effectively improve their water drinking behavior (Rodger et al., 2021).

Given these barriers to water drinking, we developed an intervention with two components. First, all participants completed an education component on the importance of hydration, to create or strengthen intentions to drink water. Then, half of the participants formed implementation intentions, to boost remembering to drink water in specific situations, and thus help participants act on their water drinking intentions.

1.2. Implementation intentions

Implementation intentions provide a potential, pragmatic solution to reduce the intention-behavior gap (Sheeran & Webb, 2016). They involve the creation of a plan that identifies when, where, and how an intended behavior will take place using “if/when, then ...” statements (Gollwitzer, 2006). These statements target goal-directed behavior that people have underlying intentions for but that also suffer from low self-regulatory resources (e.g., attention), impeding people from acting on their intentions. For example, a healthy eating intention may take the form, “If I am riding the bus home after work, then I will eat an apple” (Adriaanse, Gollwitzer, De Ridder, de Wit, & Kroese, 2011).

This type of planning has been theorized to promote health behavior via two processes (See Bieleke, Keller, & Gollwitzer, 2021; Wieber, Thürmer, & Gollwitzer, 2015). Firstly, the critical situation identified in the if-part (e.g., “riding the bus”) becomes highly accessible as a result of planning, such that people are more likely to recall and attend to information about the critical situation (Bieleke et al., 2021). Secondly, a strong link is created between the critical situation and the intended behavior (e.g., “eat an apple”), such that the behavior is performed automatically when the critical situation is encountered (Bieleke et al., 2021). Indeed, implementation intentions are well evidenced as being effective in promoting the performance of new health behaviors in domains such as healthy eating (Adriaanse, Vinkers, De Ridder, Hox, & De Wit, 2011; Bieleke et al., 2021; Carrero, Vilà, & Redondo, 2019; Gollwitzer & Sheeran, 2006).

Most research on these underlying processes has been done in tightly controlled experimental settings that lack ecological validity (Bieleke et al., 2021). Significant literature outlines why relying on this type of research to understand underlying processes is problematic (See Diener, Northcott, Zyphur, & West, 2022; Meehl, 1990; Proulx & Morey, 2021; Scheel, Tiokhin, Isager, & Lakens, 2020). Additionally, the primarily quantitative research to assess effectiveness does not provide an in-depth insight into peoples’ experience of using implementation intentions. Therefore, in addition to assessing the effectiveness of implementation intentions to promote water drinking, we also aim to evaluate participants’ experience of using them to gain more insights into the processes that may underlie the effects of implementation intentions in complex, real-life settings. Evaluating the processes underlying intervention effects is essential to developing optimal and effective intervention strategies (Hagger, Moyers, McAnally, & McKinley, 2020).

1.3. Overview

The current mixed-methods experiment was designed to assess the effects and experiences of a planning-based water drinking intervention in a sample of adults in the UK. Mixed methods allow researchers to use the contrasting strengths and account for the contrasting limitations of quantitative and qualitative research methods (Maxwell, 2022). For example, quantitative methods can provide insight into the effect of interventions, while qualitative methods can provide insight into the processes underlying interventions (Bonell, Warren, & Melendez-Torres, 2022; Maxwell, 2022).

All participants received the education component before being randomized into either the control or intervention group and being told

to try and drink three additional glasses of water per day. We defined a glass as 250 ml. Participants in the control group were given no further instructions beyond the instruction to drink three additional glasses each day. Participants in the intervention group were asked to select three situations where they did not drink water and to create implementation intentions to help them drink one glass of water in each situation.

We asked intervention participants to drink water in situations they usually did not, as people must drink consistently throughout the day to maintain healthy hydration (Perrier et al., 2020). In other words, they likely must drink water across various situations (Rodger et al., 2021). However, prior research shows that low water drinkers tend to drink water in situations that infrequently occur throughout the day (e.g., upon waking up) or in only one situation (i.e., when working) (Rodger et al., 2021; Rodger & Papies, 2021). Therefore, alternative approaches, such as drinking an extra glass in an established water drinking situation, may be less effective in promoting healthy hydration. For example, if someone only drinks water at work, drinking more in this situation is not conducive to healthy hydration on non-working days. This approach is hindered further when the water drinking situation is highly infrequent or covers a short time, as this limits the consistency and amount of water intake. For example, someone cannot drink their entire recommended daily water intake upon waking up. Additionally, drinking water across various situations is conducive to high water intake (Rodger et al., 2021; Rodger & Papies, 2021). Considering this evidence, developing interventions that help people drink water in new situations may be important.

All participants self-reported their water intake at the end of each day over a five-day follow-up. We hypothesized that participants in the intervention group would report drinking more water (ml) than those in the control group over the follow-up.

At the end of the follow-up, we used a qualitative survey (Braun, Clarke, Boulton, Davey, & McEvoy, 2020) to understand better the intervention from the participants’ perspective and their experience of trying to increase their water intake. This allowed us examine potential mechanisms of implementation intentions outside the laboratory (See Bonell et al., 2022 for an overview of using indirect qualitative approaches to inform intervention mechanisms). The qualitative data was used to assess the following research question: What is the lived experience of participants as they try to increase their water intake over the follow-up period? Specifically, what facilitates and hinders them from drinking the three additional glasses of water a day?

2. Method

The University of Glasgow Ethics Committee approved this research. We preregistered this study on the Open Science Framework (See <https://osf.io/b48fq>) and have uploaded supplementary materials, including raw data, analysis files, for transparency (See <https://osf.io/3sd24>). We report all measures, manipulations, and exclusions in this study.

2.1. Participants

One hundred participants from the UK were recruited via the online recruitment platform Prolific (<https://prolific.co/>). Participants had to be fluent in English, aged 18 years or older, and have a self-reported water intake of 1.2 L or less per day. The participant pool consisted of participants that had reported drinking 1.2 L or less of water per day in a previous study conducted in December 2020 (Rodger & Papies, 2021) and an additional pre-screening study conducted in June 2021. This threshold was chosen based on previous research indicating that people who consistently drink 1.2 L or less per day show biomarkers related to underhydration (Perrier et al., 2020). The sample size was decided based on an a priori power analysis for a linear model in G*Power (Faul, Erdfelder, Buchner, & Lang, 2009) (see OSF for more details and

sensitivity power analysis). The minimum effect size of interest of 500 ml was chosen based on previous research indicating that this amount is potentially clinically meaningful and has been shown to improve hydration outcomes (Liska et al., 2019).

Five (Control = 2, Intervention = 3) participants did not complete all parts of the study (see OSF for more information), leaving 95 participants for the quantitative analysis and 96 for the qualitative analysis. See Table 1 for participant demographics.

2.2. Materials

All materials were created in Qualtrics (www.qualtrics.com).

2.2.1. Baseline materials

We used most baseline measures in exploratory analyses presented in the supplementary materials (See OSF). Therefore, we only briefly outline these measures in the main text and fully describe them on the OSF.

At baseline, we asked participants for the following: demographic information on age, gender, ethnicity, education level, and pre-existing conditions that impact their drinking behavior; typical daily sugar-sweetened beverage intake, typical daily water intake, and typical daily water intake in each of 17 situations (see Table 2), all in number of standard glasses (250 ml) to one decimal place on a sliding scale (Range: 0–5); how much they liked water (1 = not at all, 5 = like very much), how important it was for them to drink the recommended daily amount (1 = not at all important, 5 = very important), and if they thought they would succeed in attaining a goal to drink more water (1 = definitely no, 5 = definitely yes) all on five-point Likert scales; typical daily urine color using a urine color chart (Armstrong et al., 1994; see OSF), and how many days a week they experienced specific dehydration symptoms (e.g., dry mouth, sore head, tiredness, irritability, light-headedness, and thirst).

We then asked participants to complete the General Health Consciousness Scale (McCarthy, Collins, Flaherty, & McCarthy, 2017; Sparks & Guthrie, 1998), consisting of three questions on a seven-point Likert

Table 1
Participant demographics

Demographics of Participants with Complete Data ^a	Range	M	SD
Age	19–74	39	12
	Count		
Gender:			
Man	15		
Woman	80		
Ethnicity: ^b			
White/Caucasian	78		
British	10		
Asian	2		
African	1		
Bulgarian	1		
Latin American/Hispanic	1		
Spanish	1		
Mixed	1		
Education:			
Secondary/High School	25		
College/University degree	50		
Master's/Postgraduate degree	18		
PhD or higher	2		
Pre-existing Conditions:			
Diabetes (type 1 and 2)	3		
Lactose intolerance	1		
late term pregnancy	1		

^a The additional participant included in the qualitative analysis was 18 years old, identified as a white woman, had a secondary/high school education and no pre-existing health conditions.

^b Ethnicity was an open-ended response question. A few participants reported nationalities as their ethnicity (e.g., 'British') so these categories are reported here.

Table 2

Situations used for situated measures and implementation intention creation.

