
# Water Drinking is a Complex Health Behaviour: Implications for Theory and Intervention Development.

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## Abstract

Across four projects, I aimed to develop an in-depth understanding of how water drinking behaviour is performed in real-life settings and what influences its performance to inform more effective interventions. Specifically, I aimed to define what steps are involved in water drinking and identify and explain how relevant constructs hinder and facilitate water drinking in daily life. In Project 1, I conducted a mixed-method survey study to assess what influences different water intake patterns (i.e., high versus low intake), focusing on constructs like value, reward, self-identity, and habitualness. I quantitatively (N = 400) established differences in participants' water drinking behaviour and qualitatively assessed what influences might explain these differences (N = 101). In Project 2, I conducted a mixed-method intervention study to assess what influences attempts at increasing water intake (N = 95). I quantitatively assessed the impact of implementation intentions on water intake over a five-day follow-up and qualitatively assessed what hindered and facilitated participants' attempts to increase water intake during this time. In Project 3, I conducted an observational quantitative study to establish the association and predictive ability of various influences of water drinking (e.g., taste) regarding future intake over a three-day follow-up (N = 213). In Project 4, I reviewed emerging water drinking research and generated a theoretical overview of how water drinking should be defined and what influences its performance in daily life. I then assessed the implications of this overview regarding the wider theoretical considerations in behavioural research as well as applied implications, limitations, and future directions for water drinking research. Water drinking is a complex behaviour facilitated by numerous lower-order behaviours (e.g., preparation) that must be repeated multiple times throughout the day to obtain adequate water intake. Additionally, underlying this behaviour is a complex interplay of external (e.g., water availability, toilet access) and internal (e.g., reward, habitualness) influences that can hinder or facilitate water intake depending on their nature and emergence throughout daily life. Comprehensive theories of behaviour should be used to guide water drinking research, and intervention development may benefit from a complex intervention approach.

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## Published Output

Rodger, A., & Papies, E. K. (2022). "I don't just drink water for the sake of it": Understanding the influence of value, reward, self-identity and early life on water drinking behaviour. *Food Quality and Preference*, *99*, 104576. https://doi.org/10.1016/j.foodqual.2022.104576

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## Author's Declaration

This thesis contains the work conducted by Amy Rodger at the School of Psychology and Neuroscience, University of Glasgow, under the supervision of Dr Esther K Papies, between October 2020 and October 2023. I hereby declare that except where stated, the work included in this thesis is my own, and no part has been submitted to any other university or degree.

## Contributors Statement

Below are the contribution roles for each chapter of this thesis. Contributions are listed following the Contributor Roles Taxonomy (CRediT) format.

**Key**

AR: Amy Rodger; EKP: Esther K. Papies; LB: Lawrence Barsalou; AV: Ariel Vezevicius

**Chapter 1**

AR: Conceptualisation, Writing – Original draft, Writing – Review & Editing. EKP: Conceptualisation, Writing – Review & Editing.

**Chapter 2**

AR: Conceptualisation, Methodology, Formal analysis, Investigation, Resources, Data curation, Writing – Original draft, Writing – Review & Editing, Visualisation, Project administration. EKP: Conceptualisation, Methodology, Resources, Writing – Review & Editing, Supervision.

**Chapter 3**

AR: Conceptualisation, Methodology, Formal analysis, Investigation, Resources, Data curation, Writing – Original draft, Writing – Review & Editing, Visualisation, Project administration. EKP: Conceptualisation, Methodology, Resources, Writing – Review & Editing, Supervision. AV: Conceptualisation, Methodology, Formal analysis, Investigation, Resources, Writing – Review & Editing.

**Chapter 4**

AR: Conceptualisation, Methodology, Formal analysis, Investigation, Resources, Data curation, Writing – Original draft, Writing – Review & Editing, Visualisation, Project administration. EKP: Conceptualisation, Methodology, Resources, Writing – Review & Editing, Supervision. LB: Conceptualisation, Methodology, Resources, Writing – Review & Editing.

**Chapter 5**

AR: Conceptualisation, Methodology, Resources, Writing – Original draft, Writing – Review & Editing, Visualisation. EKP: Conceptualisation, Methodology, Resources,

Writing – Review & Editing. LB: Conceptualisation, Methodology, Resources, Writing – Review & Editing.

# Abbreviations

| | |
|---|---|
| Hyp. | Hypothesis |
| RWD | Real Water Drinker Group Membership |
| S-R Habit Theory | Stimulus-Response Habit Theory (chap 1) |
| $SAM^2$ | The Situated Assessment Method |
| OSF | Open Science Framework |
| SSBs | Sugar-Sweetened Beverages |

# 1. Chapter 1: General Introduction

## 1.1 Introduction

Water drinking is an important health behaviour (Rodger et al., 2021) because underhydration is linked to adverse outcomes (Armstrong & Johnson, 2018; Perrier et al., 2020), and large proportions of the populations of industrialised nations could be underhydrated (Drewnowski et al., 2013; Ferreira-Pêgo et al., 2015; Gibson & Shirreffs, 2013). Increasing water intake could be an effective prevention strategy against these outcomes (Perrier et al., 2020). However, current water drinking interventions are typically ineffective, leading to insignificant increases in water intake (Franse et al., 2020; Vargas-Garcia et al., 2017). These interventions tend to be informed by theories and research on the broad domains of health and consumption behaviour rather than specific theorising and research on water drinking (Rodger et al., 2021). Water drinking may share similarities with other health and consumption behaviours. However, recent water drinking research suggests that this behaviour has unique features regarding how it is performed and what influences its performance (Rodger et al., 2021). Therefore, applying interventions developed in other domains may not be effective because they do not account for specific water drinking considerations (e.g., Claassen et al., 2022). Unfortunately, there is limited research on water drinking to inform intervention efforts. Therefore, this thesis aims to improve the theoretical understanding of water drinking by using diverse psychological research methods to describe how this behaviour is performed in real-life settings and what influences its performance. I hope this work can inform the development of more effective water drinking interventions and future theorising on water drinking as well as other health and consumption behaviours.

## 1.2 Chapter Overview

This chapter aims to comprehensively outline important concepts, theories, and terminology I use throughout this thesis. I begin by justifying the focus of this thesis by evidencing the importance of adequate water intake and the ineffectiveness of current intervention efforts to increase water intake. I then review water drinking research to establish what is currently known in this domain while illustrating limitations and gaps in knowledge. I then detail the overarching thesis aims and the theoretical perspectives (i.e., philosophy of science,

methodology, and theories of behaviour) that informed the research I conducted to meet these aims. Finally, I outline the specific aims and content of the empirical and theoretical chapters that follow.

### 1.3 Importance of Adequate Water Intake

Adequate water intake is essential as water is vital for sustaining all physiological functions (see Jéquier & Constant, 2010; Kavouras & Anastasiou, 2010). Inadequate intake can lead to underhydration (i.e., maintaining hydration status with continually low water intake), which is linked to adverse health outcomes such as chronic kidney disease, cardiovascular disease, obesity, diabetes, recurring urinary tract infections and more (Perrier et al., 2020; Seal et al., 2019). Underhydration also negatively impacts psychological processes, impairing cognitive ability (e.g., attention) and leading to negative mood states (Benton & Young, 2015; Masento et al., 2014; Seal et al., 2019). Finally, the health issues associated with underhydration are also significant economic burdens. For example, the annual cost of chronic kidney disease to the UK in 2022 was £3.03 billion, and it is predicted to rise if there are no changes to policy or standard of care (Tangri et al., 2023).

Although it is hard to estimate the prevalence of underhydration, research shows that large proportions of industrialised nations do not meet adequate water intake guidelines and may be at risk of underhydration (Drewnowski et al., 2013; Elmadfa & Meyer, 2015; Ferreira-Pêgo et al., 2015; Gibson & Shirreffs, 2013). For example, in a survey of adults across 13 countries and three continents, 60% of men and 40% of women did not meet adequate intake guidelines (Ferreira-Pêgo et al., 2015). Therefore, addressing underhydration is important and increasing water intake to achieve healthy hydration could be an effective prevention strategy against the adverse outcomes of underhydration (Armstrong & Johnson, 2018; Perrier et al., 2020).

Drinking water is one of many means of obtaining adequate water intake, as food and other drinks also contribute. However, obtaining adequate intake is unlikely solely through eating, as drinking accounts for most daily water intake (Elmadfa & Meyer, 2015). Additionally, plain water is the optimal drink choice because it is a healthy source of water (Perrier, 2017), compared to other drinks

(e.g., sugar-sweetened beverages) that contain a lot of water but are associated with negative health outcomes (e.g., all-cause mortality; Anderson et al., 2020). Therefore, obtaining adequate water intake through water drinking, specifically, is important.

This research establishes that water drinking is a very important health behaviour. However, this behaviour is often forgotten or merely glossed over in important practices such as establishing dietary guidelines, educating health professionals, and researching health and consumption behaviours (Douglas et al., 2015; Drake et al., 2014; Rush, 2013). For example, UK dietary guidelines recommend drinking "6-8 glasses" of water daily but give no information regarding glass volume (NHS, 2022). They also fail to address that adequate water intake varies depending on certain factors (e.g., age and gender; Dolci et al., 2022).

### 1.4 Limited Impact of Water Drinking Interventions

Increasing water intake is a feasible means of addressing the adverse impacts of underhydration. However, current interventions aimed at increasing the water intake of the general public have limited effectiveness. Most interventions do not change water intake or lead to small increases in intake that are unlikely to address the adverse impacts of underhydration (Rodger et al., 2021). For example, two meta-analyses found that the intervention groups drank an average of 29 ml (Franse et al., 2020) and 67 ml (Vargas-Garcia et al., 2017) more water than the control groups. However, underhydration research indicates larger increases in water intake are needed to regain adequate hydration status and avert underhydration-related impacts (e.g., 1500 ml; Johnson et al., 2020; Pross et al., 2014).

A possible explanation of this ineffectiveness is that most intervention research treats water drinking as a secondary objective, promoting increased water intake to reduce sugar-sweetened beverage consumption or as part of a broader health behaviour change strategy (Franse et al., 2020; Vargas-Garcia et al., 2017). Therefore, the messaging on water drinking may not be prominent for participants (Franse et al., 2020). Additionally, water drinking interventions are primarily informed by research in other domains (e.g., health or consumption behaviours) and top-down knowledge from expert stakeholders academic (e.g., health

professionals and acadeimc researchers; Vercammen et al., 2018) rather than research on water drinking. For example, Franken et al. (2018) used peer influence in their intervention, assuming that social norms influence water drinking. This assumption was informed primarily by research in the broader domain of consumption behaviour, citing research on eating and smoking. Although this assumption may be correct, limited evidence establishes if and how social norms influence water drinking. Additionally, top-down knowledge from expert stakeholders can be limited as it may rest on assumptions not supported by empirical evidence or over-simplifying the intervention strategy necessary. For example, previous frameworks for understanding and developing interventions for health behaviour have conceptualised water as a simple health behaviour that may not need to be broken down into lower-order behaviours as with more complex health behaviours (e.g., exercise; Gardner, 2015; Gardner et al., 2016). However, recent research on water drinking has challenged this assumption, evidencing that water drinking can be perceived as challenging when people try to drink in new situations, especially when preparing water (i.e., a lower-order behaviour; Rodger et al., 2021). Therefore, the influences of water drinking need to be established more systematically to develop effective interventions to increase water intake.

### 1.5 Current Understanding of Water Drinking

Cross-sectional and qualitative research provides initial insights into water drinking behaviour, but this literature is limited.

One of the most common types of cross-sectional research on water drinking is surveys establishing demographic trends in intake (Rodger et al., 2021). For example, women are more likely to meet adequate intake guidelines than men (Elmadfa & Meyer, 2015; Ferreira-Pêgo et al., 2015; Gibson & Shirreffs, 2013). However, Elmadfa & Meyer (2015) found that men aged 18-24 had the best compliance with adequate intake guidelines. Older people, both men and women, tend to have the highest risk of not meeting adequate intake guidelines across age groups (Drewnowski et al., 2013; Elmadfa & Meyer, 2015; Ferreira-Pêgo et al., 2015; Gibson & Shirreffs, 2013). Additionally, adequate water intake is more likely in high-income groups (Drewnowski et al., 2013).

These results can help identify groups of individuals most at risk of underhydration and needing to increase their water intake. However, they provide no insight into what influences water drinking in daily life, which is needed to aid intervention efforts. Specifically, it is unlikely that demographics such as age, gender, or socioeconomic status are causing the reported differences in water intake. More likely, these demographic trends illustrate that some demographic groups are more susceptible to influences hindering water drinking, and others are more susceptible to influences facilitating water drinking. For example, the limited intake in elderly populations can be partially explained by the barriers to water drinking that are specific to or particularly prevalent in this group (e.g., urinary incontinence concerns; Bhanu et al., 2020). Additionally, the higher intake in high-income groups can be partially explained by high-income communities being more likely to perceive tap water as safe to drink (Onufrak et al., 2014).

Limited cross-sectional surveys and qualitative research provide insight into what influences water drinking. Vézina-Im & Beaulieu (2019) reviewed research on what influences adolescents' water drinking. Individual-level influences that were positively associated with water drinking include physiological states (e.g., thirst), health behaviours (i.e., sleep, healthy eating, and exercise), and reward (e.g., belief in water's cleanliness and health benefits, liking the taste, and finding it energising) (See also Hess et al., 2019). Peer influence (see also Smit et al., 2018) and the availability of water at home and school also seem to influence adolescent water drinking. For example, using peer influence to increase children's water intake (Smit et al., 2016) was one of the most effective intervention strategies in a recent meta-analysis (Franse et al., 2020). However, the effect of this intervention was small: 146 ml difference in water intake between groups. As this research focuses on adolescents, some insights may be less likely to generalise to water drinking in other groups. For example, adolescents' drinking behaviour is often dependent or at least heavily controlled by adults (Chouraqui, 2023; Franse et al., 2019). However, many of the above influences could generally relate to water drinking.

Indeed, there is less research on the influences of young adults and adults' water drinking, but it has similar insights to research on adolescents' water drinking: The main influence on university students' water drinking seems to be thirst and beliefs that water is necessary for hydration (Block et al., 2013). Health

behaviours are also correlated with water intake in more general adult samples (Elmadfa & Meyer, 2015). Social influence (e.g., advertisements for other drinks), lack of availability, and cost of bottled water are perceived as prominent barriers (Etale et al., 2018; Hess et al., 2019; Wippold et al., 2020). Water quality and safety perceptions are related to intake, at least within the US context (Onufrak et al., 2014). Finally, taste facilitates water drinking when water is the preferred drink (Wippold et al., 2020) but hinders it when other drinks are preferred (Bhanu et al., 2020; Block et al., 2013).

The current water drinking literature provides a broad overview of potential influences of water drinking and their association with water intake (Rodger et al., 2021). However, it provides a limited understanding of how water drinking is performed and how these influences impact performance in real-life settings. Additionally, much of this research is informed by cross-sectional quantitative surveys, where insights on water drinking are constrained to influences the researchers determined relevant and measured (Scheel et al., 2020). Therefore, this literature may not comprehensively cover the influences of water drinking.

Before conducting the research reported in this thesis, I conducted a large-scale qualitative interview study to address these knowledge gaps. This study's insights have informed much of this thesis, so I have outlined the key insights below. I gained the following insights through in-depth interviews and thematic analysis of a diverse sample of 60 UK-based participants (Rodger et al., 2021):

Water drinking behaviour seems situated, meaning participants developed and maintained habitual water drinking within specific situations (e.g., time of day, location, internal state, routines). As such, water drinking occurred effortlessly and consistently in habitual water-drinking situations but effortfully and inconsistently in non-habitual situations. Water drinking being difficult to perform in non-habitual situations challenges current conceptualisations of water drinking as a simple health behaviour (Gardner, 2022; Gardner et al., 2016).

The nature of habitual situations impacted water intake. Some situations infrequently occurred throughout the day (e.g., drinking before bed) or went unnoticed when concurrent behaviours were prioritised (e.g., thirst going unnoticed while working), leading to low daily water intake. Some situations did not occur for

long periods (e.g., work does not occur on days off), leading to low or no water intake in their absence. Therefore, habitual water drinking was not conducive to high water intake unless it was habitual across various daily situations. However, participants who situated water drinking as part of their self-identity (i.e., water drinking driven by habits seen as part of oneself) had high and consistent intake across various situations.

In line with prior research, many participants had negative attitudes towards drinking water as they were unaware of the importance of adequate hydration and the benefits of drinking water (Bhanu et al., 2020; Douglas et al., 2015; Drake et al., 2014). This hindered reported attempts to increase water intake. For example, these participants' tended to react passively to prominent barriers to drinking water (e.g., distraction and forgetfulness during work) and often struggled to situate new instances of drinking water in their daily lives. In contrast, participants who successfully reported increasing water intake knew the importance of adequate hydration and believed in or reported experiencing the benefits of drinking water. Additionally, these participants removed or dealt with prominent barriers to drinking water (e.g., having a water bottle within eyesight at work to combat distraction and forgetfulness). I note this was not an intervention study, and reported attempts to increase intake were based on participants' naturally occurring prior experience.

These results suggested that the following influences are important for understanding water drinking in real-life situations: situatedness (i.e., the perspective that behaviour and what influences it vary considerably across situations), habitualness (i.e., a descriptor of behaviour denoting the degree of regularity, consistency, and automaticity the behaviour is performed with) and knowledge and attitudes (See also Werner et al., 2022). However, more research is needed to understand water drinking behaviour comprehensively.

### 1.6 The Current Thesis

Overall, this thesis aims to provide an in-depth understanding of how water drinking behaviour is performed in real-life settings and what influences its performance. I hope this work can be used to develop new interventions and tailor current interventions, improving intervention effectiveness at increasing water intake. Additionally, I hope to provide theoretical insights that inform future

theorising and research approaches to understand and change water drinking behaviour or health and consumption behaviour more broadly. Although domain-specific considerations likely need to be made for different consumption behaviours, there are also likely general considerations that can be shared across domains (e.g., influence of taste perceptions). Specifically, I aimed to do the following:

1. Define water drinking behaviour (i.e., what steps are involved in drinking water) and describe how it occurs in daily life (e.g., regularity, consistency, automaticity).
2. Identify constructs (e.g., knowledge, reward, etc.) that influence the performance of water drinking behaviour in daily life.
3. Explain how these constructs influence (i.e., hinder and facilitate) water drinking behaviour in daily situations.

The rest of this section outlines the theoretical perspectives that informed the empirical and theoretical work I conducted to obtain these aims. I also provide an overview of the aims and research conducted in the three empirical chapters (2 – 4) and theoretical review chapter (5) that follow.

### 1.6.1 Philosophy of Science & Methodology

The wider philosophy of science and methodology literature on using experimental research and other methods in psychology, and the need for improved theory development heavily informed this research. Therefore, I briefly overview this literature for context.

Experimental methods dominate psychological research, largely due to the positivist philosophy of science that laid much of the field's foundations (Douglas et al., 2015; Scheel et al., 2020). For example, deep-seated norms such as “correlation does not equal causation” provide important reminders not to draw causal conclusions from non-experimental research carelessly but imply that experimental research is the gold standard scientific method (Diener et al., 2022; Grosz et al., 2020; Rohrer, 2018). Although experimental research has strengths, such as internal validity, it has substantial weaknesses. For example, experimental research has limited external validity, meaning the generalisability of causal inferences from experiments is limited given these

inferences are dependent on the experiments, context, sample, and timing (see Diener et al., 2022; Vazire et al., 2022). Experimental research also has limited construct validity, meaning the difference between an experiment's operations (e.g., measurement methods) and the psychological constructs it is meant to provide inferences on is often much larger than assumed in practice (Diener et al., 2022; Vazire et al., 2022). These are just two examples of the various limitations of experimental research (see also Meehl, 1990) and these weaknesses exist even assuming experimental research is conducted correctly – the caveat is that experimental research is typically conducted incorrectly, and these weaknesses are often poorly acknowledged (Diener et al., 2022; Scheel et al., 2020; Wadhwa & Cook, 2019). For example, ten of the most cited randomised control trials violate some key assumptions necessary for causal inference in this research design (Diener et al., 2022). Given the limitations of experimental research, a wide literature now advocates that psychology needs a more balanced use of diverse research methods.

There are also many calls for psychology to generate more comprehensive theories that explain how behaviour is performed in the real-world (e.g., Barsalou, 2019; Eronen & Bringmann, 2021; Oberauer & Lewandowsky, 2019; Proulx & Morey, 2021; Scheel et al., 2020). According to numerous researchers working on psychology research methodology, theory development should typically involve the following steps: observing and describing the behaviour in real-life settings, defining constructs regarding the behaviour and its influences, developing measures of the behaviour and its influences, establishing relationships between these constructs, specifying the conditions in which these relationships hold, and deriving and testing statistical predictions (Barsalou, 2019; Borsboom et al., 2021; Scheel et al., 2020). Despite the linear presentation of these steps, I note that this process is iterative. However, most psychological research focuses solely on the final step (i.e., hypothesis testing), which has led to mere descriptions of experimental effects being passed off as theories (Meehl, 1978, 1990; Proulx & Morey, 2021) and issues such as the replication crisis (see Scheel et al., 2020). Scheel et al., (2020) advocate that research should focus on improving insights from earlier steps in the theory development process that inform statistical predictions to combat these issues. Importantly, experimental research is unlikely to be the

most appropriate method during these earlier steps unless conducted in a non-confirmatory manner (Scheel et al., 2020).