Situation	Chosen by % Intervention Participants
upon waking up	55.32
while sitting at the desk at work	21.28
in between tasks at work or at home	14.89
while studying	2.13
while watching television	38.30
while making breakfast	4.26
while eating breakfast	6.38
while making lunch	8.51
while eating lunch	14.89
while making dinner	6.38
while eating dinner	40.42
while having a snack	10.64
during a workout or manual labour	6.38
before leaving the house	12.77
upon returning home from being out	21.28
with medication	17.02
while brushing teeth	19.15

Note. These situations were chosen based on prior research into water drinking behavior (see Rodger et al., 2021) and are listed in the order they were presented to participants. The first situation was chosen most frequently by participants; however, the rest of the most chosen situations were from varied positions in the list, indicating that the situation presentation order likely did not influence which situations participants chose. The situations were also not randomly ordered in the drinks diaries to help reduce attrition by facilitating participants gaining familiarity with the diaries data collection approach, increasing the ease of filling them.

scale (e.g., "I think of myself as someone who generally thinks carefully about the quality of the drinks I select," from 1 = strongly disagree to 7 = strongly agree), and the Hydration Facilitators and Barriers Scale (Veilleux et al., 2020), consisting of 18 questions of a five-point Likert-type scale (e.g., "I'm more likely to drink water if I'm accountable to someone else," from 1 = not at all like me to 5 = very much like me).

2.2.1.1. Hydration education. We then gave participants an educational quiz to educate them on why the human body needs water, the symptoms and consequences of dehydration and the health benefits of drinking water. We modelled the educational quiz on the Hydration Knowledge Scale (Veilleux et al., 2020), which assesses the accuracy and confidence of participants' responses. All eight educational quiz questions presented a statement (e.g., "Your brain needs water to make important chemicals and hormones that regulate mood and bodily functions.") and asked participants to indicate if they felt the statement was 'definitely inaccurate' (−2), 'probably inaccurate' (−1), 'not sure' (0), 'probably accurate' (1), and 'definitely accurate' (2). The correct response was then presented with additional information to increase participants' hydration knowledge. After the quiz, we asked participants how important it was for them to drink the recommended daily amount again to see if the quiz impacted participants' perception of water's importance.

2.2.1.2. Implementation intentions and control group instructions. Finally, we randomly assigned participants to the intervention or control group by embedding a Qualtrics' randomizer into our survey flow. We asked all participants to drink an extra three glasses of water a day over the next five days. We asked only the intervention participants to create implementation intentions to help them drink the extra glasses of water following Adriaanse, Gollwitzer, De Ridder, de Wit, and Kroese (2011) instruction format. We instructed intervention participants to pick three situations where they do not usually drink water from a pre-determined list (see Table 2) and to drink one glass of water in each situation. To help them do this, participants then created an "if/when, then" plan for each of their chosen situations. We gave, "when I wake up in the morning and walk to the kitchen, I will drink a glass of water" as an example. We told participants to repeat each implementation intention

in their minds a few times and imagine themselves doing the actions it would take to drink the glass of water in each situation successfully.

2.2.2. Drinks diaries

We asked the participants, “How many standard glasses (250 ml) of water did you consume in each of the following situations today?” The same 17 situations from the baseline measures were used (Table 2). All responses were given on a sliding scale to one decimal place (Range: 0–5). We also asked participants, “How many standard glasses (250 ml) of other beverages (not including alcohol) did you drink today?” on a sliding scale (Range: 0–10). However, as this was an exploratory variable it is not discussed further.

To help participants report their water intake accurately as the number of standard glasses, they were shown the reference image in Fig. 1 along with the following instructions, “Please use the picture below as a reference for what we mean by a **standard glass** of water. How many standard glasses (Glass A pictured above, 250 ml) of water did you drink today in each of the following situations? The sliders allow you to enter partial glasses. E.g., if you filled up 2 standard glasses of water in one situation but only drank half of the second one move the slider to 1.5. If the situation did not occur, leave the slider at 0.” The reference picture and instructions are in line with previously validated measures of water intake (Veilleux et al., 2020).

2.2.3. Qualitative survey

We then asked participants to complete a qualitative survey we developed based on our research questions, prior knowledge of the literature, and Braun et al.'s (2020) recommendations on developing qualitative surveys that provide rich, comprehensive data suitable for in-depth exploration of participants' lived experiences. We instructed participants that there were no right or wrong answers as we were interested in hearing their thoughts and experiences. We asked all participants to think of the follow-up period and to describe: a time they drank and did not drink water, how effortful/effortless drinking water was over the follow-up, how successful/unsuccessful they felt they were at drinking the three extra glasses, anything that hindered and anything that helped them drink water, how helpful/unhelpful they found the study instructions, and whether they would continue to drink more after the study ended. Control participants were also asked to describe any

techniques they used or felt would have been helpful upon reflection. Every question had a prompt for the participant to explain their answers further.

2.3. Procedure

Participants completed the baseline measures on the morning of Monday 7th June. Participants were invited to complete the drinks diaries from 6 p.m.–11 p.m. on Monday 7th June - Friday 11th June. The drinks diary on Friday also included the qualitative survey. Participants in the intervention group were instructed only to complete the drinks diary once their final implementation intention situation had occurred.

The initial data collection time of the drinks diaries and qualitative survey needed to be changed during data collection to reduce attrition. Participants with incomplete data were messaged as follows.

1. At 8 a.m. the next day, informing them that they still needed to respond and to do so by 12 p.m. that day.
2. At 12 p.m., informing them that they needed to respond by 4pm that day or their submission would be classed as missing.
3. At 4 p.m., informing them that data collection was finished and that they had a final chance to catch up on the drinks diary using an anonymous Qualtrics link by the end of the day.

In all messages, we reiterated that payment was based upon completing all surveys. Most participants responded by 11 p.m. each night. Most who missed the 11 p.m. close responded by 12 p.m. the next day. Six participants used the link to catch up. All participants were paid £5.50.

2.4. Analysis

We ran the confirmatory quantitative analysis before the qualitative analysis, as we felt the qualitative component could provide potential explanations for the trends seen in the quantitative data. Therefore, we wanted to have insights into the intervention effect and the change in water intake over time before starting the qualitative analysis. The exploratory quantitative analyses were conducted in tandem with the qualitative analyses. All exploratory analyses are clearly outlined as such in the results section. For additional exploratory analyses, see the OSF.

All quantitative analyses were conducted in R (R Core Team, 2014). We checked our randomization approach by assessing the differences between groups across all demographic and baseline variables. There was a small difference in education demographic between groups; however, including this as a covariate in our models did not change our results. Therefore, no additional demographic or baseline measures were used in our models. See supplemental analysis on the OSF for details.

During descriptive analysis and visualization, we realized that recording the water intake per each of the 17 situations, per day, per participant led to a high proportion of zeros (See Fig. 2). The zeros in our data could have been caused by the situation not occurring instead of the participant not drinking water in the situation. However due to limitations in our data collection methods, there is no way of knowing the cause of the zeros. Although this could have inflated the true zeros in our data, the other data features suggested we had semicontinuous data. We used a two-part model for our intake analyses in line with recommendations on analyzing semicontinuous data (Baldwin, Fellingham, & Baldwin, 2016; Boulton & Williford, 2018).



Fig. 1. Reference picture for meaning of standard glass size.

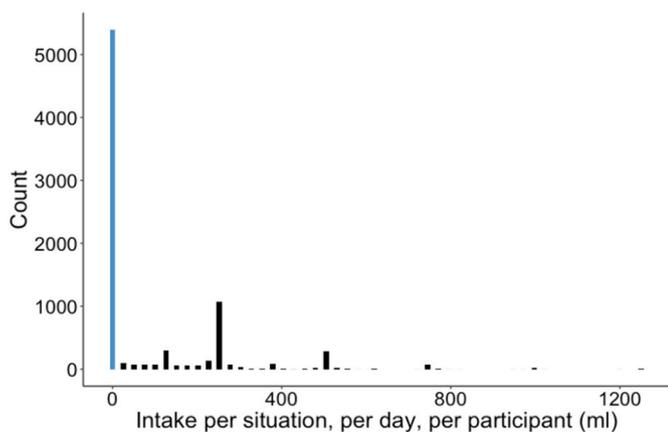


Fig. 2. Histogram of water intake per situation, per day, per participant. *Note.* The histogram shows the number of observations for each amount of water intake per situation, per day, per participant. Observations with intake = 0 ml are blue, and observations with intake > 0 ml are black.

The first model was a logistic mixed effect model. We created a new binary drinking occasion variable from the water intake per situation, per day, per participant (ml) variable. A non-drinking occasion, 0, was defined as water intake per situation, per day, per participant = 0 ml. A drinking occasion, 1, was defined as water intake per situation, per day, per participant > 0 ml. The second model was a linear mixed-effects model and modelled only the amount of water intake per situation, per day, per participant for the drinking occasions (i.e., intake > 0 ml). The random-effects structures for both models did not deviate from the preregistration.