Based on this literature's recommendations, I determined that the domain of water drinking was in the earlier steps of theory development. These recommendations also informed the aims I established previously and the research I designed to address these. Regarding how this informed my aims, a key component of theory development is defining the behaviour of interest, which has various implications, such as how that behaviour is measured (Scheel et al., 2020). Defining behaviour involves asking the following: what do I mean by water drinking behaviour? This informed the first aim of this thesis. Another key component of theory development is defining constructs that influence the behaviour of interest and establishing how these constructs influence this behaviour. This informed the second and third aims of my thesis.

I note that psychology is a diverse field. As such, the critiques covered in this section are more relevant to certain subdisciplines than others (Proulx & Morey, 2021). Additionally, these critiques do not advocate for the disuse of experimental research in psychology, merely for a more balanced and appropriate use (Diener et al., 2022; Scheel et al., 2020).

### 1.6.2 Guiding Theoretical Perspectives

I adopted a critical realist perspective throughout this thesis as it provides a more balanced framework for using diverse methods and engaging in theory development than typical perspectives adopted in psychology (Ryba et al., 2022; Willis, 2023). For example, in positivist frameworks, only quantitative methods can typically inform causality (Willis, 2023). Positivism treats causal influence as an unobservable 'black box' focusing solely on establishing regular associations between observable events (e.g., changes in X precede and are associated with a change in Y; Ryba et al., 2022; Willis, 2023). Conversely, in critical realist frameworks, quantitative and qualitative methods can and should inform causality (Ryba et al., 2022; Willis, 2023). Critical realism takes a more complex view of causal influence. It assumes all entities (i.e., all objects from abstract social and psychological constructs to concrete physical things) have the capacity for causal influence, and this influence emerges under certain conditions, giving rise to events (e.g., observable

behaviour; Willis, 2023). Here, causality is not gleaned solely by assessing associations between observable events but by explaining the causal influences that emerge and give rise to observable events under certain conditions (Ryba et al., 2022; Willis, 2023). Evidence from diverse methods is needed to inform this explanatory work (Ryba et al., 2022).

An in-depth overview of critical realism is outside the scope of this thesis. However, I outline some key assumptions of this perspective that influenced this research. See Fletcher for an in-depth review and research case study (2017).

Unlike other perspectives, critical realism does not reduce what exists to what can be known, outlining human knowledge as a small understanding of a larger reality. It suggests a stratified reality with three levels: the empirical (people's lived experience of events), the actual (events that occur regardless of people's experience) and the real (casual influences of events). Casual influences at the real level are intrinsically linked to and exist within the events they govern at the empirical level. As such, theories of causal influence can be generated by researching events (e.g., peoples' behaviours and thoughts) at the empirical level.

Critical realism also assumes knowledge is gained through these theories and that some are closer to reality than others (Danermark et al., 2019). As such, prior knowledge and theories within a domain are a good starting point for empirical research. However, as they may not accurately represent reality, there should be no commitment to the content of prior knowledge and theories. Prior theory and research work should merely be a starting point that empirical research can build on to provide a more accurate explanation.

This perspective was appropriate for the current thesis, which aimed to use diverse methods to understand how water drinking behaviour is performed in real-life settings and what influences its performance. I used prior research on water drinking (see section '1.5 Current Understanding of Water Drinking') and the relevant theories of behaviour this research identified (outlined in the proceeding sections) as a starting point for this thesis. Additionally, this perspective informed decisions during research design, data analysis, etc. For

example, during data analysis, I viewed participants' responses as their true understanding of what influences their water drinking and used these to inform theoretical explanations of the causal influences of water drinking. However, I acknowledged that this understanding is shaped by participants' knowledge, language, culture, and experience, so their responses may not directly map onto the actual causal influences of their behaviour (Fletcher, 2017).

The following two sections briefly outline two key theories of behaviour that prior research on water drinking (see Rodger et al., 2021) suggests may be relevant starting point. Specifically, the Grounded Cognition Theory of Desire and Motivated Behaviour and Stimulus-Response Habit Theory. Both theories have been used to research various health and consumption behaviours (see Papies et al., 2022; Wood et al., 2022) and were key guiding theories I used throughout the research presented in the following chapters. I note that numerous other theoretical perspectives are potentially relevant for understanding and changing water drinking behaviour and could have been used to guide this research. Indeed, in the coming chapters, I will discuss and interpret results using theories such as the COM-B model, which outlines how capability, opportunity, and motivation interact to generate behaviour (Michie et al., 2011), Identity Based Motivation theory, which outlines how self-identities' ability to influence behaviour depends on what aspects of self-identity are salient in a given situation (Oyserman, 2015), goal-directed behaviour theories, which outline that behaviour is driven by goals (i.e., representations in memory that contain aspects of the outcome of behaviour before it is performed; Hommel, 2021), and dual processing, which outlined how behaviour is regulated via two systems: one that generates impulsive (i.e., quick and spontaneous) behaviour and one that generates reflexive (i.e., slow and deliberate) action (Hofmann et al., 2008). A complete coverage of all potentially relevant theories is not feasible in the confines of this thesis introduction. Therefore, I cover the two key theories that most deeply informed my research within this introduction, while other theories will be overviewed as they are discussed in the following chapters. I ground my outline of each theory's core assumption in the context of water drinking to aid comprehension and provide an example of how each theory has been used to interpret evidence from prior water drinking research.

#### 1.6.2.1 Grounded Cognition Theory of Desire and Motivated Behaviour

The grounded cognition theory of desire and motivated behaviour (Papies et al., 2020, 2022) posits that as behaviour is performed repeatedly in a situation, multi-modal features of sensory experience (e.g., taste, smell), external context (e.g., time of day, location, other people being present), internal context (e.g., bodily, and cognitive states), self-relevance (e.g., self-identity and social norms), and motor behaviour are learned and associated in memory as a situated conceptualisation (Barsalou, 2020; Papies et al., 2022). Later, the features present in a given situation activate the best matching situated conceptualisation, which then guides how a situation is interpreted and what behaviour is performed (Barsalou, 2020; Papies et al., 2022).

Situated conceptualisations can activate simulations, which can be considered modality-specific (e.g., taste) partial re-enactments of previously encoded experiences that guide behaviour (Papies et al., 2022). Rewarding simulations of consumption behaviour can lead to desire and performance of the simulated consumption behaviour (Papies et al., 2020, 2022). Consequently, a person who experiences rewarding simulations of water drinking would drink water more frequently than a person who does not (Papies, 2020; Papies et al., 2020). Rewarding simulations do not occur in isolation, but as part of the situation in which this behaviour is performed (Papies, 2020; Papies et al., 2020). Therefore, performing a rewarding water drinking behaviour more frequently in similar situations would lead to a more deeply encoded situated conceptualisation (Barsalou, 2020; Papies et al., 2022). The situated conceptualisation would then be more likely to be activated within this situation, and water drinking behaviour would then be performed habitually to some degree (i.e., performed consistently in similar situations with a high degree of automaticity) (Barsalou, 2020; Papies et al., 2022).

This theory has been informative for understanding the insights from prior water drinking research. For example, Rodger et al., (2021) evidenced that numerous factors such as external stimuli, internal cues (e.g., thirst), concurrent goals (e.g., socialising), and cognitive states (e.g., idleness) seem to regulate water drinking behaviour in daily life situations. This insight is consistent with situated conceptualisations guiding behaviour, as these representations in memory are assumed to store associations between these factors and water

drinking. See Rodger et al., (2021) for a more detailed discussion of how their results can be understood within this theoretical framework.

#### 1.6.2.2 Stimulus-Response Habit Theory

Stimulus-Response (S-R) habit theory aligns with one specific form of dual processing frameworks where behaviour is either stimulus-driven and automatic or goal-driven and deliberate (Kruglanski & Szumowska, 2020; Wood & Rünger, 2016). Consequently, water drinking behaviour would either be a habit, and hence a learned, automatic response to an external stimulus that is performed independent of goals, or it would be a goal-driven behaviour, and hence a deliberate action in pursuit of a desired outcome (Wood et al., 2022). In this account, goals would regulate water drinking behaviour if it was goal-driven and early during habit formation but would no longer regulate behaviour later, during maintenance (Verplanken & Orbell, 2022; Wood et al., 2022; Wood & Rünger, 2016). Water drinking habits would largely form via instrumental learning, so repeating rewarding water drinking behaviours within stable situations would develop and strengthen the association between water drinking and a specific external stimulus within the situation (Wood et al., 2022). I note that evidence suggests that this strong association between water drinking behaviour and an external stimulus would take extensive overtraining to form (Kruglanski & Szumowska, 2020; Yin & Knowlton, 2006). Once formed, water drinking habits would be performed automatically in response to this specific external stimulus, as it would activate the related stimulus-response association in memory unless reward processes inhibited this response to pursue goal-driven behaviour (Mazar & Wood, 2022; Verplanken & Orbell, 2022).

I acknowledge that there are numerous iterations of habit theory (see De Houwer, 2019; Gardner, 2015). However, the S-R habit perspective is the most established and commonly used framework (Wood & Rünger, 2016). Additionally, most iterations have a similar core assumption: habit maintenance is regulated by a critical stimulus independent of goals.

This theory is also potentially relevant for understanding and changing water drinking behaviour. For example, prior research Rodger et al., (2021)

evidenced that within habitual water drinking situations, people reported drinking automatically (i.e., with no conscious thought or subjective effort). Automaticity is a commonly used measure for S-R habits (Gardner et al., 2012), and therefore, this insight could suggest that drinking in habitual situations is an S-R habit. Additionally, many people reported using and relying on external stimuli to prompt their water drinking, which aligns with S-R habit theory's assumption that external stimuli can prompt behaviour.

### 1.6.3 Overview of Empirical and Theoretical Chapters

I conducted the following research to understand how water drinking behaviour is performed in real-life settings and what influences its performance. I use the pronoun "we" instead of "I" during this section to acknowledge the contributions of the co-authors involved in these chapters:

We conducted a mixed method study (Chapter 2) to assess what influences different water intake patterns (i.e., high versus low), focusing on constructs like value, reward, self-identity and early life drinking habits. We used an initial quantitative survey (N = 400) to assess self-reported differences in water drinking behaviour (e.g., amount, frequency, automaticity) in high and low-water drinkers. We then used a qualitative survey to assess what influences might explain these differences in a subset of participants (N = 101). We aimed to establish how people with high versus low water intake perceive their water drinking behaviour (e.g., how simple it is to perform) and what influences it during daily situations.

We then conducted a mixed method study (Chapter 3) to assess what influences effective and ineffective attempts at increasing water drinking in an intervention study (N = 95). We quantitatively assessed the impact of using implementation intentions to increase self-reported water intake over a five-day follow-up. Implementation intentions are "If-Then plans" that are thought to provide the when, where, and how of performing a new behaviour (Bieleke et al., 2021). We aimed to assess the effectiveness of applying this commonly used and previously effective health behaviour intervention to water drinking. We also used a qualitative survey to assess what influenced participants' attempts to increase water intake during this time. Additionally, we aimed to establish how people with low water intake experience trying to increase their

water intake within an intervention setting and what facilitated and hindered their attempts.

We then conducted an observational study (Chapter 4) to establish a predictive profile of water drinking in daily life and explore how this profile varied across individuals and situations (N = 213). The situations and predictors for this study were developed by reviewing prior research and pilot testing. We used a quantitative survey to collect participants' typical (survey-based) and actual (diary-based) water intake in various daily situations. In these daily situations, we also collected participants' ratings regarding the potential influences of water drinking (e.g., how motivated they are to drink water because they like the taste). We then assessed the ability of these water drinking influences to predict water intake across participants and situations and how much these influences varied across participants and situations. We aimed to assess how varied water drinking intake are across individuals and situations. Additionally, we aimed to assess how well previously identified influences of water drinking predict water intake across situations in daily life.

Finally, we developed a theoretical overview of water drinking (Chapter 5) by reviewing water drinking research to date, including the empirical work in this thesis, and establish what these insights suggest regarding how water drinking behaviour is performed in real-life settings and what influences its performance. We assess the impact of these insights regarding the theoretical considerations, applied implications, limitations, and future directions for water drinking research. This theoretical review provides the information covered in a typical thesis discussion section; therefore, no further discussion section is presented.

We prepared Chapters 2 – 5 as separate journal articles, so their content may overlap, especially in the Introduction sections of each chapter. Chapter 2 was published in *Food Quality and Preference* (see Rodger & Papies, 2022). Chapter 3 was published in *Appetite* (see Rodger et al., 2023). Chapters 4 and 5 are available as pre-prints, and we intend to submit them to an appropriate journal at the beginning of 2024.

# 2. Chapter 2: “I don't just drink water for the sake of it”: Understanding the influence of value, reward, self-identity, and early life on water drinking behaviour.

This chapter is an exact copy of the following published manuscript:

Rodger, A., & Papies, E. K. (2022). “I don’t just drink water for the sake of it”: Understanding the influence of value, reward, self-identity and early life on water drinking behaviour. *Food Quality and Preference*, *99*, 104576. https://doi.org/10.1016/j.foodqual.2022.104576

## 2.1 Abstract

The prevalence and negative health outcomes of underhydration call for a better understanding of water drinking motivations to inform interventions. This mixed methods study assessed the motivational processes underlying different patterns of water intake (i.e., high versus low) with a focus on constructs like value, reward, self-identity and early life drinking habits. We used an initial quantitative survey (N = 400, M age = 24, N female = 293), followed by a qualitative survey (N = 101, M age = 33, N female = 75) in the general UK population. The quantitative survey assessed self-reported differences in water drinking behaviour (e.g., amount and frequency) in high and low water drinkers. The qualitative survey assessed underlying reasons for these differences, in a subset of participants. Participants who associated water drinking with valued, rewarding outcomes were more likely to drink a high and consistent amount of water, with less subjective effort than participants who did not. Participants with health-conscious self-identities were more likely to associate water drinking with reward, but this association was disrupted in situations where other aspects of self-identity were prominent. Finally, for many participants, drinking patterns from early life persisted into later life and were experienced as hard to change. Our results suggest that reward may be important in habit formation and maintenance. Interventions trying to increase water intake need to make water rewarding in line with drinking outcomes that people value. Early intervention is essential given the persistence of early life drinking habits.

## 2.2 Introduction

Underhydration has been linked to an increased risk of major health issues such as chronic kidney disease, cardiovascular disease and obesity (Armstrong & Johnson, 2018; Perrier et al., 2020; Seal et al., 2019). Large proportions of populations in industrialised nations do not drink the recommended amount of water (Drewnowski et al., 2013; Ferreira-Pêgo et al., 2015) and so could be underhydrated. Therefore, it is important to develop effective interventions to increase peoples' water intake to avoid negative health outcomes. However, we first need a better understanding of what conscious or unconscious motivational processes drive peoples' daily water drinking behaviour, such as reward and habit. Although variables such as taste, lack of availability, health beliefs and social norms have been associated with water intake (Block et al., 2013; Hess et al., 2019; Vézina-Im & Beaulieu, 2019), previous research does not examine the processes through which they affect whether people drink or do not drink water during the day.

A recent qualitative exploration of these processes outlined a broad range of processes that seemed to drive peoples' water drinking behaviour (Rodger et al., 2021)(Rodger et al., 2021). A key process identified was that most participants had low and inconsistent water intake because they developed situated water drinking habits that were limited to a small number of specific situations. Gardner (2015) defines habit "as a process by which a stimulus automatically generates an impulse towards action, based on learned stimulus-response associations." In the situated water drinking habits that participants described, water drinking seemed to be cued or modulated by a variety of contextual factors such as internal cues (e.g., thirst) or cognitive states (e.g., distraction) (Rodger et al., 2021). In many cases, situated water drinking habits were associated with low and inconsistent water intake because participants were unlikely to drink water outside of their habitual situations, and their habitual situations occurred infrequently. In contrast, participants who perceived water drinking as part of their self-identity seemed to perform this behaviour with high automaticity across a variety of different daily situations, and therefore had high and consistent water intake.

Self-identity has also been associated with other health behaviours. In the domain of eating, health-conscious self-identity predicts fruit and vegetable consumption intentions and behaviours (Canova et al., 2020; Carfora et al., 2016) as well as healthy eating habits (McCarthy et al., 2017). People tend to make consistent efforts to eat food

that fits their self-identity (Bisogni et al., 2002), and experience negative affect when they do not do so (Bisogni et al., 2002; Strachan & Brawley, 2008). Although self-identity is a major factor affecting various health behaviours (Freijy & Kothe, 2013; Stone & Focella, 2011), no previous research has directly examined its role in water drinking. The present article, therefore, assesses the role of self-identity in water drinking while remaining aware of the potential roles of other variables as outlined by previous research.

Self-identity is the mental representation a person holds about themselves based on memories, beliefs, motivations and emotions as well as interactions with other people and the wider environment (Verplanken & Sui, 2019). Self-identity may be an underlying causal mechanism of behaviour, as people seek to perform behaviours that are in line with what they value (McCarthy et al., 2017; Verplanken & Sui, 2019). Identity Based Motivation theory suggests that different situations cue different aspects of self-identity and influence how people interpret these aspects of self-identity (Oyserman, 2009). Therefore, self-identity's ability to predict behaviour depends on the stability of the situations cueing self-identity (Oyserman, 2015). Once a behaviour is linked to self-identity, it is likely to be repeated (Oyserman, 2009). Therefore, behaviours linked to self-identity could theoretically become habitual through repeated performance. Indeed, one of the items on the Self-Report Habit Index, which is often used to assess the perceived habitualness of behaviours, includes an item on self-identity as although it may not be the case for all habits, some habits may be associated with self-identity (Verplanken & Orbell, 2003). To our knowledge, however, there is limited research on this link, and the appropriateness of including self-identity in the Self-Report Habit Index is questioned within the habit literature (Rebar et al., 2018). Habits, in turn, are a key predictor of many health behaviours (Gardner et al., 2019), and as we previously outlined have been found to play a role in water drinking behaviour (Rodger et al., 2021).

Although our initial focus was self-identity, we interpreted value and reward as prominent variables affecting participants' water drinking behaviour during data familiarisation. Our survey also generated relevant data on participants' perceptions of how their water drinking patterns had changed from early life. We, therefore, adapted the research questions to include these insights. Briefly, value refers to people’s judgements of the importance, usefulness and worth of consumption behaviours, which are informed by numerous, heterogenous input variables (Berkman, 2018). For example, the value of

eating healthy may be informed by variables such as the effort needed to perform this behaviour, social norms, and identity relevance (Berkman, 2018). Reward refers to a desirable outcome a person may expect to occur because of their consumption behaviour, and which motivates the performance of this behaviour (Shiota et al., 2021). For example, people's representations of the immediate reward associated with the consumption of a drink predict intake of that drink (Papies et al., 2021).

Here, we used mixed methods to understand the impact of self-identity on water drinking behaviour. Collecting mixed methods data for completeness (McEvoy & Richards, 2006) is in line with our critical realist perspective (Fletcher, 2017).

In the quantitative stage, we validated that were differences in water drinking and water drinking-related behaviours between the two different water drinking identity groups we created. We assessed the behaviours of participants (N = 400) who self-identified as "real water drinkers" or not. We hypothesised that participants who identified as "real water drinkers" would report: drinking a higher amount of water (Hyp. 1); drinking water more frequently (Hyp. 2), in a higher number of situations (Hyp. 3), and more automatically (Hyp. 4); perceiving drinking water as easier (Hyp. 5), having more knowledge of water's importance (Hyp. 6), having lighter average daily urine colour (Hyp. 7) and having a lower frequency of dehydration symptoms (Hyp. 8).

In the qualitative stage, we explored the underlying motivations (i.e., self-identity, value, and reward) that could explain the differences in water drinking behaviour, through a qualitative survey (N = 101). This stage addressed the following research questions: (1) How do people conceptualise water drinking as part of their self-identity and how does this impact the nature (e.g. amount and consistency) of people's water drinking behaviour? (2) How does the value people ascribe to water drinking and the reward they experience from water drinking shape the effectiveness of their water drinking behaviour? (3) How do people perceive their water drinking patterns in the present compared to early life?

## 2.3 Methods

This research was approved by the University of Glasgow Ethics committee. See https://osf.io/w4eq7 for preregistration, supplementary materials, and data.

### 2.3.1 Survey Development

Both surveys were created on Qualtrics (www.qualtrics.com)

#### *2.3.1.1 Quantitative Survey*

The quantitative survey started with the question, "Do you consider yourself a 'real water drinker'?, Yes or No," to create two groups of participants who would be more vs. less likely to perceive water drinking as part of their self-identity.

Participants then answered questions on their water intake amount (ml), water intake frequency (instances per week), number of water drinking situations, automaticity (Gardner et al., 2012), perception of ease of drinking water, perception of knowledge, urine colour (See Figure 1), and frequency of dehydration symptoms. Table 1 outlines how each variable was measured.