We used Reflexive Thematic Analysis (Braun & Clarke, 2008, 2019, 2021; Clarke, Braun, & Weate, 2016) in NVivo (Mac Version 12) to generate and outline tendencies in the qualitative data. We situated the analysis within critical realism, which argues that people understand and represent reality through their knowledge, language, culture, and experience (Fletcher, 2017). We viewed participants' responses as their experience of what drives their water drinking behavior. We also treated the data from control and intervention participants as one data set initially to not inadvertently overemphasize between-group differences.

AR first read and reread the data, making annotations of her initial thoughts. AR then coded the data with mainly descriptive codes derived from the data. However, coding was shaped by AR's prior knowledge. For example, AR was familiar with the distinction between preparation

and performance (Gardner, Rebar, & Lally, 2019) before this analysis, which was noticeable in their coding. AR reviewed and edited their coding until the data was coded consistently. They then assessed the evidence within each code by group to see whether there were differences between the control and intervention participants' experiences.

AR grouped codes that had similar core ideas. They then reviewed the data within the groups of codes while considering the research question to generate tendencies. AR also reinterpreted the tendencies they generated, considering theoretical concepts within the literature (e.g., habit) to generate potential causal explanations and the conditions necessary for these causal mechanisms to create the tendencies they generated. AR then generated themes that accurately represented the data and collected supporting quotes as evidence.

AR kept a reflexivity journal throughout the analysis process to assess how their water drinking behavior and prior research knowledge impacted their analysis. AR and EP also had recurrent meetings where AR's analysis was discussed, and alternative interpretations considered.

3. Results

3.1. Assessing the impact of the intervention on water intake during follow-up

The mean average daily water intake during the follow-up was higher in the intervention group ($n = 47, M = 1667 \text{ ml}, SD = 729 \text{ ml}$) compared to the control group ($n = 48, M = 1422 \text{ ml}, SD = 717 \text{ ml}$). The mean difference between groups was 245 ml. See Fig. 3. The mean difference between the groups followed a downward trend over the five days (see exploratory analyses on OSF)

3.1.1. Model 1: Drinking occasion logistic mixed effects model

To test our main hypothesis that implementation intentions would increase intake during the follow-up, we first used a logistic mixed effects model to model the binary drinking occasion data summarized in Table 3.

Table 3
Summary of drinking occasion data per group.

Group	N Observations	N Non-Drinking Occasions	Prop of Non-Drinking Occasions
Control	4080	2771	0.68
Intervention	3995	2625	0.66

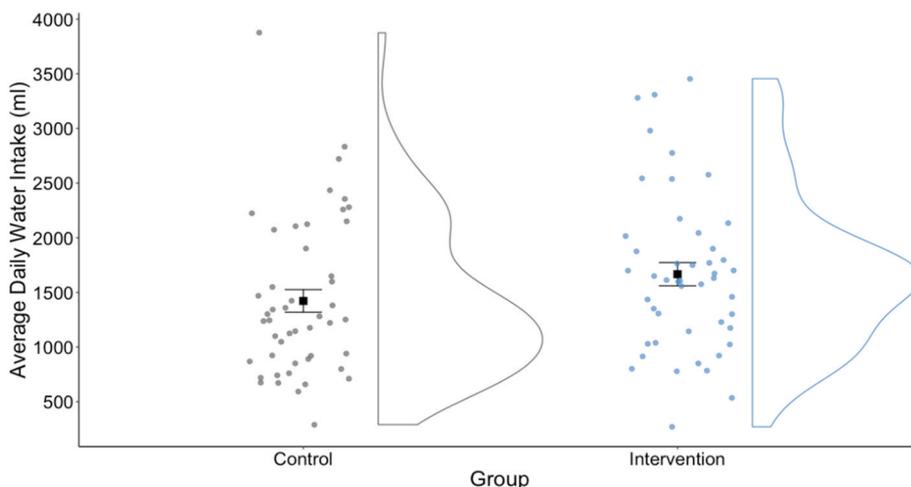


Fig. 3. Average daily water intake over the follow-up per group. *Note.* Per group: each circular point shows a participant's average daily water intake over the follow-up. The density distribution to the right of the circular points shows the data distribution, and the black squares show the mean average daily water intake with $\pm SE$ error bars.

Table 4
Drinking occasion logistic mixed effects model summary.

Fixed Effect	Estimate	SE	Significance test (one-tailed)	
Intercept	-1.41	0.34		
Group	0.14	0.23	$z = 0.60, p = 0.274$	
Baseline Intake	0.0006	0.0003		
Random Effect		Variance	SD	Correlation
Participant	Intercept	0.99	0.99	
	Situation	0.94	0.97	
	Slope	0.14	0.37	-0.37
Day	Intercept	0	0	
	Slope	0.009	0.097	-

Note. We fit the mixed-effects model using a maximal random effects structure (Barr, Levy, Scheepers, & Tily, 2013) and Restricted Maximum Likelihood. We calculated the p-value using the Kenward-Roger approximation as this is one of the most conservative approaches (Luke, 2017). All of this was done using the R package lmerTest (Kuznetsova, Brockhoff, & Christensen, 2017). Significance is not reported for the intercept or baseline intake fixed effects as we had no hypotheses related to these fixed effects.

The model is summarized in Table 4. The group fixed effect suggests that the odds of having a drinking occasion over the follow-up increased by 1.15 times (i.e., $e^{0.14}$) for the intervention group compared to the control. The probability of observing the data that produced this group effect was high, assuming that the null hypothesis was true ($p = 0.274$). From the random effects, we see that participants accounted for the most variance, followed by situations. Days accounted for little variance once we accounted for the other fixed and random effects, indicating that there was little to no variation in drinking occasion across the days.

3.1.2. Model 2: Drinking Occasion Water Intake linear mixed effects model

To further test our main hypothesis that implementation intentions would increase intake during the follow-up, we used a linear mixed effect model to model the continuous drinking occasion intake data shown in Fig. 4. The mean drinking occasion intake amount was higher in the intervention group ($n = 1370$ observations, $M = 286$ ml, $SD = 172$ ml) compared to the control group ($n = 1309$ observations, $M = 261$ ml, $SD = 184$ ml) by 25 ml.

The model is summarized in Table 5. The group fixed effect suggests that the intervention group drank 13.59 ml more per situation, per day than the control group over the follow-up. The probability of observing the data that produced this group effect was high under the assumption that the null hypothesis was true ($p = 0.257$). From the random effects, we see that again, participants accounted for the most variance followed by situations and then days.

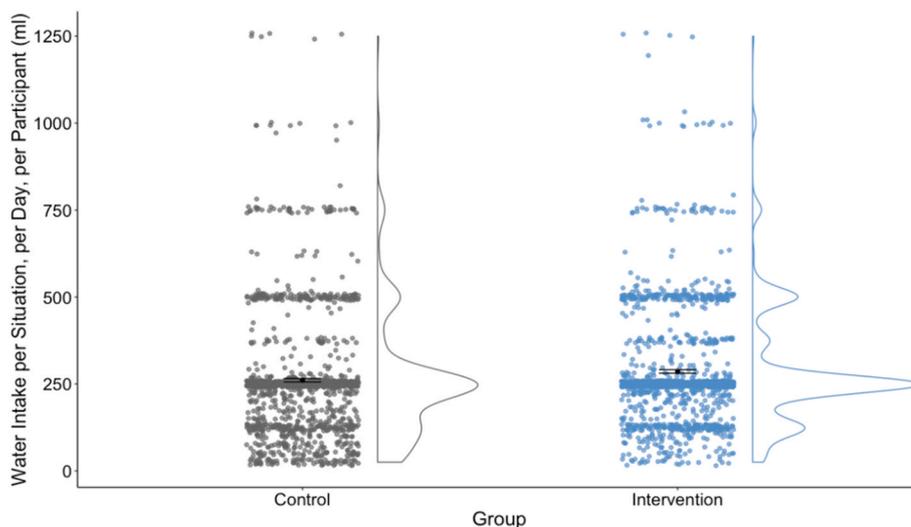


Fig. 4. Drinking occasion water intake per situation, per day, per participant over the follow-up per group. Note. Per group: each circular point shows the water intake of a participant, on one of the five days, in one of the 17 situations over follow-up, the violin shape to the right of the circular points shows the distribution of the data, and the black squares show the mean average daily water intake, with $-/+ SE$ error bars. The plot only shows data points where water intake per situation, per day, per participant >0 ml because the linear model models the amount of intake assuming a drinking occasion has occurred.

Table 5
Drinking occasion water intake per situation, per day, per participant model summary.