All variables were included based on prior research (Rodger et al., 2021), which showed that participants who perceived water drinking as part of their self-identity typically drank a high amount of water through drinking often in various situations, even if they only drank small amounts each time. These participants also seemed to drink water automatically, reporting that it did not take conscious thought or subjective effort, and they understood why water drinking was important. Finally, these participants reported light urine colours. Therefore, in the current study, we expected to see these patterns, along with infrequent dehydration symptoms, in the group who identified as "real water drinkers", compared to those participants who did not identify as "real water drinkers". Validated surveys on fluid intake and water drinking behaviour also informed our question development (Veilleux et al., 2020).

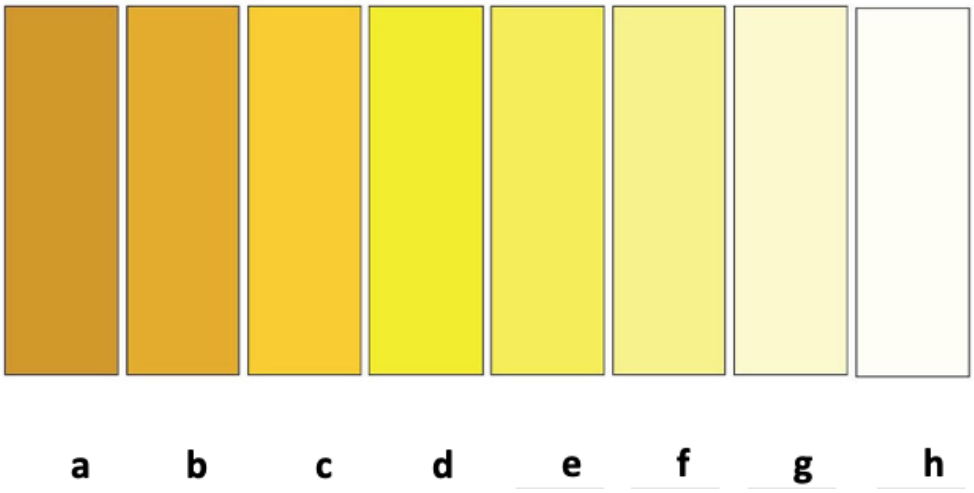
**Table 1**

**Quantitative Survey Questions**

| Variable | Questions | Note |
|---|---|---|
| Water intake (ml) | What glass or bottle do you use most often to drink plain water on a typical day? 450ml glass, 250ml glass, 500ml bottle, 750ml bottle<br>How many of the glasses or bottles that you chose above do you drink on a typical day? | We multiplied these two responses to calculate water intake |
| Water intake frequency (instances per week) | How many days do you drink water, in a typical week?<br>How many times during each of those days do you drink water, on average? | We multiplied these two responses to calculate water intake frequency |
| Number of water drinking situations | Please select all the situations where you regularly drink water from the list below, e.g., "when you are thirsty", "during mealtimes". | |
| Automaticity | Participants indicated how much they agreed with four statements adapted from the Self-Report Behavioural Automaticity Index (Gardner et al., 2012) such as "Drinking water is something I do automatically, 0, strongly agree – 100, disagree." | We calculated the average of the 4 responses to get an automaticity score |
| Perception of ease of drinking water | How easy or difficult is it for you to drink water during your day-to-day life? 0, very difficult – 100, very easy | |
| Perception of knowledge | How much knowledge do you have on why drinking water is important? 0, none at all – 100, expert knowledge | |
| Urine Colour | What colour is your urine most often, on a typical day? See Figure 1 | |
| Frequency of dehydration symptoms | How often do you experience i.e., dry mouth, headache, fatigue, irritability, light-headedness? 0, rarely – 100, most of the time | |

**Figure 1**

**Urine Colour Chart**




*Note.* Based on Armstrong and colleagues (Armstrong et al., 1994), with added letters to indicate response options.

### *2.3.1.2 Qualitative Survey*

Qualitative surveys allow researchers to explore under-researched phenomena while capturing varied perspectives (Braun et al., 2020). This method is sometimes thought to generate data that lacks depth given its inability to probe participants. However, Braun and colleagues (2020) show that this method generates data that can provide meaningful insights when viewed as a whole, even when individual responses are brief. This approach also offers anonymity, allowing participants to discuss topics they might choose not to discuss in interviews. For example, from our experience participants were uncomfortable discussing toilet breaks being a barrier to drinking water during interviews. Finally, data collection occurred during COVID-19, so we judged online qualitative surveys to be a safe and practical method of data collection.

We created our qualitative survey by consulting prior research on the role of self-identity in eating behaviour (Bisogni et al., 2002; McCarthy et al., 2017), results from our previous study (Rodger et al., 2020), the aims of this study, and recommendations by Braun and colleagues (2020). We designed the questions to access participants' perspectives on what motivates their water drinking, focusing on self-identity. The term "self-identity" was not used in the survey as previous research has shown some participants may struggle to understand it (Bisogni et al., 2012). The surveys for participants who responded "yes" and those who responded "no" to being

a “real water drinker” were as similar as possible. The final surveys had 11 and 12 open-ended questions, respectively, ordered from broader to more specific questions (see Table 2), and responses had no word limit.

**Table 2**

**Qualitative Survey Questions**

| Question | Note |
|---|---|
| What does being 'a real water drinker' mean to you? | Only "real water drinker - Yes" participants |
| Why do you not think that you are 'a real water drinker'? | Only "real water drinker - No" participants |
| How would you describe the kind of water drinker you are? Please explain why you describe yourself in this way | Only "real water drinker - No" participants |
| What role does drinking water play in your day-to-day life? Has it always been this way for you? If not, please provide an example of a time this has changed. | |
| Why do you think drinking water came to have this role in your day-to-day life? | |
| Please walk us through your day (morning to evening) and describe everything you drink (i.e., what and how much) in each situation. Please also explain why you drink each drink. Whatever you are drinking during the day is of interest to us, we truly want to understand your daily drink choices. | |
| How does drinking water day-to-day fit in with who you are as a person? | |
| Think about drinking water in your normal day-to-day life. Please explain how easy or hard it is for you to drink water. Please also explain why you think this is the case. | |
| Can you tell us about situations where you choose not to drink water, or situations where you are not able to drink water? Does this have any impact on you? Please outline the situation(s) and explain why you do or do not feel impacted by this. | |
| Please tell us about the effect (if any) that thinking about yourself as 'a real water drinker' has on your day-to-day water drinking. | Only "real water drinker - Yes" participants |
| You previously described the kind of water drinker you are. Please think about the description you gave and tell us about the effect (if any) that thinking about yourself in this way has on your day-to-day water drinking. | Only "real water drinker - No" participants |
| Think about drinking water in situations outside of your normal day-to-day life. Please explain how easy or hard it is for you to drink water. Please also explain why you think this is the case | |

| Question | Note |
|---|---|
| Think of a time when your daily routine changed considerably (i.e. change in education, work or home environment). Did your water drinking behaviour change because of this? Please outline the change you experienced and explain why your water drinking changed or why it did not.<br>Give an example of a time you experienced people mentioning your water drinking? Please explain the effect (if any) these comments had on your behaviour. If you have not experienced this, what do you think other people in your life think about your water drinking? Please explain the effect (if any) this has on your behaviour | |

Table 3 summaries the quantity of data we generated. Each participant seemed engaged, writing at least a sentence per response, but usually more. Data quantity was not the sole feature for determining data quality. As Table 4 shows the content of both low and high word count responses contributed meaningfully to the analysis process. We judged our data to be high quality if it allowed us to address the research questions by providing theoretical or practical considerations through a meaningful narrative (Braun & Clarke, 2021) that was robust to alternative explanations (Korstjens & Moser, 2018).

**Table 3**

**Word Count Descriptives for Responses per Qualitative Survey**

| | "Real water drinker - No" | "Real water drinker - Yes" |
|---|---|---|
| Min Words | 162 | 200 |
| Max Words | 984 | 948 |
| Average Words | 456 | 454 |
| Total Words | 22,792 | 23,611 |

**Table 4**

**Examples of Quality Low and High Word Count Responses**

| Question | Response | Interpretation* | Word Count |
|---|---|---|---|
| Give an example of a time you experienced people mentioning your water drinking? | "I don't think anyone has really commented on it." [P11] | Both quotes, regardless of word count, provided evidence to support the narrative we present in Theme 3 on whether water drinking was linked to participants' identities as part of their social groups. | 10 |
| | "my sister drinks quite a lot of water, and she actually pointed out to me that I don't drink enough. since then, I have made an effort to drink more water, and often remind myself to be more like her in that sense. I think people have pointed out how much coffee I drink rather than pointing out my lack of water drinking, but I think it has had a similar effect, as it has made me more aware of the beverages I choose to consume, and therefore reminded me that I need to drink more water." [P30] | | 98 |
| Why do you think drinking water came to have this role in your day-to-day life? | "My Nana taught me the importance of hydration" [P2] | Both quotes, regardless of word count, provided evidence to support the narrative we | 9 |

| Question | Response | Interpretation* | Word Count |
|---|---|---|---|
| | | present in Theme 4 on the features of early life that seemed to influence present day water drinking patterns. | |
| | "I've never really liked soft or fizzy drinks, squashes and pure juices - I find most non-alcoholic drinks like this way too sweet. I never drank very sugary drinks when I was growing up as I never had the taste for them. I much preferred milk or water. After I realised how water was necessary for good health it was easy to switch to drinking more because I like the taste and I'm quite cheap so I like free liquids, and I wanted to decrease my dairy consumption. However as an adult I also drink tea, coffee and alcohol, although I prefer non-sweetened versions of all of these. I also have to take quite a few medications every day for health reasons, so am used to having a glass in the morning with these, and I get migraines and headaches so tend to try and stick to just water when I have these attacks." [P29] | | 155 |

### 2.3.2 Participants, Recruitment, and Procedure

All data was collected via the online participant recruitment platform prolific (www.prolific.co). Online-recruitment platforms come with challenges such as sampling bias, potentially poor data quality, and unethical participant treatment (Newman et al., 2021). We chose Prolific as it provides more representative

participant samples and ethical payment terms (Newman et al., 2021; Palan & Schitter, 2018). We also followed recommendations by Newman and colleagues (2021) for addressing poor data quality concerns.

We collected data from 400 participants for the quantitative survey on 16th December 2020 (average duration 4 minutes, £0.63). This sample size was determined by power calculations using data simulation and the smallest effect size of interest (see "quantitative supplement" for an overview). The inclusion criteria were fluent English speaker, 18+ years of age, and currently living in the UK. Participants were only excluded from a specific analysis if they had missing data for the dependent variable related to that analysis, and the number of participants per group is presented for each analysis in the results section. See Table 5 for participant demographics.

**Table 5**

**Participant Demographics: Quantitative Survey**

| **Demographics** | | |
|---|---|---|
| | **Range** | ***M (SD)*** |
| **Age (years)** | 18 - 72 | 24 (12) |
| | **Count** | **%** |
| **Gender:** | | |
| Female | 293 | 73.25 |
| Male | 106 | 26.5 |
| Prefer not to say | 1 | 0.25 |
| **Employment:** | | |
| Full-Time | 179 | 44.75 |
| Part-Time | 87 | 21.75 |
| Due to start a new job within the next month | 3 | 0.75 |
| Not in paid work (e.g., homemaker', 'retired or disabled) | 44 | 11.00 |
| Unemployed (and job seeking) | 41 | 10.25 |
| Other | 33 | 8.25 |
| Prefer not to say | 13 | 3.25 |
| **Student Status:** | | |
| Yes | 85 | 21.25 |
| No | 311 | 77.75 |
| Prefer not to say | 4 | 1.00 |
| **Nationality:** | | |
| United Kingdom | 338 | 84.50 |
| Ireland | 5 | 1.25 |
| Poland | 5 | 1.25 |
| Australia | 3 | 0.75 |
| France | 3 | 0.75 |
| India | 3 | 0.75 |
| Italy | 3 | 0.75 |
| Brazil | 2 | 0.50 |
| Germany | 2 | 0.50 |
| Hungary | 2 | 0.50 |
| Japan | 2 | 0.50 |
| Lithuania | 2 | 0.50 |
| Mexico | 2 | 0.50 |
| Nigeria | 2 | 0.50 |
| Portugal | 2 | 0.50 |

| **Demographics** | | |
|---|---|---|
| **Nationality:** | **Count** | **%** |
| South Africa | 2 | 0.50 |
| Sri Lanka | 2 | 0.50 |
| United States | 2 | 0.50 |
| Venezuela, Bolivarian Republic of | 1 | 0.25 |
| Austria | 1 | 0.25 |
| Bulgaria | 1 | 0.25 |
| Canada | 1 | 0.25 |
| Dominica | 1 | 0.25 |
| Finland | 1 | 0.25 |
| Greece | 1 | 0.25 |
| Iran | 1 | 0.25 |
| Malaysia | 1 | 0.25 |
| New Zealand | 1 | 0.25 |
| Pakistan | 1 | 0.25 |
| Palestinian Territory | 1 | 0.25 |
| Philippines | 1 | 0.25 |
| Qatar | 1 | 0.25 |
| Romania | 1 | 0.25 |
| Spain | 1 | 0.25 |
| Prefer not to say | 2 | 0.50 |

Note: All demographics presented are the standard demographics held by the online participant recruitment platform Prolific (www.prolific.co)

We collected data from 101 of the 400 quantitative survey participants for the qualitative survey on 16th – 17th December 2020 (average duration 27 minutes, £3.75). All quantitative survey participants were invited to participate in the relevant qualitative survey, until we had reached the planned number of participants. We did not collect qualitative data from all 400 participants as we determined that a moderate sample size was sufficient to provide high quality data to address our research questions based on recommendations from Braun & Clarke (2021). One extra participant was added to the "yes" survey as this participant contacted AR outlining that they wanted their data included despite technical difficulties. See Table 6 for participant demographics. The mean age of qualitative survey participants was nine years higher than the quantitively survey. This may indicate that older participants were more likely to take part in the qualitative survey.

**Table 6**

**Participant Demographics: Qualitative Survey**

| **Demographics** | | |
|---|---|---|
| | **Range** | ***M (SD)*** |
| Age (years) | 18 - 69 | 33 (11) |
| | **Count** | **%** |
| Gender: | | |
| Female | 75 | 74.26 |
| Woman | 1 | 0.99 |
| Male | 24 | 23.76 |
| Male (transgender) | 1 | 0.99 |
| Employment Status: | | |
| Full-time | 75 | 74.26 |
| Part-time | 1 | 0.99 |
| Unemployed | 6 | 5.94 |
| Student | 13 | 12.87 |
| Homemaker | 6 | 5.94 |
| Ethnicity: | | |
| White | 39 | 38.61 |
| White - British/Scottish/English/Irish/European | 33 | 32.67 |
| British/Scottish | 7 | 6.93 |
| Asian | 4 | 3.96 |
| Indian | 2 | 1.98 |
| Mixed | 2 | 1.98 |
| Chinese | 1 | 0.99 |
| African Caribbean | 1 | 0.99 |
| Black African | 1 | 0.99 |
| British - Asian/Indian | 1 | 0.99 |
| British Bengali | 1 | 0.99 |
| Caucasian | 1 | 0.99 |
| White - Finnish | 1 | 0.99 |
| Greek | 1 | 0.99 |
| Japanese | 1 | 0.99 |
| Middle Eastern | 1 | 0.99 |
| Other white background | 1 | 0.99 |
| Pakistani | 1 | 0.99 |
| Sri Lankan Asian | 1 | 0.99 |
| NA | 1 | 0.99 |

Note: All demographics presented were asked as open-ended questions as part of the qualitative survey

Given that most participants in this sample identified as being either “White” or “Female”, generalisations of our results to samples with different demographic profiles should be made tentatively. However, our analysis focused on making interpretations of trends that were evidenced across the sample as whole, rather than trends evidenced by only the predominantly represented demographic groups.

Finally, although data was collected during COVID-19, the impact of the pandemic was not a focus of our study, which instead aimed to assess trends in participants’ water drinking behaviour and water drinking motivations that would likely be relevant regardless of the pandemic. Therefore, we did not ask participants any questions directly related to this. We instead reasoned that participants had the opportunity to spontaneously mention the pandemic where it was relevant to their experience and that we could contextualise our findings appropriately if needed.

### 2.3.3 Data Analysis

We started with the qualitative analysis as we reasoned that support for our hypotheses in the quantitative analysis could cause us to over-emphasise group differences and ignore similarities during the qualitative analysis.

All qualitative analyses were conducted in Nvivo (Mac Version 12). AR used reflexive thematic analysis (Braun & Clarke, 2006, 2019) as this allowed her to generate tendencies in participants’ experience across the dataset. AR primarily analysed the data at the descriptive level of the participants subjective experience using descriptive coding, derived mainly from the data. Themes were not generated using a single core feature in the data, but instead themes had a core idea that linked multiple features of the data together. We decided that AR should treat both survey groups as one dataset initially so that she did not ignore tendencies that were shared across the groups. She then considered them separately to see whether the interpretation of the data within each code was different per group.

During analysis AR noted that constructs of value and reward seemed to be important in understanding water drinking, so she proceeded to examine how value and reward were associated with water drinking and amended the research questions

to assess this. Weekly meetings with EP during analysis led to a critical dialogue on the relevance and strength of each theme as well as alternative explanations. AR also kept a reflexivity journal during analysis to document reflexive thoughts on how AR and EP's backgrounds influenced the analysis process. For example, our prior study on water drinking behaviour (Rodger et al., 2021) was a prominent theorical influence on the entire research process.

AR conducted all quantitative analyses in R (R Core Team, 2014) and Table 7 outlines how the group differences were assessed for each variable. During discussions on the descriptive analysis, we made the following amendments to the preregistered analysis plan: (1) Extreme outliers were not removed, but we treated these as naturally occurring outliers. AR ran sensitivity analyses (see "quantitative supplement") when extreme outliers were present (i.e., water intake amount and frequency) to assess the impact of these data points on the model parameters. Removal of extreme outliers always resulted in a slightly larger effect size than the models presented in the main manuscript. (2) The analysis using "number of situations" as a dependent variable was modelled using ordinal regression (Christensen, 2018) rather than a simple linear regression, as this variable was ordinal rather than continuous.

**Table 7**

**Quantitative Data Analysis Overview**

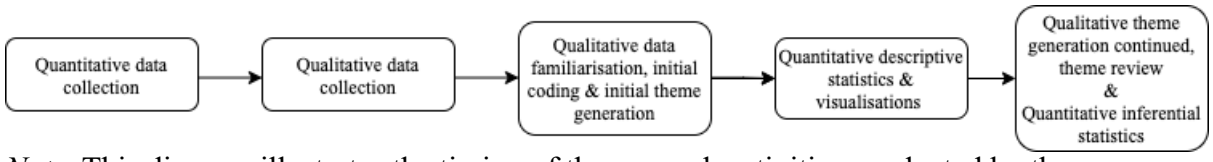
| Dependent Variable | Type of Data | Model used to test difference between groups* |
|---|---|---|
| Intake Amount (ml) | Continuous | Simple linear regression (with unequal variance) |
| Intake Frequency (instances per week) | Continuous | Simple linear regression (with unequal variance) |
| Number of Situations | Ordinal | Cumulative link model |
| Automaticity | Continuous | Simple linear regression |
| Perception of Ease | Continuous | Simple linear regression |
| Perception of Knowledge | Continuous | Simple linear regression |
| Urine Colour | Ordinal | Cumulative link model |
| Frequency of Dehydration Symptoms | Continuous | Simple linear regression |

Note: All models were ran with the same formula format Dependent Variable ~ Group (i.e., "real water drinker - yes" vs “real water drinker - no")
*Simple linear regression is equivalent to a t-test

Figure 2 provides an overview of the study process.

**Figure 2**

**Study Method Process Diagram**




*Note.* This diagram illustrates the timing of the research activities conducted by the researchers.

## 2.4 Results

### 2.4.1 Quantitative Survey Results

In line with our hypotheses, the “real water drinker - yes” group reported drinking more water (Hyp. 1), more frequently (Hyp. 2) and in a higher number of situations (Hyp. 3) than the “no”-group. The “yes”-group reported drinking 873.96ml

more water per day, having 29 more instances of water intake per week. They were 5.14 times more likely to report drinking water in a higher number of situations.

In line with our hypotheses, the “real water drinker -yes” group also reported drinking water more automatically (Hyp. 4) and with a higher subjective ease (Hyp. 5) than the “no”-group. The “yes”-group reported a 30.96 higher mean automaticity score and a 23.27 higher mean score on the subjective ease item, both on 100-point scales.

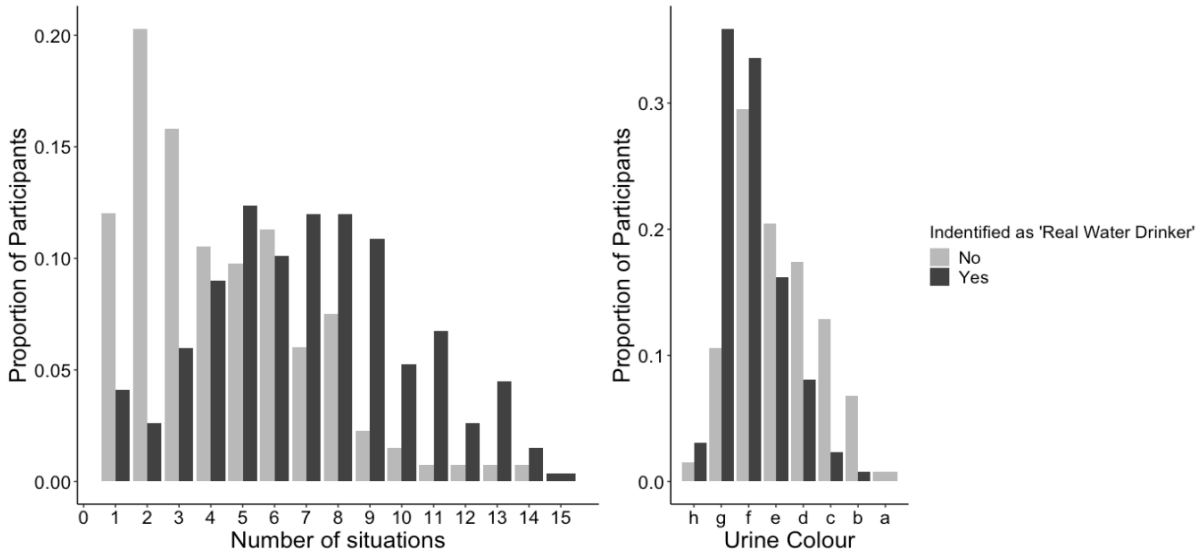
In line with our hypothesis, the “real water drinker - yes” group also reported having more perceived knowledge of water drinking’s importance (Hyp. 6) than the “no”-group, indicated by a 6.55 higher mean score on the perception of knowledge item, again on a 100-point scale.

Finally, in line with our hypotheses the “real water drinker - yes” group also reported having lighter urine colours (Hyp. 7) and fewer experiences of dehydration symptoms (Hyp. 8: 11.28 lower score) than the “no”-group. The “no”-group were 4.32 times more likely to report darker urine colours).

Figures 3 and 4 show the distribution and spread of each variable by group, and Table 8 summarises the descriptive statistics of each variable by group. The differences between the two groups outlined ain this section were all significant ($p < 0.00125$), suggesting that the “real water drinker – yes” group had different water drinking experiences, behaviours, and outcomes compared to the “no” group. Table 9 summarises the hypothesis test statistics for the group differences we outlined above.

**Figure 3**

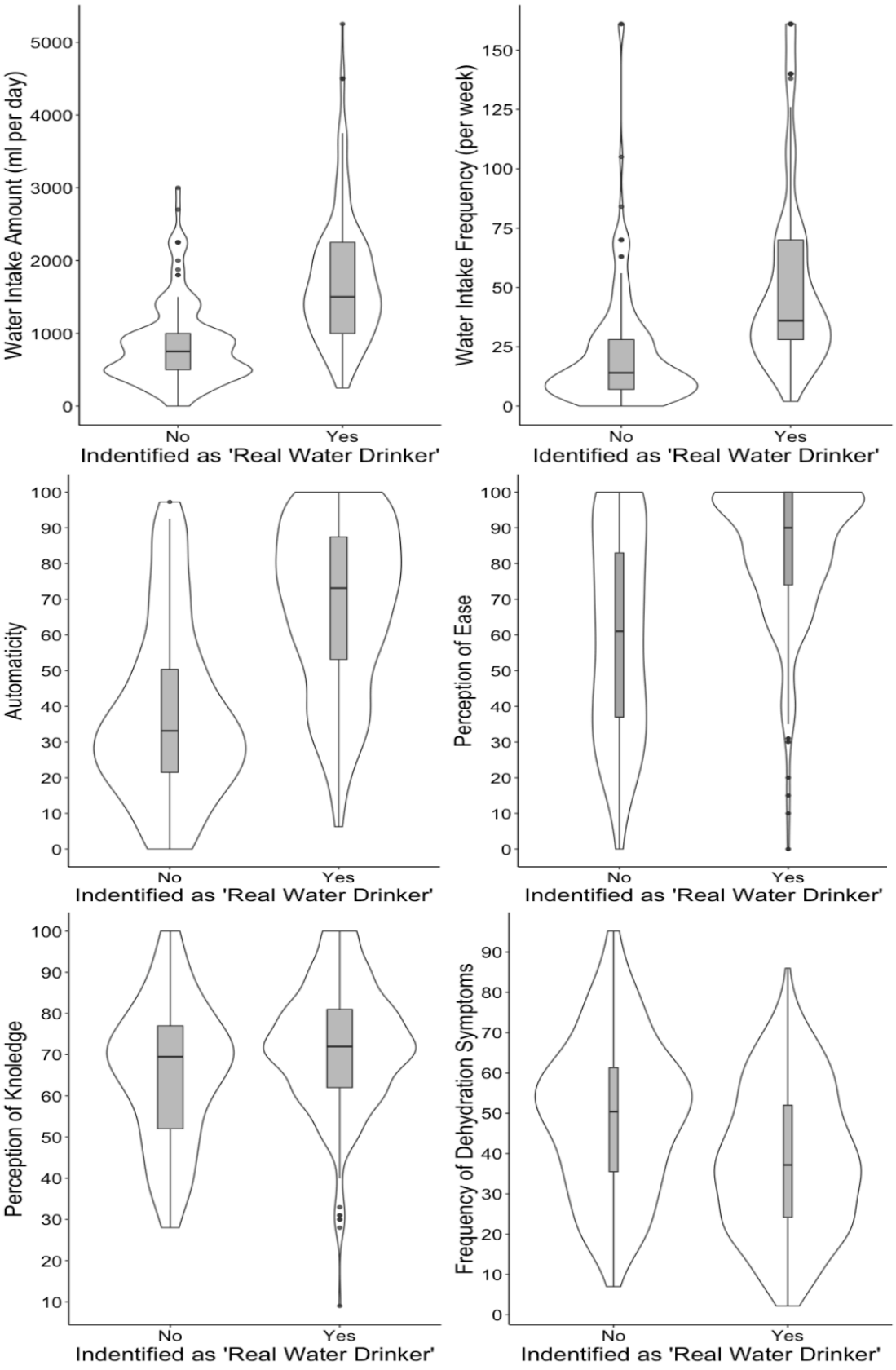
**Histograms of Ordinal Dependent Variables**




*Note.* The plot grid shows the proportion of participants that reported each number of situations (Hyp. 3) and urine colour (Hyp. 7) per group

**Figure 4**

**Violin, Boxplots of Continuous Dependent Variables**



*Note.* The plot grid shows the mirrored continuous distribution and boxplot of self-reported water intake amount (Hyp. 1), water intake frequency (Hyp. 2), automaticity (Hyp. 4), perception of ease (Hyp. 5), perception of knowledge (Hyp. 6) and frequency of dehydration symptoms (Hyp. 8) per group. Given the difference in intake and frequency in the analyses for Hyp 1 and 2, the group of 'real water drinkers' are referred to as "high water drinkers" and the other group are referred to as "low water drinkers". The boxplot shows the median of each group with lower and upper hinges representing the first and third quartiles respectively. The whiskers represent values 1.5 times the interquartile range away from their respective hinge and the dots represent data points beyond this threshold.

**Table 8**

**Quantitative Data Descriptives**

| **Dependent Variable** | **“Yes” - "real water drinker"** | | | **“No” - "real water drinker"** | | |
|---|---|---|---|---|---|---|
| | ***M*** | ***SD*** | **n** | ***M*** | ***SD*** | **n** |
| Intake Amount (ml) | 1717.56 | 862.63 | 252 | 843.6 | 569.76 | 125 |
| Intake Frequency (instances per week) | 52 | 39 | 256 | 23 | 26 | 129 |
| Automaticity | 68.32 | 23.39 | 258 | 37.66 | 24.26 | 132 |
| Perception of Ease | 83 | 19 | 267 | 60 | 28 | 133 |
| Perception of Knowledge | 72 | 15 | 265 | 66 | 17 | 130 |
| Frequency of Dehydration Symptoms | 38.31 | 17.98 | 261 | 49.58 | 18.88 | 123 |
| | ***Median*** | **Range** | **n** | ***Median*** | **Range** | **n** |
| Number of Situations | 7 | 1 - 15 | 267 | 4 | 1 - 14 | 133 |
| Urine Colour | 3 (urine colour chart, f) | 1-7 (h-b) | 259 | 4 (urine colour chart, e) | 1-8 (h-a) | 132 |

*Note.* Automaticity, Ease, Knowledge, and Frequency of dehydration symptoms scales ranged from 0-100

**Table 9**

**Quantitative Data Analysis Results Overview**

| Dependent Variable | Effect of Group | 95% CI | Hypothesis Test | Significance* |
|---|---|---|---|---|
| Intake amount (ml) | 873.96 | 727.97 - 1019.95 | t(345.58) = 11.73, p = 1.58e-27 | Significant |
| Intake frequency (instances per week) | 29 | 23 - 36 | t(350.34) = 8.8, p = 6.53e-17 | Significant |
| Number of situations | 1.64** | 1.25 - 2.03 | LRT(397) = 71.74, p = 2.45e-17 | Significant |
| Automaticity | 30.67 | 25.68 - 35.65 | t(388) = 12.10, p = 8.16e-29 | Significant |
| Perception of ease | 23.27 | 18.59 - 27.95 | t(398) = 9.78 p = 2.23e-20 | Significant |
| Perception of knowledge | 6.55 | 3.26 - 9.84 | t(393) = 3.91 p = 0.0001 | Significant however, this effect size may not be relevant given our pre-registered smallest effect size of interest (i.e., 10 points) |
| Urine colour | 1.46** | 1.07 - 1.86 | LRT(386) = 54.46, p =1.58e-13 | Significant |
| Frequency of dehydration symptoms | -11.28 | (-15.21) - (-7.35) | t(382) = -5.64, p = 3.27e-8 | Significant however, this effect size may not be relevant given our pre-registered smallest effect size of interest (i.e., 10 points) |

*A significant result is interpreted as meaning the data observed is unlikely assuming the null hypothesis is true, the cut-off was <0.00125
**These effects are logits. To get the odds reported in the main text you take the exponent of these effects.

### 2.4.2 Qualitative Survey Results

We generated four themes (see Table 10 for an overview) covering: drinking water with a sense of value and reward (Theme 1) as well as out of obligation (Theme 2), the association between self-identity and water drinking (Theme 3), and the persistence of drinking patterns from early life (Theme 4). Although most of the evidence for Theme 1 and Theme 2 came from participants in the "real water drinker - yes" and "real water drinker - no" groups respectively, these themes did not directly map on to each group. We use the suffix RWD (i.e., real water drinker) after participant numbers to denote when a supporting quote came from the "real water drinker - yes" group. Quotes without this suffix came from the "real water drinker - no" group. Additional supporting quotes are provided in the supplementary materials.

**Table 10**

**Overview of the Narrative of the Qualitative Themes**

| Theme Name | Summary |
|---|---|
| Theme 1: “I don't just drink water for the sake of it” – Drinking Water with a Sense of Value | Participants who drank high and consistent amounts of water seemed to value water drinking. They also experienced rewarding outcomes when they drank water, and sometimes adverse outcomes when they did not. From these participants’ perspectives, reward was a salient motivation for drinking water during the day. For these participants, water was also an easy and accessible default choice in most situations. These participants described performing their water intake and preparation behaviours with automaticity, indicating that these behaviours could be habitual. |
| Theme 2: “I don't drink it because I enjoy it, I just know I should” - Drinking Water out of Obligation | Participants with low and inconsistent intake seemed to feel obligated to drink water, but did not seem to value water. They seemed to experience no reward when they drank water, nor adverse outcomes when they did not. From these participants’ perspectives, the lack of reward was a salient reason why they lacked motivation to drink water during the day. Because they found drinking water unbeneficial, unenjoyable and effortful, but they found drinking other drinks beneficial, enjoyable, and effortless, it is not surprising that these participants drank water infrequently. |
| Theme 3: Self-Identity and Water Drinking Behaviour | The impact of self-identity on participants valuing water drinking seemed complex. Some aspects of self-identity, such as health-consciousness, seemed to align with participants valuing water drinking and experiencing reward from this behaviour. However, in situations where other aspects of self-identity were prioritised, this association was not as clear. Additionally, water drinking only seemed to be related to social identity for those individuals who perceived water drinking having a social signalling function, and not for others who perceived water drinking as individualistic. Finally, self-identity did not seem to be a salient motivation of water drinking behaviour for all participants with high intake. |
| Theme 4: “It has always been this way for me” – The Persistence of Drinking Patterns from Early Life | Drinking patterns from early life seemed to persist into many participants’ adult lives. The drinking patterns these participants had growing up were |

| Theme Name | Summary |
|---|---|
| | often identical or very similar to their current drinking patterns. Even when there were attempts to change drinking patters in later life, this seemed harder when early patterns were deeply engrained. |

#### *2.4.2.1 Theme 1: "I don't just drink water for the sake of it" – Drinking Water with a Sense of Value*

The most common and simple motivation to drink water expressed by participants was to quench thirst: "If I am thirsty, I drink" [P45, RWD] and "I just drink when I'm thirsty" [P2]. However, participants who drank a high and consistent amount of water did not value water solely because it quenched their thirst. These participants' responses suggested that they valued drinks that were good for their wellbeing or provided them hedonic pleasure, and that they felt rewarded by drinking water because this resulted in valued outcomes: "I don't just drink water for the sake of it. I drink it because I enjoy the experience, how it makes me feel and the overall health benefits I notice" [P36, RWD].

The specific reasons participants gave for valuing water fell into three broad categories, with many participants mentioning several of these reasons. The first category was the tangible impact water drinking had on wellbeing: "[Water] makes me stay happy, healthy, with good hair and skin. It keeps me alert and stops the cravings for a snack" [P12a, RWD]. The second category was hedonic enjoyment of water: "I really enjoy water […] it gives me pleasure" [P27, RWD]. Finally, the last category was beliefs that hydration is important or necessary for health: "[I am] a person who understands the importance of staying hydrated via water […] that no other drink is a substitute for water" [P14, RWD]. Tangible impact and hedonic enjoyment were the most common.

When participants valued water's tangible impact on wellbeing or hedonic enjoyment, they seemed to experience an almost immediate outcome from water drinking. This outcome could be rewarding when water drinking occurred (e.g., improved mood), but could also be adverse when water drinking did not occur (e.g., fatigue): "I can notice a huge difference in my mood and how well I operate on a day-to-day basis when I am properly hydrated versus not" [P16, RWD]. Not all participants experienced adverse outcomes when they did not drink water, for

example, “if for some reason I forget [to drink water] it does not affect me” [P3, RWD].

When participants valued water due to their belief that hydration was important or necessary for health, this belief seemed to be enough to get them to drink water in the present, despite no clear evidence that they experienced short-term rewards from drinking: “I value the health benefits… water is a simple necessity, so I drink it, but I have never noticed specific health effects as a result” [P7, RWD].

Participants who valued water drinking and perceived it as rewarding thought drinking water was easy, habitual or automatic (e.g., “it’s so automatic that you don't even notice when you drink it” [P28, RWD]) and it was their default drink choice: “My drink of choice is water. It is the first drink I go to instead of tea/coffee, fizzy drinks or alcohol” [P20, RWD]. This meant that there were very few and infrequent situations (e.g., socializing situations) during the day that would limit these participants’ intake: “I will occasionally have a can of Pepsi or Coca-Cola when I’m out eating but this rarely happens as I prefer water” [P7, RWD]. The automaticity and subjective ease with which these participants described their water intake could indicate that this behaviour was habitual, as self-reported automaticity is commonly used to capture the relationship between habit and behaviour (Gardner et al., 2012).

Participant’s descriptions of water intake suggested that there was a lot of preparation involved in making water easy to access. This preparation behaviour, too, appeared easy and automatic for these participants, indicating that it could also be habitual. For example, preparation behaviours, such as always having a bottle on hand, were common: “I don't really realise I'm drinking until the bottle is empty. I keep a water filter always topped up as well so I can refill the bottle easily” [P28, RWD], but participants described doing these preparation behaviours using phrases such as, “it’s relatively easy as it’s habit,” illustrating the subjective ease of this preparation behaviour. However, for someone who does not ‘habitually’ make sure they have a bottle wherever they go, this may be experienced as effortful. Therefore, appraisals of the ease of drinking water seemed to be inherently subjective.

#### *2.4.2.2 Theme 2: "I don't drink it because I enjoy it, I just know I should" - Drinking Water out of Obligation*

Many of the participants who had low and inconsistent water intake seemed to be motivated to drink water out of obligation as they frequently used phrases such as "I should," "I need," "a chore," and "I force myself" when they described drinking water: "I drink water because I feel I should for my body's functioning. Very occasionally when I am very thirsty, or it is very hot, is drinking water anything other than a chore" [P13]. Descriptions like this seemed to communicate that these participants viewed drinking water as an effortful and unpleasant task they should perform, stemming from a general perception that water drinking was a healthy behaviour

Underlying this sense of obligation, however, was a lack of actual value ascribed to water drinking because these participants rarely experienced reward or adverse outcomes from drinking or not drinking water, respectively. If they did not feel thirsty or dehydrated, water drinking was viewed at best as a neutral activity: "If water was the only option, I'd be reasonably happy to drink it." [P33]. These participants often expressed that when they increased their water intake or did not drink water this had no noticeable impact on them, indicating that they did not experience any rewarding outcomes, which contrasts with the participants in Theme 1 who did: "I don't feel negatively impacted by [not drinking water]. My concentration is satisfactory, and my attention span is not affected by this" [P12]. These participants were also unlikely to experience any hedonic enjoyment from drinking water: "I just find it so boring!" [P23].

These participants also preferred other drinks over water and perceived those other drinks as providing rewards that water cannot. For example, coffee providing energy or tea creating a calm mood state: "I drink a lot of caffeine as I have young kids who wake a lot at night-time, and I feel exhausted" [P25]. Other drinks were the default drink choice for these participants in the majority of situations and they would only drink water in very specific situations such as during exercise: "If I go to the gym I will have a water bottle […] but I would rarely ever choose to drink water" [P23]. For some of these participants, drinking water seemed like a last resort, and even then, they did not seem like they would enjoy it or even choose to drink it: "if there's anything else to drink, I probably will

always choose something else […] if there's only tap water, I'm not necessarily going to drink it" [P32].

Participants' lack of motivation to drink water was also illustrated when they expressed that although water was technically available to them in most situations, they would not choose it or even consider choosing it: "I could technically always have water with me making it easy to drink like they do, but I don't like water" [P45]. These participants' view of water drinking as easy and accessible, when considering this behaviour more generally, contrasted with the effort (e.g., "force" and "chore") they illustrated when they discussed actual instances of drinking water.

#### *2.4.2.3 Theme 3: Self-Identity and Water Drinking Behaviour*

The value that some participants with high water intake ascribed to water seemed to be informed by aspects of their self-identity, and the most prominent identity aspect mentioned was being health conscious. Health-conscious participants seemed to value water drinking because it was in line with the importance that they placed on taking care of their health, or because it made them feel like a healthy person: "I think starting to become healthier and more conscious of what I eat/drink made drinking water seem more important" [P19, RWD]. For some of these participants, health-consciousness was closely related to age as they expressed a shift in their self-identity as they got older to include health-consciousness: "I changed to drink water in the last couple years […] I'm getting older and I want to keep myself as healthy as possible" [P10, RWD]. The influence of health-consciousness on the value participants ascribed to water was also illustrated by participants with low water intake as they seemed to lack the motivation to drink water because they did not perceive themselves as health-conscious: "I keep myself occupied with other things […] taking care of my health isn't at the forefront" [P44].

When health-conscious participants described the impact their self-identity had on water drinking, it seemed that health-consciousness motivated these participants to drink water as this was in line with their self-identity: "[being health-conscious] encourages me to drink more as to not break my fragile self-perception of being healthy" [P33, RWD]. Health-consciousness also seemed to lead to adverse outcomes for these participants if they had not drunk water as this

was not in line with their self-identity: “[health-consciousness] makes me more likely to put the effort into drinking. Makes me feel guilty if I don't consume enough water” [P19, RWD].

Other aspects of self-identity seemed to be prioritised over health-consciousness in certain situations or more broadly during a participant’s daily life, such that health-consciousness did not always seem to motivate water drinking. For example, Participant 26 (RWD) discussed stopping their water drinking behaviour during religious fasts: “When fasting for religious reasons - e.g. Karva Chauth, Ramadan. [Not drinking water] did impact me and at times I found that I needed to break the rules for my own health.” In situations characterised by religious traditions, this participant felt that they were expected to prioritise behaviours in line with their religious identity over those in line with health-consciousness, so their water intake changed. When this participant decided to drink water during this religious situation, their use of “break the rules” suggests they experienced conflict between what was expected of them as a religious person and what was expected of them as a health-conscious person. Another example is Participant 47, who said that they were “generally quite a healthy person so my water consumption doesn't tally with that,” but they reasoned that they were, “now a mother […] I'm too busy to think about drinking water. I drink a lot of caffeine instead.” This participant seemed to prioritise being a mother over being health-conscious and so her drinking choices aligned the with the expectations of being a mother over the expectations of being healthy.