Fixed Effect	Estimate	SE	Significance Test (one-tailed)	
Intercept	229.55	27.19		
Group	13.59	20.65	$t(71.13) = 0.66, p = 0.257$	
Baseline Intake	0.05	0.02		
Random Effect		Variance	SD	Correlation
Participant	Intercept	6874.70	82.91	
	Situation	3909.10	62.52	
Day	Slope	1243.40	35.26	-0.29
	Intercept	228.30	15.11	
	Slope	70.40	8.39	-1.00

Note. We fit the mixed-effects model using a maximal random effects structure (Barr et al., 2013) and Restricted Maximum Likelihood. We calculated the p-value using the Kenward-Roger approximation as this is one of the most conservative approaches (Luke, 2017). All of this was done using the R package lmerTest (Kuznetsova et al., 2017). Significance is not reported for the intercept or baseline intake fixed effects as we had no hypotheses related to these fixed effects.

In sum, the quantitative analyses show that in contrast to our hypothesis, implementation intentions to drink a glass of water in three additional situations in did not meaningfully increase water intake.

3.2. Exploring participants' lived experience of increasing their water intake

We generated two themes from the qualitative data analysis, which we will present next. Table 6 provides an overview of the themes and subthemes, and the subsequent section presents each theme in more detail, followed by supporting quotes in tables. We give supporting quotes from the control and intervention participants evenly to illustrate that our interpretations were similar across the control and intervention groups. Any differences we interpreted between these two groups are clearly outlined. We use the word “some” to indicate less than 24 participants, “many” to indicate 30–40 participants, and “most” to indicate that over 48 of the 96 participants mentioned something relevant to the interpretation we are making.

3.2.1. Theme 1: Remembering, preparing, drinking & the process of drinking water

During the follow-up, the process underlying participants' water drinking occasions involved the following stages: remembering to either prepare or drink water, preparing water, and drinking water. Within this

Table 6
Theme overview.

Theme		Summary
Theme 1: Remembering, Preparing, Drinking & The Process of Drinking Water	Subtheme 1.1: Remembering Comes Before Preparing and Drinking	Remembering seems to be an important stage in the process of drinking water. This interpretation was supported by most participants directly mentioning problems remembering to drink water during the follow-up. Additionally, many participants indirectly supported this interpretation when they mentioned relying on external reminders to help them remember and that performing other, more valued behaviors made them forget to drink water. Surprisingly, the intervention participants mentioned problems remembering to drink water and using external reminders just as frequently as the control participants. This suggests that the implementation intentions did not work as we assumed they would, based on the current literature.
	Subtheme 1.2: The Difference Between Preparing and Drinking	Participants mentioned that their water drinking was helped or hindered based on whether the preparation stages had been completed or not, therefore highlighting the important distinction between preparing and drinking. Additionally, most participants found the preparation stages rather than the drinking stage of this process effortful. Recognizing the difference between preparing and drinking also showed a limitation of the current format of the implementation intentions that participants created. These statements focused solely on drinking water, and as a result, participants did not fully consider the preparation required for drinking a glass of water in their implementation intention situations. Finally, some aspects, such as taste preferences or distraction, helped or hindered both preparing and drinking.
Theme 2: The Need for Motivation to Engage in the Process of Drinking Water	Subtheme 2.1: Appraisals of the Study Task and Feelings of Accountability.	The degree to which participants experienced the study task as a goal, as well as how helpful, manageable, and clear this goal was, impacted their motivation to engage in the process of drinking water. Surprisingly, control

Table 6 (continued)

Theme	Summary
	participants appraised the study task just as positively as the intervention participants, which could explain why most participants regardless of group increased their water intake during the follow-up. Additionally, feelings of accountability, whether external or internal, impacted participants motivation to engage in the process of drinking water and achieve the goal. Participants who expressed feelings of accountability seemed more motivated to achieve the goal.
Subtheme 2.2: Education and Reward Provided Motivation.	The education component motivated participants to engage in the process of drinking water as it gave them a reason for increasing water intake and knowledge of the potential benefits they might experience. Additionally, participants who experienced reward more generally seemed more motivated to engage in this process and continue to so once the study ended, compared to participants who experienced little or no reward.

process, the order and frequency of these stages varied depending on the nature of a participant’s water drinking occasion. For example, to drink water between tasks at work, a participant might need to *remember* this goal before they start working to *prepare* a glass of water to sit on their desk. Then, when the participant is between tasks, they would need to *remember* to drink from the glass on their desk before *drinking* from it. Alternatively, a participant might need to *remember* this goal once they have finished a task at work to get up from their desk and *prepare* a glass of water before immediately *drinking* from it. Participants who completed one stage did not always complete the next, as participants found some of these stages effortful. For example, participants mentioned that drinking water took conscious thought, subjective effort, and time, suggesting that they did not engage in this process automatically.

3.2.1.1. Subtheme 1.1: Remembering comes before preparing and drinking. Most participants explicitly mentioned the need for remembering in the process of drinking water, and many participants mentioned this in the context of forgetfulness and the need for conscious thought. Problems remembering to drink more water was the most common barrier hindering control and intervention participants during the follow-up.

We did not expect to interpret intervention participants as having problems remembering to drink more water. We assumed that when these participants encountered their chosen implementation intention situations, these situations would act as a reminder to drink water. However, nearly half of the intervention participants explicitly mentioned problems remembering their implementation intentions, suggesting that implementation intentions did not work as we assumed they would. Some intervention participants who found the implementation intentions helpful still needed external reminders to help

them remember their implementation intentions.

Many participants reported relying on external reminders. Most commonly, this was the sight of a preprepared glass or bottle of water and sometimes the daily drinks diaries. However, although external reminders were helpful, participants seemed likely to forget to drink water when their external reminder was not present or disrupted. Participants mentioned relying on external reminders frequently, indicating that remembering is an important part of the process and that external reminders can help with this stage.

Intervention participants discussed using external reminders as frequently as control participants. Again, we had not expected the intervention participants to require additional reminders. When we asked intervention participants to describe an instance when they drank water, many of them described drinking water in an implementation intention situation. However, when we asked them *why* they drank water in this instance, most participants did not mention that the implementation intentions helped. Only a few responses indicated that the implementation intention situations acted as a reminder. The frequency that intervention participants instead relied on other external reminders indicated that the implementation intentions did not help participants remember to drink water as well as we had assumed they would.

Many participants also described the need for remembering when they mentioned that performing other, more valued behaviors, such as work or childcare, during the day made them forget to drink water. Participants' responses in this context also highlighted the need to remember to drink water on those occasions when preparing and drinking water are feasible. Some participants expressed that they remembered drinking water but did not stop their other, more pressing activities to prepare or drink water. Performing other, more valued behaviors during the day seemed to explain why forgetting was so common in participants' experiences. See Table 7 for supporting quotes.

3.2.1.2. Subtheme 1.2: The difference between preparing and drinking. Once participants remembered to drink water, they either had to do preparation behaviors (e.g., filling a glass, carrying around a water bottle) or drink previously prepared water. The difference between preparing and drinking water is important because preparation helped participants drink water when it had been done but hindered them from drinking water when it had not. Many participants also alluded to the difference between preparing and drinking when they mentioned effort being related to a specific stage or different between the two stages.

Some participants felt that drinking water was an effortful stage in the process of drinking water, and this was usually because these participants did not like the taste of water. However, participants mentioned the drinking stage being effortful less frequently than the preparation stages being effortful. Many participants felt that the effort they needed to perform preparation behaviors stopped them from completing the preparation stages and caused them not to drink water. From this interpretation, we identified a limitation of the implementation intentions that we had asked participants to create.

Intervention participants created implementation intentions that only covered the drinking stage in the process of drinking water. It is typical for implementation intentions to focus on the performance of a behavior, such as drinking water, rather than the preparation behaviors, such as carrying a bottle of water around at work, that are needed for performance to happen. However, creating implementation intentions in this way assumed that the preparation stage of water drinking had already been done. Therefore, our intervention participants may not have fully considered the preparation stages or barriers involved in drinking a glass of water in the situations they chose when they created their implementation intentions.

Indeed, a key barrier to water intake for many intervention participants was that some of the situations they chose were not practical when they tried to drink water in them. Additionally, many intervention

Table 7
Subtheme 1.1 supporting quotes.