Whether a participant related water drinking to their identity as part of a social group or not, seemed to depend on if they felt water had a social signalling function. For some participants, drinking water signalled to others that they were heath-conscious or an in-group member in certain social groups, and this could be experienced as rewarding for some participants but not all of them: “My parents have noticed I drink a lot of water. It makes me feel good as it is a reminder that I am improving my health.” [P6, RWD] and “a lot of my friends and colleagues are dedicated water drinkers so it’s not unusual” [P25, RWD]. However, many participants thought that people in their social groups had no opinions about their water drinking and that others’ opinions would not change their water drinking: “I can't imagine anyone else pays any attention to how much water I drink.” [P47, RWD]. Water drinking seemed to be an individualistic behaviour for these

participants that did not serve any social signalling function and was not related to social identity.

Although self-identity seemed to inform the value some participants ascribed to water and motivate water drinking behaviour, this was uncertain for others. Although Participant 5 (RWD) outlined valuing water as being, "good for your health," and this could be interpreted as them having a health-conscious identity, this interpretation seems unlikely. They consistently referred to their enjoyment of water and their water drinking routine at home when describing why they drank water indicating that hedonic enjoyment and a situated water drinking habit (Rodger et al., 2021) are more likely to motivate their water intake. For example, "It's easy for me to drink water because I really enjoy it," and "I always have a few water bottles in circulation, and when I get one out the fridge I fill another one up and put it in there as a treat for later." Although health-consciousness could be present, it did not seem to be a salient part of this participant's perspective of what motivated their water drinking behaviour.

#### *2.4.2.4 Theme 4: "It has always been this way for me" – The Persistence of Drinking Patterns from Early Life*

When reflecting on their drinking patterns throughout their life, many participants expressed a similar sentiment as Participant 2 (RWD) who said, "[Their water drinking] has always been this way for me," suggesting that their drinking patterns in the present had not changed much, if at all, from the patterns they had growing up.

The participants who drank water from a young age suggested that in doing so they never developed a preference for other drinks. Some of these participants indicated that they had never liked the taste of other drinks, so water was their default choice growing up: "I never drank very sugary drinks when I was growing up as I never had the taste for them. I much preferred milk or water" [P29, RWD]. Phrases like "I never have been interested [in sugary drinks]" suggest that these participants felt they were in control of the decision to drink water as a child. Other participants suggested that choosing water growing up was due to a guardian making other drinks options unavailable to them: "[drinking water is] something I have always done, when younger I was not allowed to have fizzy drinks" [P23,

RWD]. These early interventions geared preferences and default drink choices toward water.

Similarly, participants who drank drinks other than water from an early age attributed their lack of interest in water drinking to early life: “I've not grown-up drinking water so don't think it's in my nature” [P43]. Some participants suggested that they do not drink or value water because it was never modelled or encouraged by their guardians: “I think I was always in the habit of not drinking very much water […] My parents never drank much water so it was not something we were encouraged to do” [P10]. Other participants explained that they had always had a preference for other drinks growing up and this informed their drinking patterns in the present: “Ever since I was a child I have avoided drinking water and would always ask for squash as a day to day drink” [P42]. Phrases such as, “don't think it's in my nature” and “isn’t ingrained as such for me” when they explained why they did not drink water suggest that these participants perceive their early drinking patterns as at least part of the reason they struggle to drink water in the present.

The essence of this theme is not to state that all childhood drinking patterns will persist into adulthood as there were some, like Participant 26, who discussed a shift towards drinking water later in life: “I used to refuse to drink water when I was a child and now, I ask my mother to buy me water.” However, the tendency for drinking patterns to be relatively stable across vast periods of these participants lives was striking to us. Even when changes to drinking patterns were made, this change came after a long period of maintaining childhood drinking patterns. Participant 26 stated that they only started drinking water when they “went to university.” Additionally, they also stated that making this change was difficult due to their previous childhood drinking patterns: “[I] have to force myself to remember to drink it […] I didn’t grow up drinking water all the time, so it’s not routine to me.”

## 2.5 Discussion

Our study on water drinking motivations suggests that reward and value may play important roles in explaining the nature of participants’ water drinking. Participants who associated water drinking with valued, rewarding outcomes, were more likely to drink a high and consistent amount of water, in more situations, and with less subjective effort, compared to participants who associated water drinking with

unvalued, unrewarding outcomes. Participants who valued water and experienced it as rewarding also reported that preparation and water drinking behaviours were subjectively effortless (i.e., automatic in terms of efficiency; Moors & De Houwer, 2006). When reward and value were low, participants seemed to lack the motivation to prepare or drink water, and they experienced these behaviours as subjectively effortful.

Our findings indicate that it is important to understand the value people ascribe to drinking outcomes, as value informs what goals underly their drinking behaviour and therefore, whether they will experience drinking outcomes as rewarding. For example, if someone values taste over health with regards to drink choices, then drinking water to gain a tangible wellbeing benefit may not be viewed as rewarding as drinking a sugary drink for hedonic pleasure. Indeed, in research on food choices, health-focused attitudes were associated with heathier food choice whereas, taste focused attitudes were associated with unhealthier food choice (Zandstra et al., 2001). Our findings align with this pattern and can inform whether emphasising health benefits or increasing perceived or actual tastiness of water will be effective interventions for different groups, depending on their attitudes. Our findings are also in line with recent work showing that drinking beverages, including water, more frequently was associated with thinking about them more in terms of immediate consumption and reward experiences, and that these cognitive representations in turn predicted desire to consume and intake (Papies et al., 2020). However, thoughts about health consequences had little predictive value for motivation and intake, which differs from the findings reported here.

Our research further indicates that participants who experienced water as rewarding also were more likely to describe drinking water with greater automaticity. In studies on habit formation, reward has been shown to increase automaticity indirectly through two routes. Reward can increase the frequency of performance, and therefore increase automaticity through practice. In addition, reward can moderate the effect of frequency of performance on automaticity, such that frequently performing a behaviour has a stronger effect on automaticity when the behaviour is experienced as rewarding (Judah et al., 2018; McCloskey & Johnson, 2019; Wiedemann et al., 2014). In line with these studies, our findings indicate that when participants associated no reward with drinking water, their motivation to perform this behaviour seemed low. It is, therefore, unlikely that these participants engaged in the repeated performance of this behaviour, which could explain why these participants experienced water drinking

as effortful and inconsistent. Importantly, the prevalence of reward and value among participants with high water intake that was self-reported as automatic suggests that water drinking 'habits' could be goal-driven behaviours that have become automatic to some degree (Kruglanski & Szumowska, 2020; Moors et al., 2017). In other words, our findings tentatively suggest that reward could be important for water drinking habit maintenance, not just habit formation. However, more research on the role of reward in habit maintenance is needed.

Self-identity was associated with valuing water and experiencing it as rewarding for some, but not all participants with high and consistent water intake. Possibly, self-identity has a limited impact on this behaviour, or alternatively, participants lacked awareness around how their self-identity informs their water drinking. Prior research on self-identity and food choice indicated that self-identity was a difficult construct for participants to understand (Bisogni et al., 2002). We found that aspects of self-identity such as health consciousness may be associated with high and consistent water drinking, but that this association was not as clear when other aspects of self-identity where prioritised, such as religious identities or motherhood. This is in line with prior studies indicating that self-identity predicts healthy eating intentions and behaviour (Canova et al., 2020; Carfora et al., 2016; McCarthy et al., 2017). Although this link is made tentatively, our data was also in line with Identity Based Motivation theory, which suggests that different aspects of self-identity can be activated in different situations, therefore the association between self-identity and behaviour can vary across situations (Oyserman, 2009). Evidence for Identity Based Motivation theory also illustrates that social identities can inform attitudes towards and the performance of health behaviours (Oyserman et al., 2007). Our findings indicate, however, that the extent of social identities' association with water drinking may vary across individuals, as some viewed this as an individualistic behaviour.

Finally, for many participants, drinking patterns from early life persisted into adulthood, such that early life drinking behaviour was similar or identical to current drinking behaviour. This is in line with longitudinal research, which shows that childhood dietary patterns remain relatively stable over time (Movassagh et al., 2017). However, our findings align with longitudinal research indicating that people can develop healthier dietary patterns over time (Walthouwer et al., 2014), given that some participants reported changing their water drinking behaviour. In addition, participants described how their parents' attitudes towards and performance of water drinking

behaviour shaped their own current water intake. This aligns with research showing parents' attitudes and behaviours influencing child and adolescent performance of health behaviours such as healthy eating (Loth et al., 2016) and physical activity (Ornelas et al., 2007). These findings indicate the importance of early intervention when trying to increase water intake, for example through promoting a preference for the taste of water, and through forming water drinking habits during childhood.

An applied implication of this study is that existing interventions or health practitioners advising people to drink more water or educating people on hydration may create a sense of obligation, but not a sense of value or reward. Although this may motivate individual instances of water intake, if an individual does not experience reward as a result, it seems unlikely that this behaviour will be repeated consistently. Therefore, interventions should also try to increase the reward people associate with water drinking, by capitalizing on aspects of drinking behaviour that many people value highly. For example, if someone values taste and associates this reward with sugar-sweetened beverages, then intervention efforts that stage the change from sugar-sweetened beverages to plain water with an intermediate drink, such as flavoured water, may be more effective. Additionally, interventions could assess whether prolonged exposure to drinking water can increase liking as a way of improving the taste rewards associated with water drinking. Where this cannot be achieved, interventions could try to develop a rewarding health goal associated with water, such as aiming to reduce the frequency of dehydration symptoms. These health goals can then be primed in the moment, to override competing goals for other drinks (Papies, 2016). Our findings also suggest that interventions could use self-identity informed goal-setting, which has been a successful approach with healthy eating behaviour (Dominick & Cole, 2020).

A key limitation of this study is that the findings are situated within the cultural context of the UK. Therefore, they may not generalise to other cultural contexts. Additionally, most of the participants were white women and therefore, these findings may not generalise to more diverse groups. Although the qualitative survey allowed for a large sample, it did not allow follow-up on responses regarding more complex topics like self-identity. Other methods that allow in-depth qualitative data collection may also be needed to improve researchers' understanding. However, our qualitative approach allowed us to be open to unanticipated insights (e.g., the importance of

reward), while still maintaining enough structure to assess predetermined areas of interest (i.e., self-identity).

In conclusion, this study provides an in-depth insight into the understudied but clinically important health behaviour of water drinking. Associating water drinking with valued rewarding outcomes seems necessary for attaining high, consistent and subjectively effortless water intake. To understand whether an individual sees drinking water as rewarding, we need to understand which outcomes of drinking behaviour people value, and whether water can help attain these outcomes. Although education on the importance of hydration is important, health interventions and practitioners need to go further and allow people to experience water drinking as inherently rewarding. Healthy hydration habits are unlikely to result from recommendations to increase water intake alone, as our findings suggest experiencing reward is important for habit formation and maintenance.

# 3. Chapter 3: Can a simple plan change a complex behaviour? Implementation intentions in the context of water drinking.

This chapter is an exact copy of the following published manuscript:

Rodger, A., Vezevicius, A., & Papies, E. K. (2023). Can a simple plan change a complex behaviour? Implementation intentions in the context of water drinking. *Appetite*, *183*. Scopus. https://doi.org/10.1016/j.appet.2023.106459

## 3.1 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 behavior of water drinking.

## 3.2 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 et al., 2013; Ferreira-Pêgo et al., 2015), and many people seem to lack hydration knowledge (Drake et al., 2014; Rodger et al., 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 et al., 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.

### 3.2.1 Water Drinking Research

Previous research suggests that factors such as availability, perceptions of taste and health beliefs are associated with water intake (Block et al., 2013; Hess et al., 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 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.

### 3.2.2 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, 1999). 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, et al., 2011).

This type of planning has been theorized to promote health behavior via two processes (See Bieleke et al., 2021; Wieber et al., 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, et al., 2011; Bieleke et al., 2021; Carrero et al., 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 et al., 2022; Meehl, 1990; Proulx & Morey, 2021; Scheel et al., 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 et al., 2020).

### 3.2.3 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 et al., 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 250ml. 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 et al., 2020) to better understand the intervention from the participants' perspective and their experience of trying to increase their water intake. This allowed us to 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?

### 3.3 Method

The University of Glasgow Ethics Committee approved this research. We preregistered this study on the Open Science Framework (OSF; 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.

### 3.3.1 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 liters or less per day. The participant pool consisted of participants that had reported drinking 1.2 liters 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 liters 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 et al., 2009) (see OSF for more details). The minimum effect size of interest of 500ml 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 11 for participant demographics.

**Table 11**

**Participant Demographics**

| **Demographics of Participants with Complete Data*** | | | |
|---|---|---|---|
| | **Range** | ***M*** | ***SD*** |
| Age | 19 - 74 | 39 | 12 |
| | **Count** | | |
| **Gender:** | | | |
| Man | 15 | | |
| Woman | 80 | | |
| **Ethnicity:**** | | | |
| 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 | | |

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

### 3.3.2 Materials

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

#### *3.3.2.1 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 12), all in number of standard glasses (250ml) 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 et al., 2017; Sparks & Guthrie, 1998), consisting of three questions on a seven-point Likert 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).

**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.

**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 et al.'s (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 12) 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.

**Table 12**

**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.

#### *3.3.2.2 Drinks Diaries*

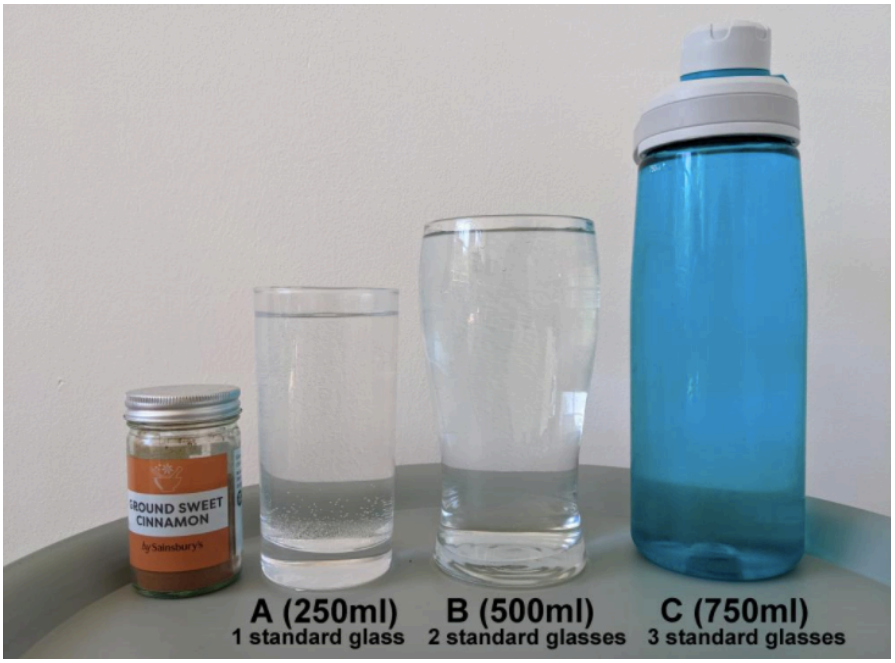
We asked the participants, "How many standard glasses (250ml) of water did you consume in each of the following situations today?" The same 17 situations from the baseline measures were used (Table 12). All responses were given on a sliding scale to one decimal place (Range: 0 – 5). We also asked participants, "How many standard glasses (250ml) 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 Figure 5 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, 250ml) 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).

**Figure 5**

**Reference Picture for Meaning of Standard Glass Size**




### *3.3.2.3 Qualitative Survey*

We asked participants to complete a qualitative survey we developed based on our research questions, prior knowledge of the literature, and Field & 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 the following: 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.

### 3.3.3 Procedure

Participants completed the baseline measures on the morning of Monday 7th June. Participants were invited to complete the drinks diaries from 6 pm – 11 pm 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 am the next day, informing them that they still needed to respond and to do so by 12 pm that day.
2. At 12 pm, informing them that they needed to respond by 4pm that day or their submission would be classed as missing.
3. At 4 pm, 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 pm each night. Most who missed the 11 pm close responded by 12 pm the next day. Six participants used the link to catch up. All participants were paid £5.50.

### 3.3.4 Analysis

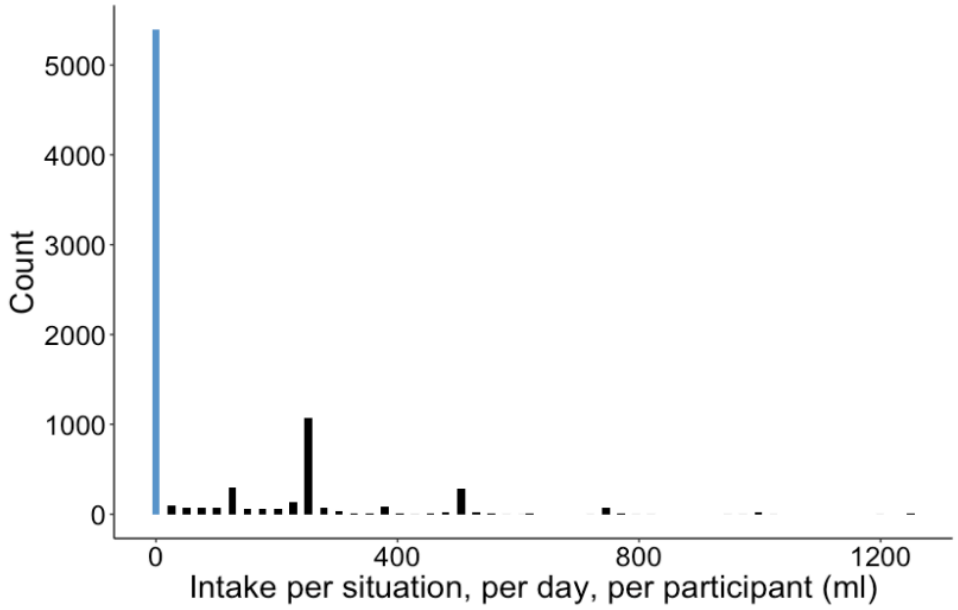
We ran the confirmatory quantitative analysis before the qualitative analysis, as we felt the qualitative component could provide potential explanations for the trends seen in the quantitative data. Therefore, we wanted to have insights into the intervention effect and the change in water intake over 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 OFS 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 Figure 6). 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 et al., 2016; Boulton & Williford, 2018).

**Figure 6**

**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 > 0ml 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 et al., 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 et al., 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.

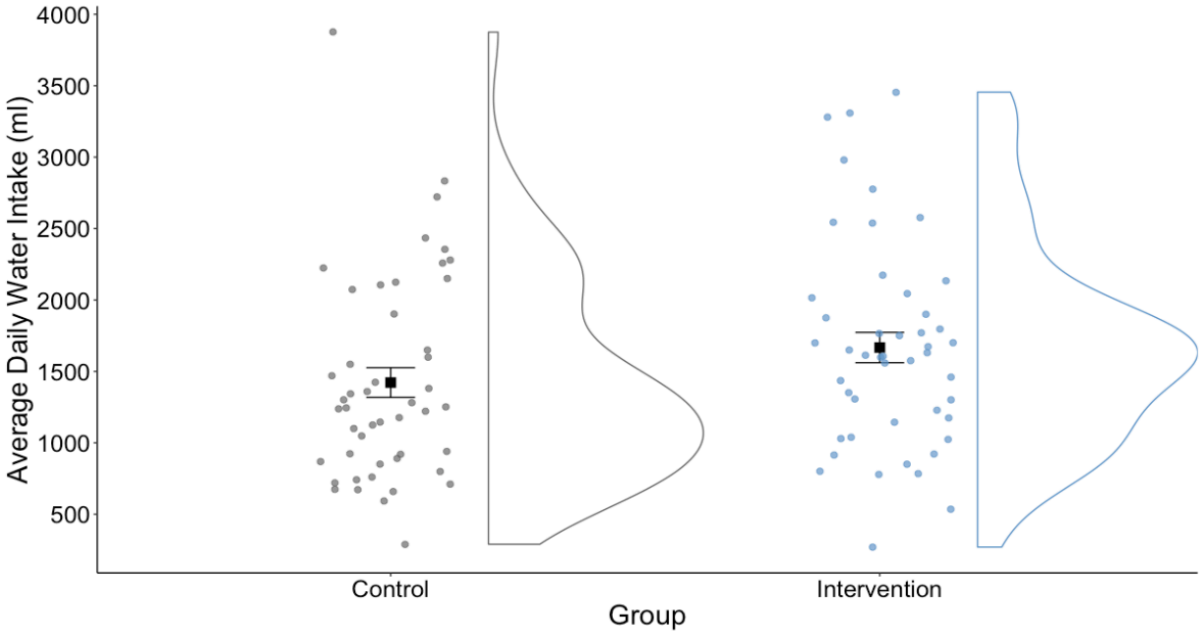
## 3.4 Results

### 3.4.1 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 ml, $SD$ = 729 ml) compared to the control group ($n$ = 48, $M$ = 1422 ml, $SD$ = 717 ml). The mean difference between groups was 245ml. See Figure 7. The mean difference between the groups followed a downward trend over the five days (see exploratory analyses on OSF)

**Figure 7**

**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 -/+ *SE* error bars.

#### *3.4.1.1 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 13.

The model is summarized in Table 14. 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.

**Table 13**

**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 |

**Table 14**

**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 | Intercept | 0.94 | 0.97 | |
| | Slope | 0.14 | 0.37 | -0.37 |
| Day | Intercept | 0 | 0 | |
| | Slope | 0.009 | 0.097 | - |

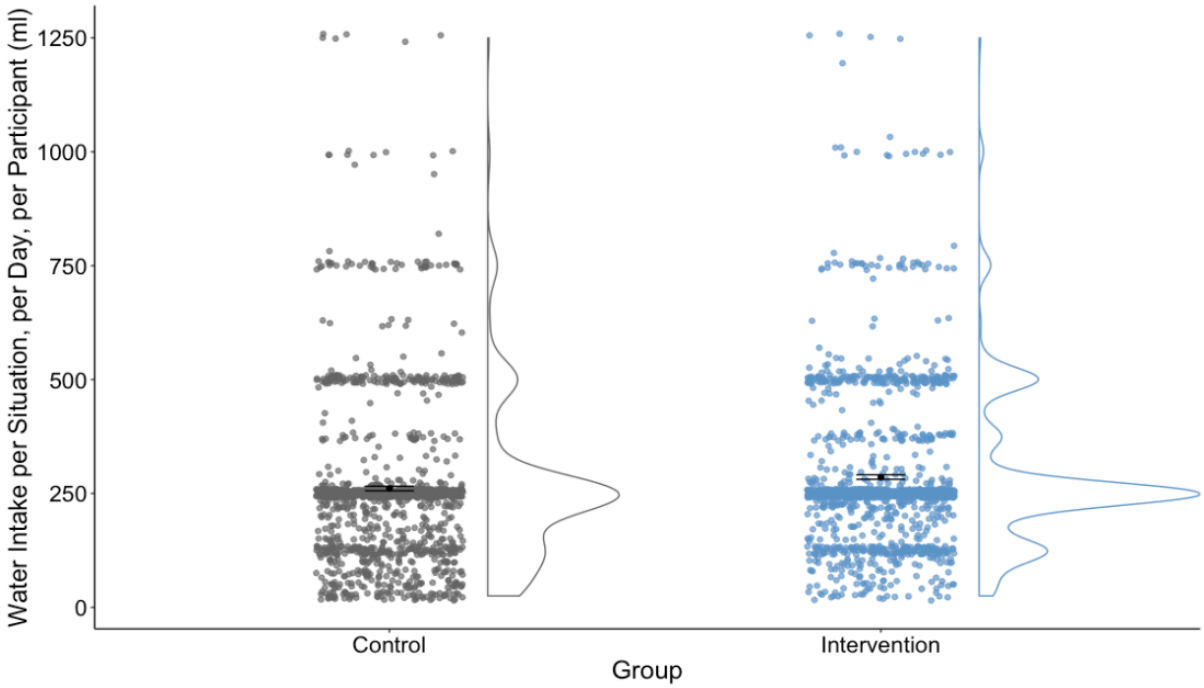
*Note.* We fit the mixed-effects model using a maximal random effects structure (Barr et al., 2013) and Restricted Maximum Likelihood. We calculated the p-value using the Kenward-Roger approximation as this is one of the most conservative approaches (Luke, 2017). All of this was done using the R package 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.

#### *3.4.1.2 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 Figure 8. 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 25ml.

**Figure 8**

**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.

The model is summarized in Table 15. The group fixed effect suggests that the intervention group drank 13.59ml 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.

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

**Table 15**

**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 | Intercept | 3909.10 | 62.52 | |
| | Slope | 1243.40 | 35.26 | -0.29 |
| Day | 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.

### 3.4.2 Exploring Participants' Lived Experience of Increasing Their Water Intake

We generated two themes from the qualitative data analysis, which we will present next. Table 16 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.

**Table 16**

**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 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 |

| Theme | | Summary |
|---|---|---|
| | | 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. |

#### *3.4.2.1 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 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.

**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.

**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 |
| | "I just find it hard to remember" | P57, Control |
| Forgetfulness and need for conscious thought | "It felt relatively effortful, as I often forget to drink water during the day" | P4, Control |
| | "It wasn't easy. I had to remind myself every time" | P74, Intervention |
| Intervention participants not remembering/needing help to remember their implementation situation | "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 |
| | "[The implementation intention] was helpful […] I wrote the plan on a notebook to keep my mind on it" | P74, Intervention |
| External reminders aid remembering: preprepared water and drinks diaries | "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 |
| | "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 |
| | "The survey reminded me each day about drinking" | P30, Intervention |
| External reminder not present or disrupted then remembering impacted | "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 |
| | "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 |
| External reminder aid remembering: implementation intention situation | "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 |

| Interpretation | Supporting Quote | Participant, Group |
|---|---|---|
| | "I definitely started to drink more water in the afternoon and evenings by associating it with different activities and combining them together" | P72, Intervention |
| Performing other, more valued behaviors can lead to forgetting | "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 |
| | "Whilst eating lunch - I am so busy making lunch for the children that I sometimes forget to tend to my own needs!" | P21, Intervention |
| Remembering while performing other, more valued behaviors is not effective | "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 |

**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 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 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 18 for supporting quotes.

**Table 18**

**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 |

| Interpretation | Supporting Quote | Participant, Group |
|---|---|---|
| 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 |

#### *3.4.2.2 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.

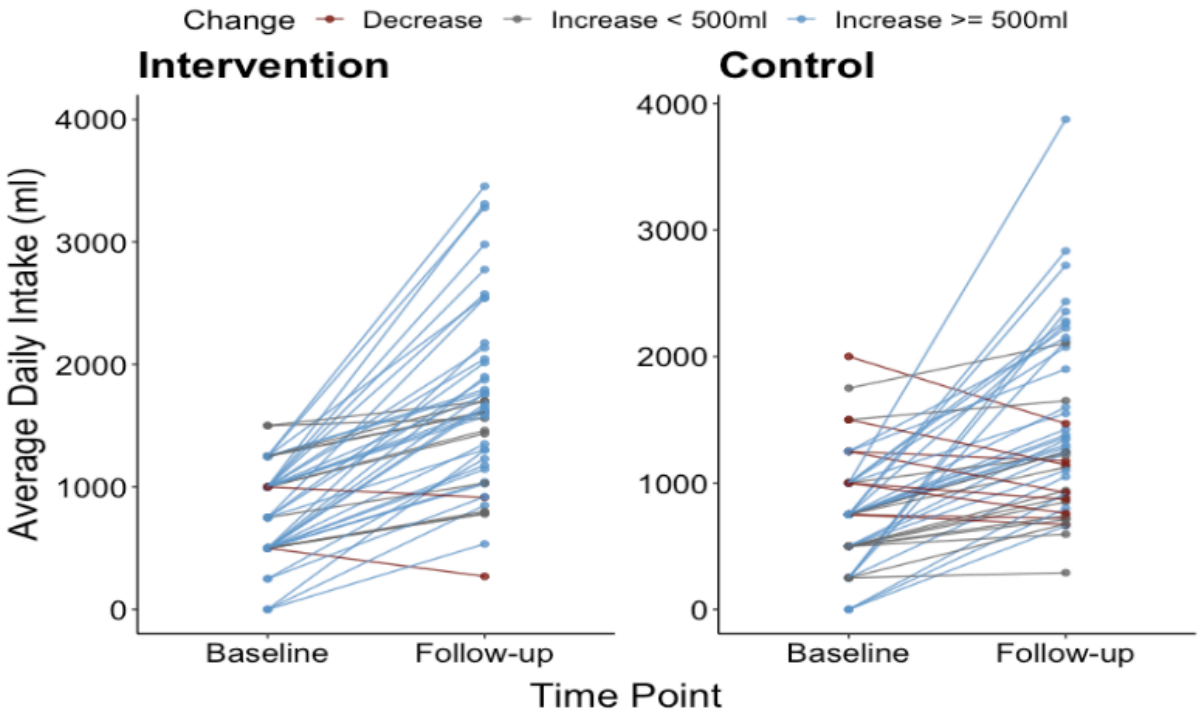
**Subtheme 2.1: Appraisal of the Study Task and Feelings of Accountability.** Most participants seemed to appraise the study task of drinking three additional glasses a day as a goal. How participants appraised the nature of this goal impacted how well it motivated them to engage in the process of drinking 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; Table 19). Therefore, to illustrate the strong nature of this finding, in Table 19, 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 up. See Figure 9.

**Figure 9**

**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 ≥ 500 ml. Control participant 76 had the largest change in water intake from baseline (1000ml) to follow-up (3875ml) 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 >= 500ml]

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 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 19 for supporting quotes.

**Table 19**

**Subtheme 2.1 Supporting Quotes**

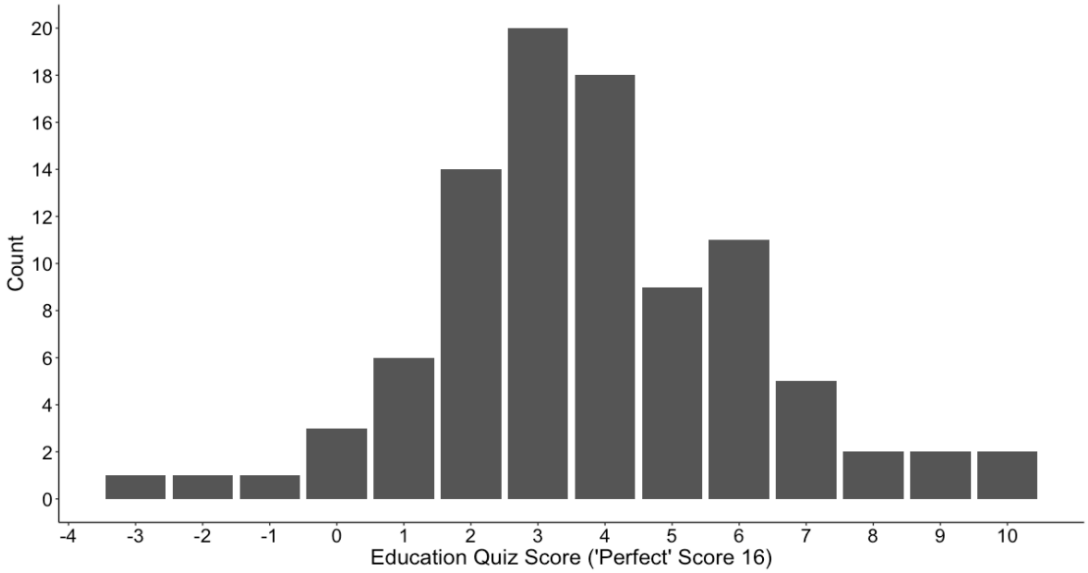
| Interpretation | Supporting Quote | Participant, Group |
|---|---|---|
| Participants appraised study task as a goal | "it gave me a target" | P12, Control & P37, Intervention |
| Judgements of the study task: helpfulness | "It [the study task] was helpful made you more mindful on what you was and when you were drinking water" | P1, Control |
| | "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." | 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" | P26, Control |
| | "The instruction was helpful as I knew exactly how much I had to drink" | 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" | P18, Intervention |
| | "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" | 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 |

| Interpretation | Supporting Quote | Participant, Group |
|---|---|---|
| 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" | P64, Control |
| | "The feeling of needing to be accountable to myself so I could fill out the diaries accurately" | P78 , Intervention |
| | "I think being asked how much I drank helped. It was like someone alongside me who cared about it" | 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" | P83, Intervention |
| | "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 wording didn't make me feel accountability or any ownership over this" | P68, Control |

**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 Figure 10). Thus, the education component may have taught participants useful new knowledge about hydration.

**Figure 10**

**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.

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 20 for supporting quotes.

**Table 20**

**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 |

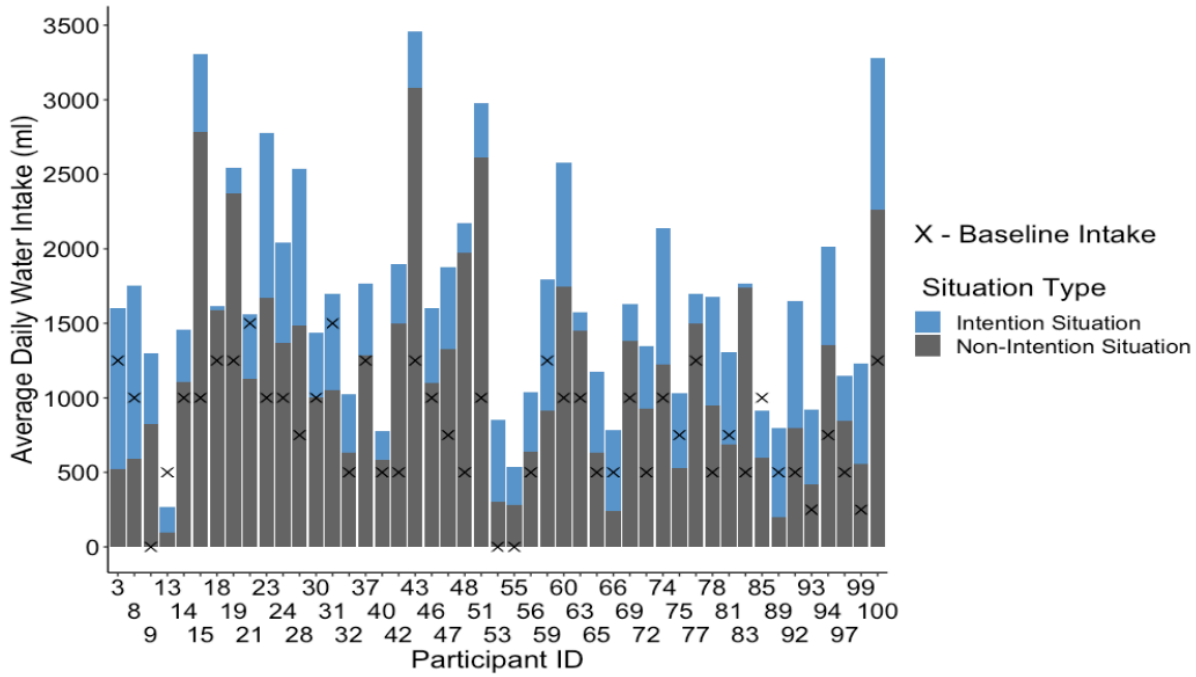
| Interpretation | Supporting Quote | Participant, Group |
|---|---|---|
| | "I have to go out of my way, leaving my shop unattended to go and get a drink, and I am put off as I am likely to need to pee after drinking more" | P45, Control |
| Experience of reward then more likely to try and continue 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 |

### 3.4.3 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. Figure 11 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.

**Figure 11**

**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.

### 3.5 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 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 in 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.

### 3.5.1 Theoretical Considerations

#### *3.5.1.1 Facilitating the "How" of the Target Behavior*

Implementation intentions are theorized to help people act on their intentions by automatically providing the "where, when and how" of this behavior (Adriaanse 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 et al., 2022; Willmott et al., 2021), provides an informative perspective on these results (Michie et al., 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 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 & 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 et al., 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.

#### *3.5.1.2 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 et al. (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 et al. (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 et al. (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 aligns with our result that some intervention participants did not find the external situations we 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.

#### *3.5.1.3 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 et al., 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 et al., 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 need 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 et al., 2018; McCloskey & Johnson, 2019; Wiedemann et al., 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).

#### *3.5.1.4 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 et al., 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.

### 3.5.2 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 3.2.3.

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.

# 4. Chapter 4: Exploring the Underlying Influences of Daily Water Intake Using the Situated Assessment Method.

This chapter is an exact copy of the following pre-print:

Rodger, A., Barsalou, L., & Papies, E. K. (2023). *Exploring the Underlying Influences of Daily Water Intake Using the Situated Assessment Method*. PsyArXiv. https://doi.org/10.31234/osf.io/5f9gm

## 4.1 Abstract

The adverse impacts of underhydration call for a better understanding of what facilitates and hinders water drinking to better inform intervention efforts. We used the Situated Assessment Method, a quantitative approach for profiling behaviours and their underlying influences, to extend previous research on what influences water drinking in daily life. We assessed the underlying influences of 213 adults' water intake in the UK across various everyday situations, such as during work and dinner. Participants reported the extent to which 13 potential underlying influences of water drinking, such as thirst or the availability of other drinks, impacted their water drinking behaviour and their typical water intake across 10 situations. During a one-week follow-up, they also reported their actual water intake in these situations over three alternating days. We then assessed (1) how varied water intake and its underlying influences were across individuals and situations and (2) the cross-sectional and prospective relationship these influences had with typical and diary water intake, respectively. Our results show that water intake varied greatly between individuals and situations and within individuals across situations, providing further evidence that this is highly situated behaviour. Additionally, the 13 underlying influences we identified individually explained substantial proportions of the variance in water intake. Notably, habitualness (e.g., subjective effort), self-relevance (e.g., health consciousness), and immediate feedback (e.g., taste) were positively associated with water intake. However, the ability of these underlying influences to facilitate water intake varied widely based on their presence across individuals and situations. These results suggest various interrelated influences underlie water drinking behaviour, evidencing the importance of using comprehensive theories of behaviour to inform research in this domain. Additionally, interventions may benefit from personalised intervention strategies and promoting the various rewarding outcomes people associate with water intake.

## 4.2 Introduction

Water drinking is an important health behaviour because underhydration is linked to adverse outcomes, including serious health conditions (e.g., chronic kidney disease, diabetes, urinary tract infections) and short-term psychological impacts (e.g., attention deficits and negative moods) (Armstrong & Johnson, 2018; Benton & Young, 2015; Liska et al., 2019; Perrier, 2017; Perrier et al., 2020). Despite this importance, high proportions of populations in industrialised nations do not drink the recommended amount (Drewnowski et al., 2013; Ferreira-Pêgo et al., 2015). Improving hydration status through increased water intake could be an effective prevention strategy for these adverse outcomes (Perrier et al., 2020). However, current water drinking interventions lead to small increases in water intake that are unlikely to improve adverse underhydration outcomes meaningfully (Franse et al., 2020; Rodger et al., 2021; Vargas-Garcia et al., 2017).

Ineffective attempts to change water drinking behaviour indicate that researchers need to understand better how and why water drinking is performed in real-world settings. Recent qualitative and mixed methods research has addressed this gap, describing how water drinking is performed (Rodger et al., 2021) and what constructs influence this behaviour (Rodger & Papies, 2022) in people's daily lives. For example, habitual water drinking behaviour seems to be formed and maintained within specific situations (e.g., a specific time, location, routine), meaning water drinking occurs regularly within habitual situations but irregularly in other situations (Bhanu et al., 2020; Rodger et al., 2021; Rodger & Papies, 2022). This means people typically drink water consistently, with a high degree of automaticity and little conscious thought in habitual water drinking situations but not in others (Rodger et al., 2021). For example, someone may report drinking water consistently with little subjective effort and conscious thought while working at their desk, but drink little to no water while watching tv at home.

The current research aimed to triangulate and build on insights from this prior research using the Situated Assessment Method$^2$ (SAM$^2$; Dutriaux et al., 2023); a new quantitative approach for exploring the underlying influences of behaviour across different individuals and daily situations. Prior research suggests that water drinking and its underlying influences vary considerably across individuals and situations (Rodger et al., 2021; Rodger & Papies, 2022; Werner, Papies, et al., 2022). Therefore, this method is better placed than traditional measurement approaches that aggregate

behaviour performance and its underlying influences across individuals and situations. SAM$^2$ has been used to explore various consumption (e.g., eating and drinking), health (e.g., stress and trichotillomania) and sustainable behaviours (e.g., see Lūka et al., 2023; Werner, Kloidt, et al., 2022; Werner, Papies, et al., 2022). We used SAM$^2$ to identify key constructs that previous research suggests influence water drinking and explore the relationship between these constructs and self-reported water intake across different individuals and situations.

### 4.2.1 Situated Assessment Method (SAM$^2$)

SAM$^2$ posits that to understand behaviour in real-world settings, researchers should measure behaviour in situations where it may occur instead of ignoring or averaging across situations and assess all constructs that might influence this behaviour in these situations. As such, SAM$^2$ situates measurements in two dimensions: (1) situational experience (i.e., situations where the behaviour could occur) and (2) the situated action cycle (i.e., a theoretical framework for identifying constructs that may influence behaviour). For example, researchers using SAM$^2$ would ask participants to report how much various constructs (e.g., habitualness, reward, health consciousness) influence their water drinking in each of various situations (e.g., work, exercise, dinner). See Dutriaux et al., (2023) for an in-depth review of this approach.

Measures of constructs that may predict water drinking are typically unsituated, meaning participants must evaluate constructs by generalising how they influence the target behaviour across every situation where they perform it (Dutriaux et al., 2023). For example, a commonly used measure of habitualness asks participants if the target behaviour is something they do automatically (Self Report Behavioural Automaticity Index; Gardner et al., 2012). If the target behaviour was water drinking, participants would have to estimate how automatically they drink water across all situations where they perform this behaviour. However, prior research indicates that the self-reported automaticity of water drinking is situated, meaning it varies across situations (Rodger et al., 2021). Therefore, unsituated measures could limit researchers' understanding of water drinking because they may capture participants' general impressions of their behaviour rather than their actual experiences in real-life situations (Dutriaux et al., 2023). SAM$^2$ addresses these limitations by identifying relevant situations where

the behaviour may occur and asking participants to evaluate their behaviour and the constructs that may influence it in each situation (Dutriaux et al., 2023).