Interpretation	Supporting Quote	Participant, Group
Remembering takes effort	"I found it an effort to keep remembering to have a glass of water during the day"	P99, Intervention
Forgetfulness and need for conscious thought	"I just find it hard to remember"	P57, Control
	"It felt relatively effortful, as I often forget to drink water during the day"	P4, Control
Intervention participants not remembering/need help to remember their implementation situation	"It wasn't easy. I had to remind myself every time"	P74, Intervention
	"I think I planned to drink water when taking medication, but I simply forgot to do this. I normally take my medication dry"	P40, Intervention
External reminders aid remembering: preprepared water and drinks diaries	"[The implementation intention] was helpful [...] I wrote the plan on a notebook to keep my mind on it"	P74, Intervention
	"I made sure my glass on my desk was always filled on most days to encourage me to keep sipping the water. Keeping it in my vision"	P22, Control
External reminder not present or disrupted then remembering impacted	"Leaving a full pint glass in the kitchen and having some water every time I noticed the glass did help ... seeing it reminded me to drink and it was easy to track my intake"	P14, Intervention
	"Usually when I did the survey it would remind me to drink a glass"	P88, Control
External reminder aid remembering: implementation intention situation	"The survey reminded me each day about drinking"	P30, Intervention
	"I then tried to make sure I drank while at my desk at work. Friday was harder as that is my day off"	P36, Control
Performing other, more valued behaviors can lead to forgetting	"I've missed a day or two of drinking extra water whilst making dinner purely because I didn't cook on those occasions"	P78, Intervention
	"When I was on my porch, leaving or entering my house I'd remember 'drink water'. That helped me to remember and go get some water"	P100, Intervention
Remembering while performing other, more valued behaviors is not effective	"I definitely started to drink more water in the afternoon and evenings by associating it with different activities and combining them together"	P72, Intervention
	"I've had a very busy week and so I often try to get so much done in a small amount of time that I forget to meet my basic needs of thirst etc."	P29, Control
Remembering while performing other, more valued behaviors is not effective	"Whilst eating lunch - I am so busy making lunch for the children that I sometimes forget to tend to my own needs!"	P21, Intervention
	"Quite often I think about having a drink but I'm nap trapped or breastfeeding my baby. By the time I am free, the thought of getting a drink has slipped my mind"	P26, Control
	"I didn't do so well in the morning when I am generally very busy and so I probably only had a few mouthfuls rather than a full glass but it definitely worked for the rest of my day when I had more time to think about what I was doing"	P63, Intervention

participants said they would have changed their choices after learning more about their water drinking behavior. These insights suggest that the implementation intentions did not help participants fully consider the preparation stages and barriers of drinking water in a situation, and that participants needed to understand their water drinking behavior better before trying to create implementation intentions. Additionally, implementation intentions did not help participants overcome barriers to drinking water when these were encountered.

Although it is important to recognize the difference between preparing and drinking, some aspects seemed to help and hinder both

Table 8
Subtheme 1.2 supporting quotes.

Interpretation	Supporting Quote	Participant, Group
Preparation helps drinking when it was been done and hinders drinking when it has not	"I made sure I always had water in my drink bottle. Usually, I can let it sit empty for hours, so this helped"	P35, Control
	"I thought I could drink a glass of water by remembering to take a glass with me to bed for the morning, but I was quite forgetful with this"	P72, Intervention
Effort differs between preparing and drinking	"the effort came in actually making myself physically go and get a drink rather than just drinking it"	P64, Control
Drinking is effortful	"It was a decent amount of effort for me, primarily due to my disliking for water"	P34, Control
	"Because I don't really like water, it took some effort to make sure I drank it"	P40, Intervention
Preparing is effortful	"I thought I should drink water before going to bed because it was a hot night [...] but I was too tired to go and get a drink from downstairs, so I didn't bother"	P7, Control
	"The only thing that hindered me was making sure I was in reach of fresh water"	P48, Intervention
Situation chosen for implementation intention not practical	"I had planned to drink more water between tasks at work, but I failed to do so [...] it is impractical to carry water around with me doing my job"	P18, Intervention
Choice of implementation intention situation could have been better	"I think my choices of where to focus extra effort weren't as good as they could have been. I should have chosen times like whilst working or whilst watching television to galvanize myself a bit more"	P78, Intervention
Barriers to both preparing and drinking: performing other, more valued behaviors and access to preferred drink choice	"at work I needed a drink of water and had none left at my desk. I didn't have the water because I was busy and didn't want to break my concentration"	P10, Control
	"I often remembered to do so but chose to drink coffee/soft drinks instead because I prefer them"	P18, Intervention
Facilitators to both preparing and drinking: less subjective effort needed, liking water, and using their own strategy to help increase intake	"possibly the first day it felt like more like a chore but I found it to actually be really easy and I just started getting into a routine of doing it"	P60, Intervention
	"I drank in excess of the required amount and found that I enjoyed it"	P76, Control
	"adding lime to water makes it more of a treat"	P19, Intervention

stages. Despite participants remembering to drink water, performing other, more valued behaviors (e.g., work, parenting or socializing behaviors) and having access to a preferred drink frequently hindered them from preparing and drinking water. In addition, participants feeling like the process of drinking water became less effortful over the follow-up, liking water, or producing their own strategy to increase water intake helped them to both prepare and drink water. However, participants discussed the aspects that helped prepare and drink water far less frequently than the aspects that hindered them. See [Table 8](#) supporting quotes.

3.2.2. Theme 2: The need for motivation to engage in the process of drinking water

Only if participants were motivated to engage in the process of drinking water did they put in the effort, conscious thought, and time it took to remember, prepare, and drink more water during the follow-up. The following subthemes show that the participants' appraisal of the study task, feelings of accountability, and their experience of the education component and reward, impacted their motivation to engage in this process.

3.2.2.1. Subtheme 2.1: Appraisal of the study task and feelings of accountability. Most participants seemed to appraise the study task of drinking three additional glasses a day as a goal. How participants appraised the nature of this goal impacted how well it motivated them to engage in the process of drinking water. Most participants judged the goal on whether it was "helpful" or not, likely due to us asking them to describe how helpful or unhelpful they found they study task instructions. However, some participants' judgements on the helpfulness of the goal were more detailed and covered whether the goal was manageable or clear. Participants who judged the goal positively seemed more motivated to engage in the process of drinking water during the follow-up.

We had not expected control participants to judge the study task positively because we had not given them guidance or strategies for reaching the goal (see Participant 17). Therefore, to illustrate the strong nature of this finding, in [Table 9](#) we intentionally provide quotes from control participants who described the task as helpful. Overall, the frequency of participants' judgements on whether the goal was helpful, manageable, and clear was similar across control and intervention participants. This lack of difference could partly explain why we found that most participants, regardless of their group, increased their water intake during the follow-up. See [Fig. 5](#).

Some intervention participants described using external situations as reminders for the implementation intentions. This approach was helpful for some of the intervention participants; it was not helpful for others. The intervention participants who did not find this approach helpful seemed to situate their water drinking in reaction to thirst, so using an external reminder was unnatural. This interpretation shows that we may need to give participants more context as to why we used external situations as cues in implementation intentions. For example, we have found that relying on thirst as a cue for drinking water can be unreliable due to the lack of awareness and suppression of thirst cues ([Rodger et al., 2021](#)).

Some participants also expressed feeling a sense of accountability, which motivated their engagement in the process of drinking water. Some of these participants mentioned that the study environment motivated them, suggesting that they felt externally accountable to us, or to the study more generally, to achieve the goal. These participants' awareness that they were part of a study seemed high during specific instances of water intake during the follow-up. A few participants suggested that they felt internally accountable to themselves for achieving the goal. For some, the drinks diaries seemed to create feelings of accountability. One participant even thought that the drinks diaries signaled that someone other than themselves was invested in whether

Table 9
Subtheme 2.1 supporting quotes.

Interpretation	Supporting Quote	Participant, Group
Participants appraised study task as a goal	“it gave me a target”	P12, Control & P37, Intervention
Judgements of the study task: helpfulness	“It [the study task] was helpful made you more mindful on what you was and when you were drinking water” “I don’t think it was very helpful. I can’t remember any tips on how to do it. Although I did try to do it.”	P1, Control P17, Control
Judgements of the study task: manageableness and clarity	“It’s a realistic aim, not out of reach but a good start at increasing” “The instruction was helpful as I knew exactly how much I had to drink”	P26, Control P76, Control
Participants who judged the task positively seemed more motivated	“It was helpful to have this as a goal. I thought it was quite a lot more to drink, but just the thought of having to drink a larger quantity was helpful to motivate me”	P7, Control
Helpfulness of using external situations in implementation intentions	“I need to drink more water and have made efforts to change this but I have never stopped to think about the specific times of the day that I could and should be attempting to drink more water” “I found the plan to drink water at specific times very artificial and difficult as I drink water whenever I feel thirsty throughout the day”	P18, Intervention P24, Intervention
External accountability to meet the goal	“I felt thirsty in work [...] Normally I would probably ignore the feeling [...] but as I was trying to drink more water because of this study I decided to go and get a glass of water to drink immediately”	P64, Control
Internal accountability to meet the goal	“Because I had planned to do so, I wanted to achieve this goal”	P40, Intervention
Source of accountability to meet the goal was unclear	“I drank more water as signing up to the study made me more conscious and made me accountable to drink more”	P59, Intervention
Drinks diaries created a sense of accountability	“Knowing that I was on this study and had been asked to aim to increase my water intake and report back on it really helped me to motivate myself to make a drink rather than just think about it” “The feeling of needing to be accountable to myself so I could fill out the diaries accurately” “I think being asked how much I drank helped. It was like someone alongside me who cared about it”	P64, Control P78, Intervention P56, Intervention
Study task did not them a goal or they did not feel accountable to the goal	“I did not commit to the plan as I did not find it very important” “I feel [the study task] was helpful but was only a suggestion by using the word ‘try’. It’s made me think more about my water intake, but the	P83, Intervention P68, Control

Table 9 (continued)

Interpretation	Supporting Quote	Participant, Group
	wording didn’t make me feel accountability or any ownership over this”	

they achieved the goal or not, and this feeling motivated them. Some participants discussed feeling accountable, but the cause of these feelings was unclear.