Additionally, SAM$^2$ aims to comprehensively capture the various constructs that may influence behaviour through the situated action cycle: a theoretical framework for identifying a comprehensive list of constructs that may influence the target behaviour. See the next section for our overview of the situated action cycle related to water drinking. This approach is less limiting than measures capturing one or a few constructs, as complex behaviour performed in real-life situations is likely influenced by many constructs. For example, water drinking seems to be influenced by various constructs, including but not limited to habitualness, reward, physiological states, cognitive states, the external environment, and concurrent behaviour (Rodger et al., 2021).

Finally, SAM$^2$ has been applied to numerous behaviours, providing valuable theoretical and applied insights in these domains. For example, Werner, Papies, et al. (2022) used the situated action cycle to assess the relationship between 34 potential underlying influences of drinking behaviour and self-reported drinking frequency across 11 drinks (e.g., coffee, water, sugar-sweetened beverages, alcohol). They established six constructs underlying these predictors: (1) socialising and positive consequences, (2) health and functionality, (3) negative consequences, (4) habitualness, (5) craving and regulation, and (6) positive taste. They then predicted the drinking frequency of each drink using these constructs and illustrated that prediction profiles were similar across drinks. For example, all constructs, bar negative consequences, were positively associated with drinking frequency, while socialising/positive consequences and habitualness had the strongest positive association. Additionally, these constructs explained a substantial proportion of the variance in drinking frequency across individuals for the 11 drinks ($R^2$ Range = 53% - 81%).

Our research aims to build on these insights by assessing the underlying influences of water drinking behaviour across real-life situations. This dimension of SAM$^2$ (i.e., situational experience) was not included in Werner, Papies, et al. (2022). Additionally, we assess the association these underlying influences have with water intake. Intake is just as important, if not more important, than frequency in this domain. This is because drinking frequently when a specific situation occurs

is not necessarily conducive to high overall daily intake (Rodger et al., 2021). For example, someone could drink frequently upon waking up in the morning. However, this situation has a short timeframe and only occurs once daily. Therefore, despite the high frequency of their intake, their daily water intake would be low. Finally, we focus solely on water drinking as it is conceptually different to other drinking behaviours in that it is the only drinking behaviour that is a physiological necessity. As such, people seem to perceive and use water differently than other drinks (Block et al., 2013; Papies et al., 2021).

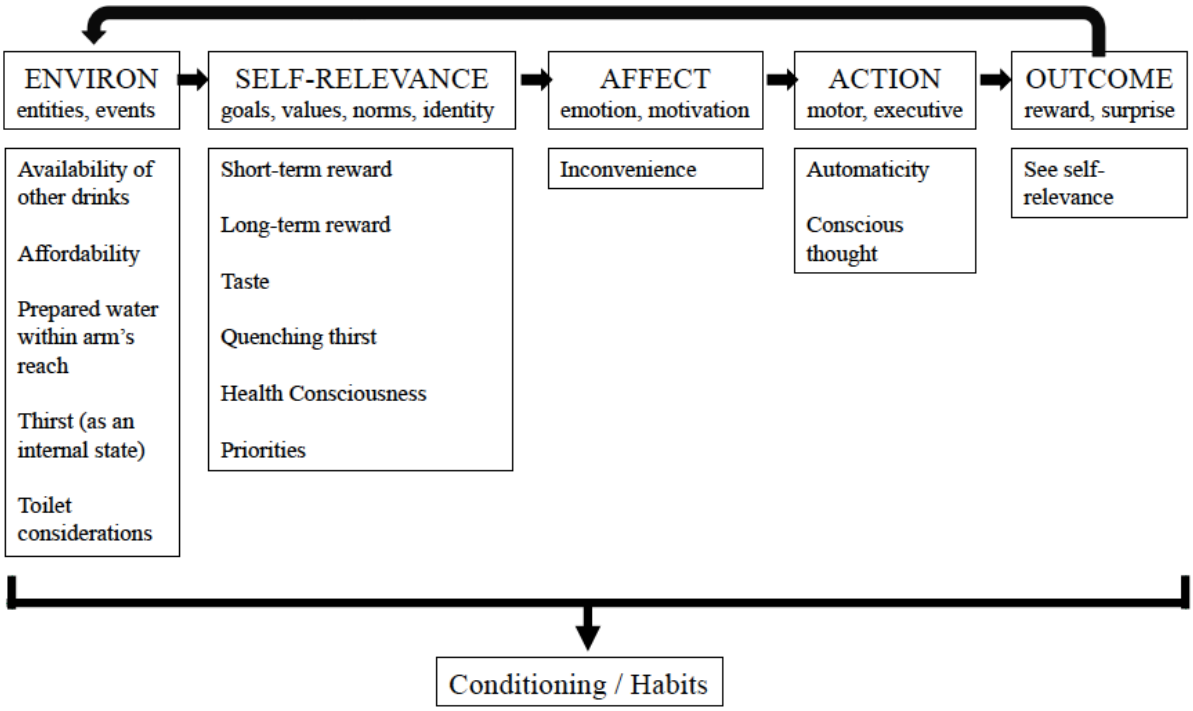
### 4.2.2 Water Drinking Influences & The Situated Action Cycle

We reviewed previous research on water drinking using the situated action cycle to identify a comprehensive list of constructs that may influence water drinking. We outline each phase of the situated action cycle and the related constructs we identified below and provide an overview in Figure 12.

The situated action cycle presents the phases underlying behaviour in an idealised independent, linear progression. In practice, these phases may occur concurrently, iteratively, or be omitted. Additionally, alternative feedback loops and relations between phases may occur. This idealised version serves to outline the phases. Additionally, constructs can relate to multiple phases depending on their conceptualisation, which we illustrate in more detail below. Barsalou (2020) reviews the situated action cycle in-depth.

**Figure 12**

**The Situated Action Cycle of Water Drinking**




Note: Although we aimed to be comprehensive, this list likely does not include all constructs that may influence water drinking. Firstly, we only included constructs evidenced in previous research, which may only partially cover the constructs relevant to water drinking. We did this as our research aimed to triangulate evidence for previously identified constructs, not identify new constructs missing in the literature. Secondly, some constructs we identified were not included due to their limited relevance to the UK context of this study. For example, perceptions of tap water quality and safety (Onufrak et al., 2014). Finally, this list presents a smaller sample of constructs than initially identified, as we reduced the number of constructs included in this research through a pilot study (see Methods).

#### *4.2.2.1 Environment*

In the environment phase, people perceive entities and events in their immediate internal and external environment that provide opportunities to enact actions and trigger habitual behaviour (Barsalou, 2020; Dutriaux et al., 2021). For example, the presence and absence of external objects associated with water drinking in a situation can facilitate or hinder water drinking depending on the nature of the object: The availability of other preferred drinks hinders attempts to start drinking water in new situations (Rodger et al., 2023) and water drinking more generally (Hess et al., 2019; Rodger & Papies, 2022). Water's affordability as a drink choice in situations also influences water drinking (Werner, Papies, et al., 2022). Free water sources (e.g., tap and public water filters) seem to facilitate drinking, whereas the perceived high or unnecessary cost of bottled water can hinder drinking (Etale et al., 2018; Hess et al., 2019; Rodger et al., 2021; Wippold

et al., 2020). The existence of a pre-prepared glass/bottle of water within arm's reach facilitates water drinking. Habitual water drinkers typically report having a water bottle in an easily accessible and salient location in habitual water drinking situations (Rodger et al., 2021, 2023). Preparation behaviours (e.g., filling a glass/bottle with water; Rodger et al., 2021, 2023; Veilleux et al., 2020) and water availability more generally (Vézina-Im & Beaulieu, 2019) also facilitate plans to increase water intake when performed but hinder these plans when they are not.

Internal physiological states, specifically thirst, are a very salient influence on water drinking. For example, thirst is a commonly used cue for water drinking, and not experiencing thirst in situations is a common reason for not drinking water (Bhanu et al., 2020; Rodger et al., 2021; Rodger & Papies, 2022; Vézina-Im & Beaulieu, 2019; Werner, Papies, et al., 2022). However, thirst is also related to the self-relevance and outcome phases of the situated action cycle (e.g., drinking water to quench thirst; see below).

Finally, toilet considerations can influence intake. For example, if people do not have access to a toilet or are unwilling to use the available toilets, they report limiting their water intake (Rodger et al., 2021; Venugopal et al., 2023). Additionally, during attempts to increase water intake, increased trips to the toilet can be seen as a barrier to or negative outcome of drinking water (Rodger et al., 2023).

#### 4.2.2.2 *Self-Relevance*

In the self-relevance phase, perceived entities and events from the environment phase trigger simulations, in other words, partial re-enactments of previous experiences encoded in memory that guide behaviour (Papies et al., 2022). For example, if someone sees their water bottle while working at their desk, this might trigger simulations of enjoying the taste of water or water quenching their thirst. These simulations are then assessed regarding their self-relevance (e.g., goals, values, identities, norms, etc.) and the most self-relevant behaviour is then performed (Barsalou, 2020; Dutriaux et al., 2021). For example, simulations of quenching thirst may not lead to water drinking if the person is not thirsty or is stressed about a work deadline, making finishing their work more self-relevant. See Papies et al. (2022) for a review of simulations and their regulation of consumption behaviour.

In line with this, water drinking research illustrates various self-relevance-related constructs influencing water drinking. Water drinking behaviour is typically performed when it is associated with rewarding outcomes and not when it is associated with unrewarding outcomes (Block et al., 2013; Etale et al., 2018; Hess et al., 2019; Papies et al., 2021; Rodger et al., 2023; Rodger & Papies, 2022; Werner, Papies, et al., 2022). For example, high-water drinkers tend to associate water drinking with numerous rewarding outcomes, whereas low-water drinkers associate water drinking with no or unrewarding outcomes (Rodger & Papies, 2022).

The rewards influencing water drinking can be categorised into short-term and long-term reward. Short-term reward relates to thirst (e.g., water's ability to quench thirst), perceptions of taste, and tangible impacts on well-being (e.g., mood). Taste and thirst seem crucial as these constructs are identified consistently across water research using varied methods. Long-term reward relates mainly to actual or perceived health benefits of water drinking (e.g., lower risk of disease, improved skin, facilitated weight loss). Importantly, being aware of the long-term health benefits of water is not always sufficient to influence water drinking (Douglas et al., 2015). Instead, water intake is associated with experiencing or believing in certain actual or perceived long-term benefits (Block et al., 2013; Etale et al., 2018; Rodger & Papies, 2022; Vézina-Im & Beaulieu, 2019).

Health consciousness is also related to self-relevance, as strong health consciousness is associated with high water intake, habitual water drinking, and finding water drinking highly rewarding (Rodger & Papies, 2022). Additionally, various health behaviours (e.g., sleeping, healthy eating, and exercise) are associated with increased water intake (Elmadfa & Meyer, 2015; Vézina-Im & Beaulieu, 2019), which also suggests that health consciousness facilitates water intake.

Finally, the influence of self-relevance is further illustrated by a commonly reported barrier to water drinking: performing other, more valued behaviours that would have to be interrupted to drink water (Rodger et al., 2021, 2023). Both high and low-water drinkers report not drinking water when prioritising other

behaviours (e.g., caring, work, studying, etc). However, this barrier is more salient and common for low-water drinkers.

#### *4.2.2.3 Affect*

Self-relevance induces the affect phase, which typically involves emotions and motivation that create a drive to pursue action aligned with goals, values, identities, norms, etc. (Barsalou, 2020; Dutriaux et al., 2021). This stage is closely related to the self-relevance phase as simulated outcomes (i.e., positive taste, quenching thirst, short-term reward, etc.) can lead to high motivation to perform the related behaviour. For example, physiological states of thirst and simulations of drinking water quenching thirst can lead to high motivation to prepare and drink water (Papies et al., 2022).

Water drinking research so far has provided limited insights on the influence of affect and motivation-related constructs. However, instances where the self-relevance phase led to water drinking considerations but low motivation levels to actually drink illustrate the importance of the affect phase. For example, while trying to increase water intake, low-water drinkers report remembering to drink water and perceiving it as self-relevant but not doing so because they lack motivation. Lack of motivation usually occurred in the presence of key barriers to water drinking, such as performing other, more valued behaviours or not wanting to use the toilet later on. In other words, despite water drinking being self-relevant, low-water drinkers typically feel it would be inconvenient to pursue actions related to water drinking when these barriers are present and often do not do so (Rodger et al., 2023).

#### *4.2.2.4 Action*

When motivation is sufficiently strong, behaviour is more likely to be enacted (Barsalou, 2020; Dutriaux et al., 2021). A key construct influencing if and how water drinking is enacted is habitualness (Werner, Papies, et al., 2022). Water drinking is typically performed consistently in similar situations with a lack of subjective effort, conscious thought, and time needed (i.e., a high degree of automaticity; Rodger et al., 2021; Rodger & Papies, 2022). Outside of situations where water drinking is highly habitual, it is typically performed inconsistently, relying on conscious thought and subjective effort (Rodger et al., 2021).

It is important to note that we define "habitualness" as a descriptor of behaviour which can be observed based on prototypical features such as regularity, consistency, and automaticity as this aligns with recent recommendations (see De Houwer, 2019; Dutriaux et al., 2023). However, there are other definitions (see Gardner, 2015).

#### *4.2.2.5 Outcome*

Finally, actions produce outcomes, including rewards (e.g., positive taste perceptions, reduced thirst symptoms, etc.) and prediction error (e.g., negative taste perceptions, thirst symptoms persisting, etc.) (Barsalou, 2020; Dutriaux et al., 2021). Constructs for the self-relevance and outcome phases are the same because they can be anticipated as outcomes in the self-relevance phase and then experienced as outcomes in the outcome phase. For example, the anticipation that drinking water will quench thirst makes the behaviour self-relevant. However, once water drinking occurs, the experience of thirst being quenched (or not) is a rewarding outcome (or prediction error). This experience is then encoded in memory and informs future water drinking simulations during the self-relevance phase (Papies et al., 2022). Therefore, rewarding outcomes lead to rewarding simulations and a higher likelihood that water drinking will occur again when similar perceived entities and events occur in the environment phase (Papies et al., 2022). However, negative prediction errors lead to unrewarding simulations and a lower likelihood that water drinking will occur again when similar perceived entities and events occur in the environment phase (Papies et al., 2022). The constructs for the outcome phase were already covered in the self-relevance section, so the outcome phase is not discussed further.

### 4.2.3 Current Research Aims & Methodology

Our research is informed by the philosophy of science and methodology literature advocating that psychology needs to use diverse research methods to develop and evaluate well-specified, comprehensive theories and use these theories to guide research (Diener et al., 2022; Eronen & Bringmann, 2021; Maatman, 2021; Meehl, 1978, 1990; Scheel et al., 2020). This literature questions the premature use of experiments to develop theoretical knowledge and researcher overreliance and overvaluation of insights derived from experiments. Diener et al. (2022) and Scheel et al. (2020) provide in-depth reviews of these perspectives.

Water drinking is an emerging research domain still in the earlier stages of theory development (i.e., concept formation, measurement development, and establishing the relationship between concepts; Scheel et al., 2020). In line with recommendations, we used the SAM$^2$ approach outlined above to understand better how water drinking is performed in real-life situations and what may influence this behaviour. Participants reported their water drinking behaviour and assessed 13 potential influences across ten real-life situations (see Tables 21 and 22).

As this work is exploratory, we had no hypotheses. However, this research is not conducted in a vacuum and is informed by our prior knowledge of water-drinking research. Therefore, we did expect to obtain similar insights from the water drinking and SAM$^2$ research outlined previously. For example, we expected that reward would be positively associated with water drinking amounts and intake, and there would be large participant and situation level differences in water drinking behaviour and in its influences.

**Table 21**

**Daily Situations**

| Label | The description given to participants |
|---|---|
| Education/Work/Other | During work (e.g., while working at your desk, construction site, floor, or home), During education (e.g., attending classes, completing assignments on campus or at home), OR If you are not in work or education, during a daily situation that takes up a large proportion of your time (e.g., during childcare if you are a stay-at-home parent) |
| Exercise | Exercise (e.g., going for a walk, working out at the gym, going for a run, yoga) |
| Dinner | Eating your evening meal at home |
| Waking Up | Waking up |
| Travel | Commuting or travelling short distances (e.g., going to work/school, to the supermarket, to visit friends) |
| Restaurant/Café | In a restaurant or café |
| Relaxing at home | Relaxing at home (e.g., watching tv, reading a book, playing video games, scrolling through social media) |
| Lunch | Eating your lunch where you most typically have it (e.g., at home, at work, etc.) |
| Outdoors | Being outdoors (e.g., walking around your local area, parks, beaches, visiting a playground with children, etc.) |
| Family/Friends | Going to visit family and friends |

**Table 22**

**Constructs Influencing Water Drinking**

| Construct | Predictor question answered by participants |
|---|---|
| Affordability | How motivated you are to drink water in this situation because it is a free/affordable drink choice? (Not at all - Extremely) |
| Automaticity | How automatically do you prepare and drink water in this situation? (Not at all - Extremely) & How automatically do you remember to prepare and drink water in this situation? (Not at all - Extremely) |
| Availability other drinks | What percentage of time do you have access to other drinks that you prefer over water in this situation? (Never, 0% of the time – Always, 100% of the time %) |
| Health consciousness | How much does wanting to be healthy matter to you in this situation? (Not at all - Extremely) |
| Long-term reward | How motivated you are to drink water in this situation because it will be good for you in the future (e.g., your health, body weight, skin, mental wellbeing)? (Not at all - Extremely) |
| Short-term reward | How motivated you are to drink water in this situation because it will be good for you right now (e.g., make you feel good, energised, less hungry, relaxed, focused)? (Not at all - Extremely) |
| Preparation | What percentage of time do you have a glass or bottle of water you could drink from within arm's reach in this situation? (Never, 0% of the time – Always, 100% of the time %) |
| Priorities | Where is drinking water on your list of priorities considering the other things you have to or choose to do in this situation? (Bottom of my list - Top of my list) |
| Taste | How motivated you are to drink water in this situation because you will enjoy the taste of it? (Not at all - Extremely) |
| Thirst | How motivated you are to drink water in this situation because it will quench your thirst (Not at all - Extremely) |
| Toilet considerations | How much do you agree with the following statement? 'I limit my water intake in this situation because I do not want to have to go to the toilet later on' (Strongly disagree - Strongly agree) |
| Conscious thought | How much do you agree with the following statement? 'I prepare and drink water in this situation without thinking about it' (Strongly disagree - Strongly agree) |
| Inconvenience | How much do you agree with the following statement? 'It would be inconvenient for me to stop what I am doing in this situation to prepare and drink water' (Strongly disagree - Strongly agree) |

### 4.3 Methods

The University of Glasgow Ethics Committee approved this research. We have uploaded supplementary materials to the Open Science Framework, including raw data, analysis files, and the supplemental methods and results files referred to throughout. They can all be accessed here: https://osf.io/pueyx/

### 4.3.1 Participants

We collected data from 213 participants 18 years or over, fluent in English, and UK residents via the recruitment platform Prolific (www.prolific.co). To ensure data quality, we only recruited participants with a 95%+ approval rating for previous studies. This was the largest sample size we could collect based on our financial resources. We aimed for the largest sample to ensure our analyses would be credible. For example, sample-level means, correlations, factor solutions, and regression coefficients are more stable and reflective of population-level statistics with higher sample sizes. Data collection took place on Tuesday 20th June – Monday 26th June 2023. The study took an average of 48 minutes and participants were paid £7.75.

Our previous research via Prolific has resulted in samples they are predominately white women (Rodger et al., 2023; Rodger & Papies, 2022). To collect a more representative sample of the UK adult population, we did the following: (1) We used Prolific's 'balance sample' feature, which recruited an even number of male and female participants. (2) We used Prolific's 'demographic pre-screening' to stratify our data collection by the 'ethnicity simplified' option. We ran two gender-balanced studies: one with 'White participants (83% of the sample) and one with 'Black', 'Latin', 'Asian', 'Mixed', and 'Other' participants (17%). The proportions for gender and ethnicity in our sample were based on population data from the Office of National Statistics (2021, 2022). See Table 23 for participant demographics.

**Table 23**

**Participant Demographics**

| **Participant Demographic** | | | |
|---|---|---|---|
| | ***M*** | ***SD*** | **Range** |
| Age | 43.08 | 13.19 | 18 - 83 |
| | **Count** | **Proportion** | |
| Gender: | | | |
| Man | 104 | 0.51 | |
| Woman | 109 | 0.49 | |
| Ethnicity: | | | |
| White | 176 | 2.79 | |
| Asian | 20 | 0.32 | |
| Mixed | 7 | 0.11 | |
| Other | 5 | 0.08 | |
| Black | 4 | 0.06 | |
| Prefer not to say | 1 | 0.02 | |
| Education: | | | |
| University Bachelors Degree | 78 | 0.37 | |
| Graduate or Professional Degree | 41 | 0.19 | |
| Vocational or Similar | 38 | 0.18 | |
| Completed Secondary School | 33 | 0.15 | |
| Some University but No Degree | 18 | 0.08 | |
| Some Secondary | 3 | 0.01 | |
| Completed Primary School | 1 | 0 | |
| Some Primary | 1 | 0 | |
| | | | |
| Typical Daily Beverage Intake (ml) | ***M*** | ***SD*** | |
| Water | 1,481 | 1,050 | |
| Hot drinks (e.g., tea, coffee) | 1,241 | 1,099 | |
| Cold drinks (e.g., sugary drinks, fruit juice) | 683 | 918 | |

*Note:* This table shows the demographics for the 213 participants that completed the initial SAM2 survey. Due to incomplete data, we excluded seven participants from analyses using the drinks diaries with the following demographics: Age (M = 37.14, SD = 8.86), Gender (Woman = 2, Man = 5), Education (University education = 6, Completed secondary school = 1), and Ethnicity (White = 6, Black = 1).