Finally, a few participants mentioned that the study task did not give them a goal to achieve or that they did not feel accountable to achieve the goal when they explained why they did not increase their intake over the follow-up. This trend provides further evidence that how participants experienced the study task and their feelings of accountability can impact their motivation to engage in the process of drinking water. See [Table 9](#) for supporting quotes.

3.2.2.2. Subtheme 2.2: Education and reward provided motivation. The education component of the intervention seemed to motivate participants to engage in the process of drinking water. Although we did not ask participants directly about their thoughts on the education component, most participants mentioned its impact during their responses. The brief educational quiz that we gave participants suggests that most participants lacked hydration knowledge or were uncertain about their hydration knowledge. Of the 8 quiz questions, participants answered on average 2.14 (*SD* = 0.78) questions incorrectly and 4.95 (*SD* = 1.74) uncertainly. Overall, the mean score was 3.79 (*SD* = 2.39), where 16 would indicate a participant answered all questions correctly with certainty (See [Fig. 6](#)). Thus, the education component may have taught participants useful new knowledge about hydration.

Some participants felt that the education component was helpful because it gave them a better understanding of why we asked them to drink more during the follow-up period. It also taught or reinforced the importance of drinking water. Many participants suggested that the education component gave them knowledge of the potential benefits they could experience from drinking water, which motivated them to engage in the process. Knowing the potential benefits seemed to allow participants to experiment with potential rewards they might experience. This knowledge also allowed participants to learn the connection between reward and drinking water, such as realizing that they were less likely to have a headache when they drank water. The potential to experience reward, or learning that drinking water led to reward, motivated participants to drink water.

Participants were also motivated by experiencing reward that was not linked to the education component. When we asked participants to describe a water drinking occasion and explain why they drank water during this occasion, many participants mentioned that situated rewards or tangible benefits motivated them to drink water. However, some participants also mentioned the idea of cost versus benefit when discussing their experience of trying to increase water intake. An increase in toilet breaks was the most common cost that participants experienced as a barrier to drinking more.

Participants’ responses on whether they would continue to try and drink more water after the study ended also showed the importance of reward. Participants who mentioned experiencing reward from increased intake were more likely to have a positive outlook on continuing this after the study. They were also more likely to mention this before seeing the question that explicitly asked about this. However, participants who experienced little or no reward while trying to increase their water intake had a negative outlook on continuing this after the study and focused on the perceived struggles associated with doing this. See [Table 10](#) for supporting quotes.

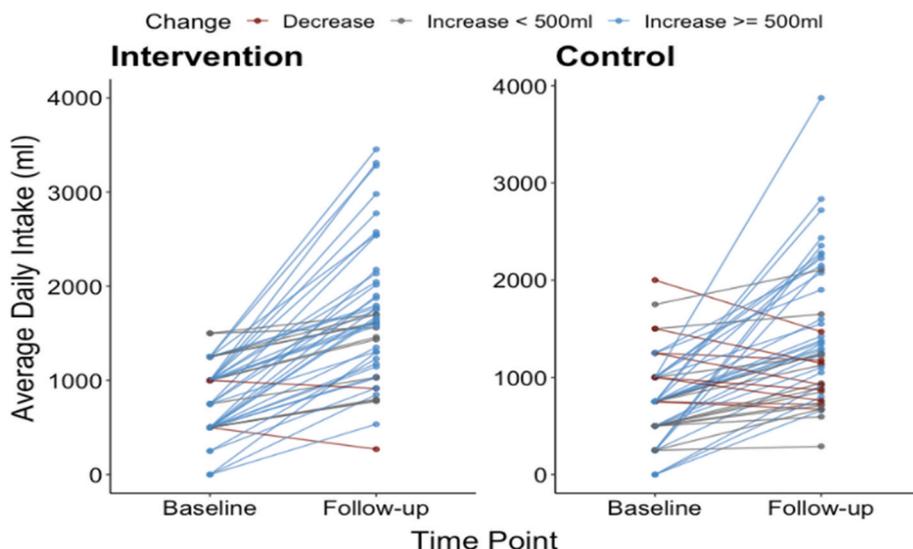


Fig. 5. Participants Average Daily Baseline vs. Follow-up Water Intake per Group. *Note.* The lines show the change in each participant’s average daily water intake from baseline to follow-up. They are colored by whether the change was a decrease, an increase <500 ml or an increase \geq 500 ml. Control participant 76 had the largest change in water intake from baseline (1000 ml) to follow-up (3875 ml) and reported that they had been “meaning to drink more water recently following having kidney stones and have found this study a useful reminder to do so.” Having prior intentions that aligned with the goal seemed to motivate participants to engage drinking more water: “I had recently had conversations with friends about my water intake, so this study was perfect timing to help me try it out!” [P94, Intervention, Change in water intake \geq 500 ml].

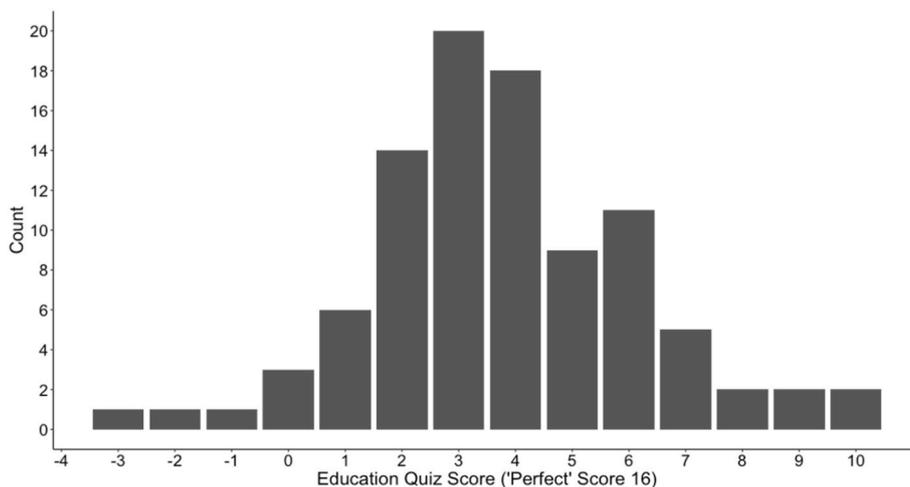


Fig. 6. Bar chart of education quiz scores. *Note.* This bar chart shows the number of observations for each score on the education quiz. A ‘Perfect’ score of 16 would indicate a participant answered all questions correctly with certainty.

3.3. Exploring the impact of implementation intentions on water intake

Throughout the qualitative data analysis, our interpretations challenged many of our assumptions on how implementation intentions would work. Therefore, we explored the intervention participants’ average daily water intake during the follow-up based on whether that intake came from an implementation intention situation or a non-implementation intention situation compared to their baseline daily water intake. Fig. 7 suggests that most of the intervention participants increased their water intake during the follow-up partly by drinking in non-implementation intention situations. This could indicate that these participants drank more water in situations where they already drank water or drank water in a new situation that was not the implementation intention situation. Unfortunately, our data does not allow insight into which is more likely. The figure also suggests that some participants may have moved their water intake from non-implementation intention situations to implementation intention situations during the follow-up rather than increasing their water intake.

4. Discussion

Asking participants to create implementation intentions to help them drink three additional glasses of water a day did not seem to meaningfully increase the odds of having a drinking occasion, or the water intake amount during a drinking occasion compared to asking participants to simply drink three additional glasses of water a day. Intervention participants also increased their water intake partly by drinking in non-implementation intention situations. The descriptive mean of average daily water intake for the intervention group was just under one glass (i. e., <250 ml) higher than the control group over the follow-up. Although these differences were smaller than what we powered for or expected, the difference between the control and intervention group was in the predicted direction. This could indicate that the intervention strategy can be effective if improvements are made to the intervention, such as improving the implementation intentions format. The lack of intervention effect could also indicate that simply educating participants on the importance and potential benefits of water drinking is enough to increase intake. However, this remains to be tested directly. As outlined below, other aspects of the research design (e.g., drinks diaries) likely played a role (i.e., accountability) in many participants’ increased

Table 10
Subtheme 2.2 supporting quotes.

Interpretation	Supporting Quote	Participant, Group
Education gave participants reason why they should drink more and taught them the importance of hydration	“Very helpful as it gave a goal and a reason to drink more”	P91, Control
	“[the education component] made me realise that I have not been drinking as much as I should be”	P14, Intervention
Experimenting with potential rewards	“I found that it was always on my mind to drink more but I was interested to find if I would feel any changes in my health by increasing my intake”	P41, Control
	“I drank water when I was stressed out. It wasn't in my plan, but I thought it would help calm me down and refocus; it worked”	P19, Intervention
Learning the connection between reward and drinking water	“It was helpful because it helped me to avoid strong headaches I normally get”	P84, Control
	“I drank water as planned after getting into the house [...] I had the start of a headache and I think having the water helped ease it”	P30, Intervention
Reward motivated instances of water drinking during the follow-up	“Drinking water with my dinner felt easier to do because I thought it might help me feel more full and less likely to snack on junk food after my meal. Thinking that way helped me to remember to drink water with my dinner”	P18, Intervention
	“I drank in excess of the required amount and found that I enjoyed it. It made me feel healthier and more in control of the state of my body”	P76, Control
Cost versus benefit of increasing water intake	“I tried but the benefits didn't seem to outweigh how often I needed to urinate”	P35, Control
	“I plan to drink water but I don't like it but I know I need it to help my body”	P43, Intervention
Cost: Increased toilet breaks	“It was a little bit of effort to refill water which made it a bit irritating and also made me urinate more”	P46, Intervention
	“I have to go out of my way, leaving my shop unattended to go and get a drink, and I am put off as I am likely to need to pee after drinking more”	P45, Control
Experience of reward then more likely to try and continue drinking water	“Definitely. It's helped to stop me snacking and I'm sure I'll see further benefits in time, like improved skin”	P73, Control
	“Yes, it feels better to have more water. Especially since I have mild hay fever [...] I feel it helps a lot with the symptoms.”	P100, Intervention
No experience of reward then less likely to try and continue drinking water	“I won't try and drink any more water as I don't feel any benefit to myself”	P25, Control
	“I was impressed with how well I did I do want to try and continue it but if I'm honest I'm not sure how long it will last. I need the toilet a lot more and it's not convenient for me when I'm in and out the house all day doing school and nursery runs.”	P53, Intervention

intake.

We included qualitative questions to assess participants' experiences of trying to increase their water intake to learn more about the mechanisms of implementation intentions affecting goal-directed behavior outside the laboratory. Our findings suggest that the process underlying drinking occasions involves three stages: remembering, preparing, and drinking. Unexpectedly, issues with remembering was the most common barrier to all participants drinking water during the follow-up. Intervention participants experienced problems remembering and used external reminders just as frequently as the control participants. This suggests that the implementation intentions did not help with remembering. Many participants used external reminders (e.g., a water bottle) to help them remember, but this did not help when the reminder was disrupted.

Also, unexpectedly, preparing water played a key role. When water had been prepared in time for a drinking occasion, this helped participants drink, but when no water had been prepared, it hindered them, such that no filled glass or bottle was within easy reach. Most participants felt that preparing was more effortful than drinking, and they frequently mentioned effortful preparation behaviors as barriers to drinking water. This insight suggests that the implementation intentions we asked participants to create, which only covered the drinking stage, did not help participants with preparing. Additionally, the implementation intentions did not seem to help participants fully consider the feasibility of drinking water in their planned situation prior to performance or remove barriers to performance once they were known.

Finally, in line with theoretically motivated expectations, participants needed motivation to engage in the process of drinking water. Both intervention and control participants appraised the study task as a goal to strive for during the follow-up, and they engaged more if they found the task helpful. This could explain why most participants, regardless of group, increased their intake with no meaningful intervention effect. Participants who mentioned feelings of external or internal accountability to the study goal also seemed motivated to engage in the process of drinking water. The education component motivated participants to engage this process as it gave them a reason for increasing water intake and knowledge of the potential rewards that they may experience. Experiencing reward, more generally, also seemed to motivate participants to repeat new water drinking behavior.

4.1. Theoretical considerations

4.1.1. Facilitating the “how” of the target behaviour

Implementation intentions are theorized to help people act on their intentions by automatically providing the “where, when and how” of this behavior (Adriaanse, Vinkers, et al., 2011). However, our quantitative and qualitative findings cast doubt on whether this is how implementation intentions affect behavior in field settings, at least regarding water drinking. We found that intervention participants were just as likely as control participants to mention preparation (i.e., the “how” of drinking water) as a barrier. They often mentioned that drinking water in their implementation intentions situations was unachievable in practice due to issues with preparation behaviors (e.g., forgetting or external barriers preventing preparation). The COM-B model, which has been used to understand and change other consumption behaviors such as eating and sustainable diets (Wehbe, Banas, & Papies, 2022; Willmott, Pang, & Rundle-Thiele, 2021), provides an informative perspective on these results (Michie, van Stralen, & West, 2011). It would suggest that the preparation issues indicate intervention participants lacked the capability and opportunity needed for water drinking in their chosen situation, despite our intervention trying to increase these components. Considering this evidence, the implementation intentions did not seem to effectively provide the “how” of water drinking.

It seems to be common practice to have participants create implementation intentions that make the implicit assumption that the object

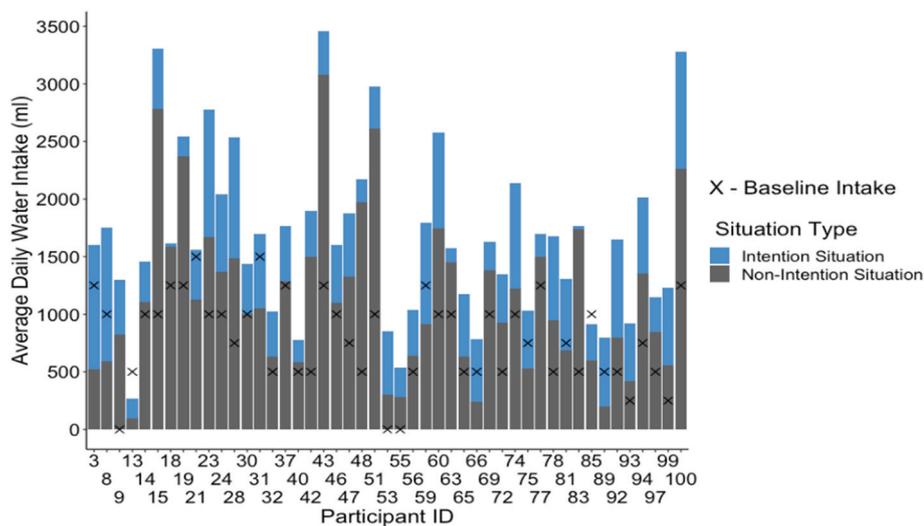


Fig. 7. Intervention participants' average daily water intake during the follow-up.

Note. Each bar shows an intervention participant's average daily water intake, during the follow-up, colored by whether that intake happened in an implementation intention situation or non-implementation intention situation. The "X" on each bar indicates the participant's baseline daily water intake for comparison. This graph illustrates that for many participants, their follow-up water intake that was above their baseline water intake came from both non-implementation intention and implementation intention situations. This suggests that increased intake came not only from drinking in the planned situations.

of their consumption has already been prepared without providing information on how to prepare. Indeed, the example we gave intervention participants, "when I wake up in the morning and walk to the kitchen, I will drink a glass of water," assumes that the person already has the glass of water prepared, or that it can be prepared effortlessly. Although the implementation intention instructions ask participants to imagine themselves doing the specific actions needed to perform the consumption behavior in their chosen situation successfully, our results suggest this may not be sufficient to provide the "how" of consumption behavior.

Gardner et al. (2019) advocate the need for breaking higher-order health behaviors, such as "going to the gym", into the lower-order behaviors, such as "packing gym bag" and "travelling to the gym", that are needed to engage in higher-order health behaviors. Similarly, Phillips and Mullan (2022) discuss the importance of accounting for behavioral complexity when trying to understand and change behavior. They outline that the number of steps involved in preparing and performing the behavior is a key quality of behavioral complexity. Gardner et al. (2019) also distinguish between habitual instigation, habitually deciding to perform an act, and habitual execution, habitually performing an act, with a recent study suggesting that habitual instigation, but not habitual execution, predicts the frequency of simple and complex behaviors (Gardner, 2022). These distinctions can help researchers pick more specific and appropriate target behaviors and cues when developing interventions informed by habit theory (Gardner, 2022; Gardner et al., 2019; Phillips & Mullan, 2022).

These distinctions offer insights into potential changes to the implementation intention format to address the issues that our implementation intentions did not provide the "how" of drinking water. For example, the target behavior in our study was merely drinking, but focusing on preparing, or preparing and drinking, may have been more effective. Indeed, research on a physical activity intervention promoting habitual preparation and performance found that increased physical activity over the follow-up period was due to increased habitual preparation, not performance (Kaushal, Rhodes, Meldrum, & Spence, 2018).

Our findings are also inconsistent with the assumption that implementation intentions mean self-regulatory resources are no longer needed to perform the target behavior (Adriaanse, Gollwitzer, et al., 2011; Bieleke et al., 2021; Wieber et al., 2015). Intervention participants were just as likely as control participants to mention needing conscious thought, subjective effort, and time to drink water. Although implementation intentions may have helped participants remember to drink water, participants still seemed to rely on self-regulatory resources to prepare and drink water. Therefore, the idea that forming implementation intentions creates the same cue-response associations as habits (Adriaanse, Gollwitzer, et al., 2011), does not seem to be

supported by our data.

4.1.2. Picking an effective cue for the target behavior

Implementation intentions are also theorized to be effective because the situation outlined in the implementation intention is easily accessible in memory and cues the target behavior automatically when people encounter the situation (Adriaanse, Vinkers, et al., 2011; Bieleke et al., 2021). However, our findings are not consistent with that view. We found that intervention participants were just as likely as control participants to mention remembering as a barrier to drinking water, and this was the most common barrier. Intervention participants also mentioned struggling to remember to drink water in their implementation intention situations and forgetting their implementation intentions entirely. Indeed, the intake of intervention and control participants did not differ meaningfully during the follow-up. Therefore, implementation intentions did not seem to effectively cue water drinking behavior automatically when participants encountered the implementation intention situations over time.

It is possible that forming three implementation intentions made our intervention less effective. Verhoeven, Adriaanse, de Ridde, de Vet, and Fennis (2013) found that one implementation intention effectively reduced unhealthy snacking, but multiple implementation intentions were not. Our use of multiple plans could have reduced their effectiveness compared to the control by creating only weak situation-water drinking associations. This could explain why intervention participants struggled to remember to drink water in their chosen situations.

However, Stawarz, Gardner, Cox, and Blandford (2020) suggest that relying on a single cue was too limited in their study on starting a routine health behavior. If the participant did not encounter the cue, the behavior did not happen. de Vet, Oenema, and Brug (2011) also found that participants did more physical activity when they created a higher number of detailed implementation intentions. Therefore, it may be that the nature of the cues in our study (e.g., lack of uniqueness and specificity), rather than the number of implementation intentions, caused issues with remembering in the intervention group.

There is evidence that allowing participants to pick their own cue is more effective than cues assigned by the researcher (Adriaanse, Vinkers, et al., 2011). This is in line with our result that some intervention participants did not find the external situations we had provided helpful. However, allowing participants to pick their own cue also assumes that participants can identify and select an effective cue themselves. We found that some intervention participants would choose different situations if they were to do the study again. This suggests that the intervention participants needed to have insight into their own water drinking behavior before they were able to choose an effective cue. This

is in line with prior research showing that participants struggled to form effectively detailed physical activity implementation intentions for themselves (de Vet et al., 2011) and that participants had a trial-and-error period when trying to find an effective cue for a new health behavior (Stawarz et al., 2020). Verhoeven et al. (2013) used a 3-day monitoring diary before getting participants to create their implementation intentions, so that they were able to identify effective cues. A monitoring phase, providing information about the importance of external cues, and providing examples of more specific external cues (Stawarz, et al., 2020) could help improve the effectiveness of implementation intentions to increase water drinking.

4.1.3. The roles of education and reward in implementation intentions

Adriaanse, Vinkers, et al. (2011) suggest that effective implementation intentions need to target a goal-directed behavior hindered by low self-regulatory resources and that people already have underlying intentions to perform. In line with this, our results suggest that education may need to precede planning when people do not (yet) have underlying intentions for the target behavior. Indeed, many of our participants seemed to lack an understanding of the importance and potential benefits of adequate hydration before the intervention. However, the education component motivated the participants to drink more water, suggesting that health education can be a necessary but insufficient intervention component in such cases (Carrero et al., 2019; Vercammen, Frelief, Lowery, Moran, & Bleich, 2018). Other theories of behavior change, such as The Transtheoretical Model of Behavior Change and the COM-B model, also suggest that education is important for individuals who do not intend to change their behavior (Michie et al., 2011; Prochaska, Norcross, & DiClemente, 2013). For example, in the COM-B model, education is thought to increase peoples' capability and opportunity to perform the target behavior (Michie et al., 2011). However, our results would suggest that education can also increase people's motivation to perform water drinking by highlighting potential rewards.

Importantly, our results on reward further suggest that for implementation intentions to be effective, people to experience the target behavior as rewarding once they have performed it (see also Papies et al., 2022). Experiencing reward seemed to motivate participants to engage in the process of drinking water repeatedly. Expectations of reward are argued to strengthen the intention to perform a behavior (Gardner & Lally, 2018) and experiencing reward has been suggested to facilitate water drinking habit formation and maintenance (Rodger & Papies, 2021) as well as habit formation in other domains (Judah, Gardner, Kenward, DeStavola, & Aunger, 2018; McCloskey & Johnson, 2019; Wiedemann, Gardner, Knoll, & Burkert, 2014). The rewards outlined by the education component and experienced by the participants were predominantly intrinsic (e.g., reducing headaches), which are potentially more effective for habit development than extrinsic rewards (Gardner & Lally, 2018). Additionally, developing or harnessing intrinsic reward attached to target behaviors may be necessary for implementation intention interventions (Phillips & Mullan, 2022).

4.1.4. Drawing conclusions on implementation intention mechanisms

We suggest that many field studies don't allow us to draw conclusions on the mechanisms that produce implementation intention effects. If only outcomes are measured (e.g., amount of fruit intake over the follow-up), any conclusions on the mechanisms that produced those effects are likely based on theoretical assumptions, not data (Sheeran, Klein, & Rothman, 2017). We found that many of the intervention participants in our study increased their water intake by drinking water in mostly non-implementation intention situations. Our qualitative results further suggested that implementation intentions did not automatize remembering and performing the behavior in ways that the current literature would suggest, and that motivation and enjoyment played significant roles in the target behavior, despite planning. In sum, many assumptions about implementation intentions mechanisms seem incompatible with our results, and much additional research will be

needed to clarify implementation intentions mechanisms in real-life settings.

4.2. Limitations and future directions

As these results are situated within the cultural context of the UK and most participants identified as white women, these results may not generalize to different cultural contexts and more diverse groups. Additionally, the weather was warmer than usual during the follow-up, which could have caused participants to increase their water intake. Twenty-seven participants (approximately 29%) mentioned that the hot weather influenced their intake or the effectiveness of the intervention: "It has been very hot this week, so it was easy to remember to drink water in almost every situation!" [P19, Intervention].

The older average age of our participants could partially explain the low effect of the intervention as field studies on implementation intention interventions tend to have larger effect sizes with younger adults (Carrero et al., 2019). This trend may be due to younger adults being more open to health behavior change than older adults. However, previous research on water drinking did suggest that health consciousness could come with age and that this aligned with having a high water intake (Rodger & Papies, 2021). Given the older average age of our population, it would have been informative to collect baseline data on thirst, as this is a key motivational process underlying water drinking (Rodger et al., 2021) that can be blunted in later life (Bhanu et al., 2020). This would have allowed to assess the difference in baseline thirst between the intervention and control group after randomization and control for a significant difference when estimating the effect of our intervention.

Additionally, our online data collection methods limited insight into whether intervention participants envisioned performing the planned behavior as instructed. Web-based implementation intention interventions show smaller effect sizes, and research suggests that offline interventions should be used to increase efficacy (Carrero et al., 2019).

Future research on using implementation intentions to increase water intake could benefit from targeting preparation behaviors over drinking, identifying more unique and specific cues to aid remembering. Additionally, when trying to get people to drink in new situations, interventions should help participants identify feasible situations for water drinking or potential barriers in unfeasible situations and help remove them. Alternatively, planning in such situations could be compared with other situated interventions, such as health goal priming or increasing availability or visibility of water (Papies, 2017).

Additionally, intervention participants may have increased their intake by drinking more water in situations where they already drank water. Therefore, targeting pre-existing water drinking situations could be a simpler and more effective approach than trying to create new water drinking situations. However, intervention efforts using this approach would have to contend with the limitation that this may not be an effective strategy for everyone, as outlined in section 1.2.

These approaches likely need to be used in tandem with an educational component that promotes the potential rewarding outcomes of water. Still, future research should directly assess the impact of this component. Future research should also use more objective measures of water intake, such as water bottles that track real-time intake, which can effortlessly capture the many moments throughout the day in which participants consume often small amounts of water.

Finally, we suggest that future work should continue to use diverse methodologies to investigate the effect of implementation intentions and how they work in the field. For example, our results suggest that experiencing the target behavior as rewarding may be necessary for future and repeated performance. Using mixed-methods in our study led to novel insights that solely quantitative or qualitative methods would not have provided.

Ethical statement

The University of Glasgow College of Science and Engineering Ethics Committee approved this research.

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Informed consent

Participants read an information page and then an informed consent page outlining the terms of the study before they were able to begin the study. They indicated their consent by clicking “consent and proceed” at the end of the informed consent page.

Declaration of competing interest

EKP received travel expenses and registration fee from Danone Research to attend the 2019 Hydration for Health Scientific Conference, and for the European Federation of the Associations of Dietitians 2019 Conference, the 2020 European and International Congress on Obesity (online), and the 2021 European Congress on Obesity (online).

Data availability

The link to the OSF project hosting the data/code is in the manuscript

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