### 4.3.2 Measures

All surveys were created on Qualtrics (www.qualtrics.com), and the complete surveys are available as supplemental materials.

#### *4.3.2.1 SAM² Survey*

**Development.** We reviewed prior water drinking research (see introduction) to establish a comprehensive set of daily situations where water drinking behaviour may occur and predictor questions regarding constructs that

may influence water drinking. We then assessed these situations and predictors in pilot studies. A complete discussion of these pilot studies' methods and results is out of the scope of this manuscript. Additionally, we used similar methods and measures in these studies, as outlined in this manuscript. Therefore, we provide a brief overview of the pilot studies below and a detailed overview on the OSF (see supplemental methods SM1).

In the first pilot, we assessed whether our list of situations was comprehensive (i.e., could participants identify other situations) and whether our situation descriptions and survey questions were accessible (i.e., could participants understand them). We also identified a smaller sample of situations representing different typical water drinking amounts and frequencies for the second pilot study and current study (e.g., a sample of situations where people typically drink low, medium, *and* high amounts of water). In the second pilot, we assessed the comprehensiveness, predictive ability, and accessibility of our predictor questions in this smaller sample of situations. We used these insights to include, exclude, and reword predictors for the $SAM^2$ survey.

**Survey.** Participants provided informed consent, read the survey instructions, and responded to the data quality commitment request, which is a tool for improving data quality (see supplemental methods SM2; Qualtrics, 2022). We then randomly presented ten situations individually (see Table 1), and participants completed the following three tasks:

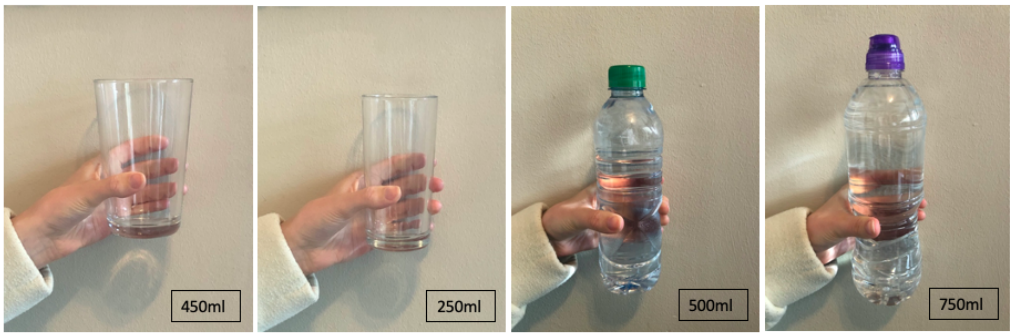
First, we asked them to describe the external and internal aspects of the situation in more detail by responding to the following open-ended questions: “Briefly describe where you typically are in this situation,” “Briefly describe what you are typically doing in this situation,” and “Briefly describe how you typically feel emotionally (e.g., stressed, calm, busy, idle) and physically (e.g., tired, energised, hot, cold) in this situation.” This task aimed to help participants immerse themselves in the situation.

Second, we asked participants about their typical water drinking frequency and intake in the situation. Frequency was measured using the following question: “How often do you typically drink water in this situation when it occurs?” Response on a sliding scale from Never, 0% of the time – Always, 100% of the

time, anchored at 0. Intake was measured using the following questions: (1) “What glass or bottle do you use most often to drink water in this situation?” Response options are shown in Figure 13. (2) “How many of this particular glass/bottle of water do you typically drink in this situation?” Response on a sliding scale from 0 – 12 glasses to 1 decimal point, anchored at 0. We multiplied the glass/bottle amount the participants chose by how many of them they reported drinking to calculate the participant's water intake (ml) for the situation. This approach aligns with previously validated water intake measures (Veilleux et al., 2020).

**Figure 13**

**Water Intake Question Response Options**




Third, we asked the participants to respond to 13 randomly ordered predictor questions (See Table 2).

After participants completed these tasks for all ten situations, we asked them about their general daily drinking behaviour. First, we asked, “What glass or bottle do you typically use to drink liquids throughout the day? Pick the one closest in size to what you would typically use,” presenting the same options as Figure 2 above. Then we asked the following: “How many of this particular glass/bottle of water do you typically drink a day?”, “How many of this particular glass/bottle of other non-alcoholic drinks (e.g., fizzy drinks/soda, fruit juice, soft drinks, etc) do you typically drink a day?”, and “How many of this particular glass/bottle of hot drinks (e.g., tea, coffee, etc.) do you typically drink a day?” All on a response on a scale of 0 – 12 glasses to 1 decimal point, anchored at 0. These questions aimed to gain insight into the average intake of water, non-alcoholic drinks, and hot drinks of our sample.

Finally, we asked for demographic information, including age, gender, ethnicity, and education.

#### *4.3.2.2 Daily Drinks Diary*

In addition to the SAM2 survey, participants completed drinks diaries at the end of three days during a follow-up period. We presented the 10 situations individually and asked participants, “Did the situation above happen today?” with “yes” or “no” response options. If participants responded “no”, they moved on to the next situation. If they responded “yes”, we asked them the same two water intake questions outlined in the SAM2 survey section above: “What glass or bottle did you use to drink water in this situation?” and “How many of the glass/bottle of water did you drink in this situation?”

### 4.3.3 Procedure

Participants completed the SAM2 survey on Tuesday 20th June 2023. We then invited them to complete a drinks diary the following Thursday, Saturday, and Monday between 6 – 12 pm.

We gave participants a day off between each drink diary to collect water intake data on diverse days of the week where different situations might occur. Additionally, it gave us a day to follow up with participants who still needed to complete the previous day's drinks diary. This approach helped reduce attrition in our prior research (Rodger et al., 2023).

We also sent reminders to participants throughout data collection to try and reduce attrition. On drink diary completion days, we sent the following reminders:

1. At 9 am, to remind participants that the drinks diary will be released 6 – 12 pm.
2. At 10 pm, to remind participants who still needed to complete the diary to complete it.

On catch-up days, we sent the following reminders to participants who had not yet completed the diary:

1. At 8 am, to remind them to complete it by 12 pm.
2. At 12 pm, to remind them to complete it by 4 pm.

3. At 4 p.m., to inform them that data collection was finished and that they had a final chance to complete the drinks diary by the end of the day. If they did not, their data for the drinks diaries was classed as incomplete (N = 7).

### 4.3.4 Data Quality Checks & Analysis Approach

We checked data quality to assess whether participants had responded randomly to our survey. Initially, we assessed survey completion times and assessed participants' data if this was less than 20 minutes (N = 16), given that average completion time was 38 minutes (SD = 19). Specifically, we assessed these participants for flatlines: the standard deviation of a participant's response to the predictor question being zero (N = 0). No participants were excluded based on these quality checks.

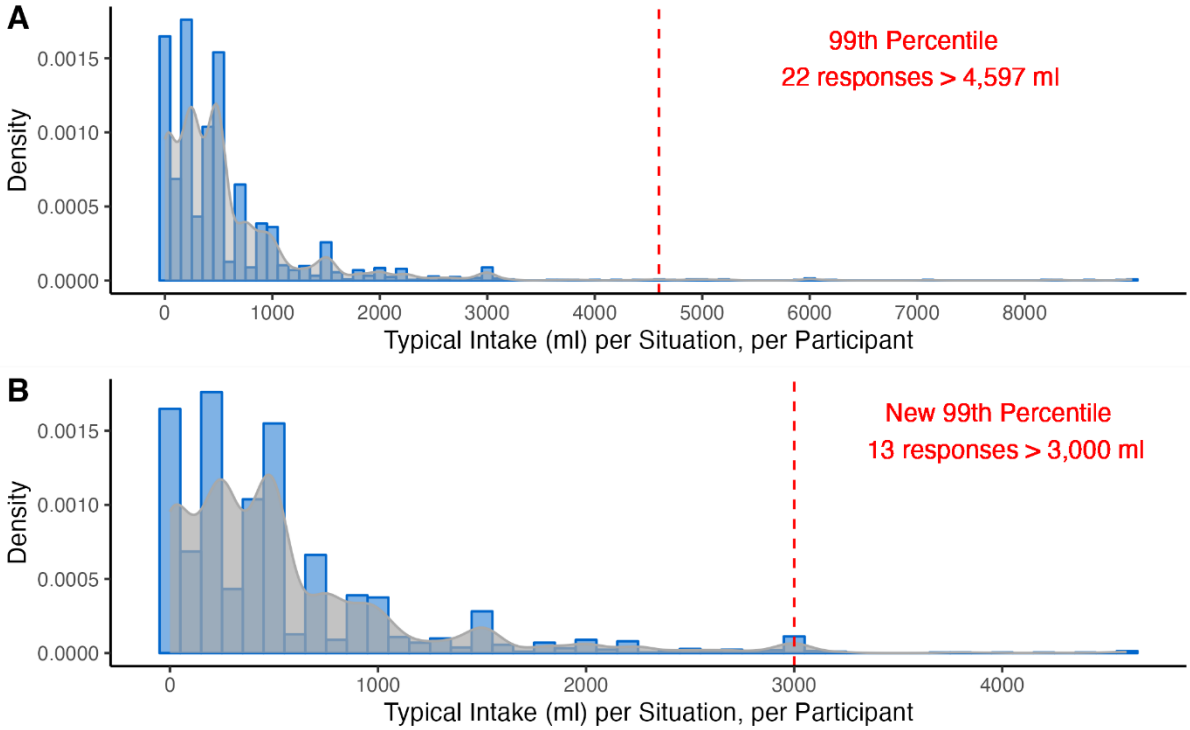
We had two outcome variables of interest: water intake and frequency. We had two measures for water intake: self-reported typical intake from the SAM2 survey and self-reported intake from the drink diaries. We had one measure for frequency: self-reported typical frequency from the SAM2 survey. These measures were recorded per participant, per situation. They are referred to as “typical intake”, “diary intake”, and “typical frequency” in the results.

We assessed typical and diary water intake for outliers (typical frequency had no outliers) following the best practices outlined by Aguinis et al. (2013). Outliers were treated as naturally occurring and not removed from the data, as water intakes in the distribution's extremes are feasible (i.e., extremely low or high water intake). However, we investigated extreme outliers to ensure these values did not result from measurement error by contacting participants to confirm whether these intakes were accurate.

There were 22 typical intake observations greater than the 99$^{th}$ percentile. These observations were recoded if participants provided an updated response (N = 19). The observation was left if the participant said it was accurate (N = 1). If participants did not respond, outliers were recoded to the upper limit of the 99$^{th}$ percentile (N = 2). Figure 14 shows the typical water intake distribution before and after our outlier assessment.

**Figure 14**

**Typical Water Intake Distribution Before and After Outlier Assessment**

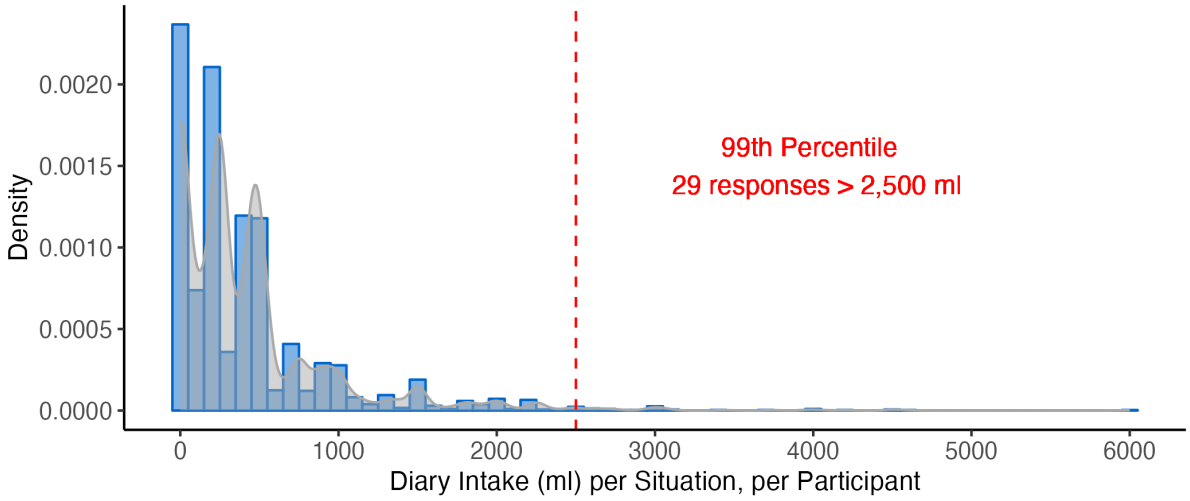



*Note.* The plots show the density distribution of typical intake before (A) and after (B) outlier assessment and recoding. Density is depicted in a bar (blue) and violin (grey) format. The red dashed line denotes the 99$^{th}$ percentile.

There were 29 diary intake observations greater than the 99$^{th}$ percentile (see Figure 15). However, these outliers were all reported as accurate during the outlier assessment, so no recoding occurred.

**Figure 15**

**Diary Water Intake Distribution**




*Note.* The plot shows the density distribution of diary intake. Density is depicted in a bar (blue) and violin (grey) format. The red dashed line denotes the 99$^{th}$ percentile.

As our analysis of each outcome variable is exploratory, we outline each analysis approach along with their respective results in the results section. We conducted all analyses in R Core Team (2014).

## 4.4 Results

The results regarding typical intake and typical frequency were extremely similar. Therefore, we only report typical intake in the manuscript as it is more theoretically relevant. This research aims to better understand water drinking behaviour to inform effective interventions to increase water *intake*. The typical frequency results are on the OSF (see supplemental results SR1). However, we report typical *and* diary water intake as this allows for replication of cross-sectional results (i.e., typical intake) using prospective results (i.e., diary intake). Additionally, similarities and differences across these results can inform applied implications (e.g., limitations of retrospective typical intake measures compared to diary intake measures).

### 4.4.1 Descriptive Analyses

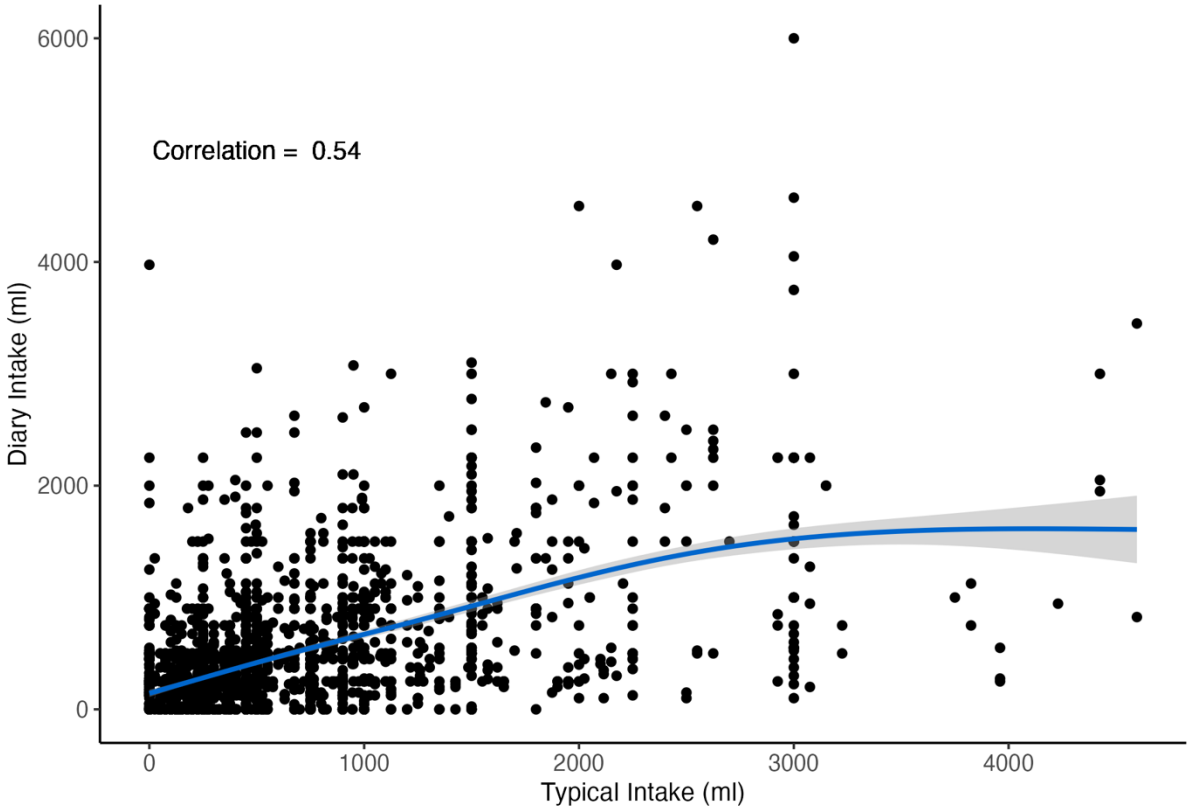
#### *4.4.1.1 Typical and Diary Water Intake*

Diary intake analyses included 206 of 213 participants in the typical intake analyses, as they completed all three drink diaries. Typical and diary intake moderately correlated positively ($r_s$ = 0.54), indicating that participants' estimations

of typical intake for a situation may not have always accurately reflected actual intake (see Figure 16).

**Figure 16**

**Typical & Diary Water Intake Scatter Plot**

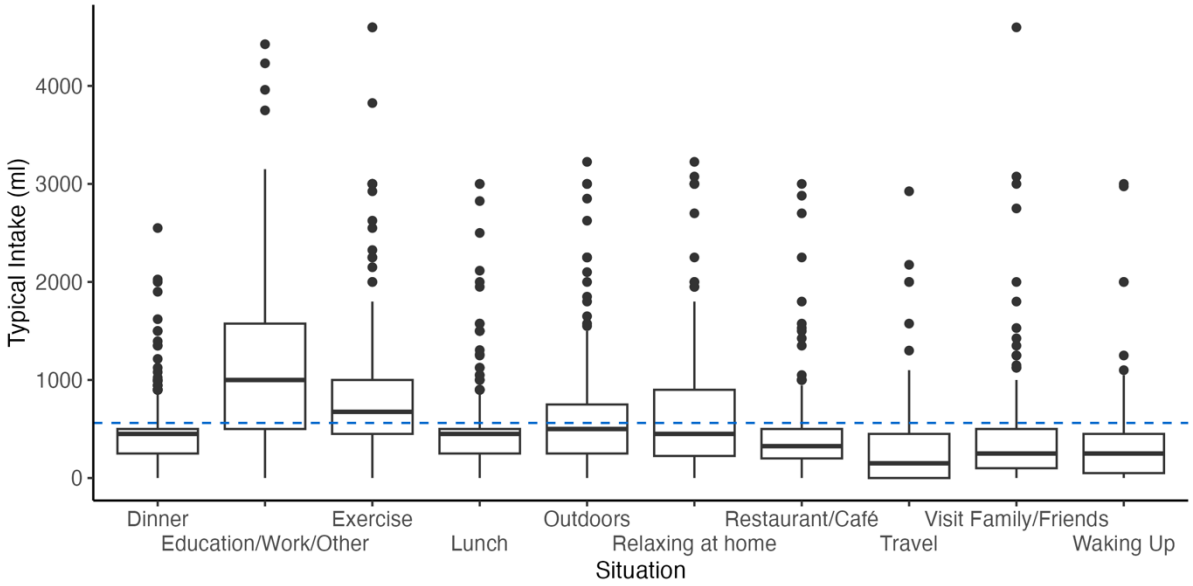



*Note.* The scatter plot dots (black) show one participant's typical and diary intake in one situation. The line of best fit (blue) was created using geom_smooth(method = 'gam' and formula = 'y ~ s(x, bs = "cs")) in R. We assessed the influence an observation has on the association between typical and diary intake (i.e., leverage) by running a simple linear mixed effects model (i.e., intake ~ frequency + (1|ID) + (1|Situation)) and calculating leverage statistics. No observations had high leverage.

For typical intake, participants reported drinking an average of 561.69 ml (SD = 630.63) during the ten daily situations. However, typical intake varied around the grand mean depending on the situation (Figure 17). For example, during *education/work/other*, which covers a large period of the day, and *exercise*, which is conducive to water intake (Rodger et al., 2021), typical intake was typically higher than the grand mean. During *restaurant/café*, *travel*, and *visiting family/friends*, which occur outside the home and are known to be conducive to drinking other beverages or limited water intake (Claassen et al., 2023), typical intake was typically lower than the grand mean. The spread of typical intake in each situation indicates that these trends are variable across participants.

**Figure 17**

**Typical Water Intake Spread per Situation**

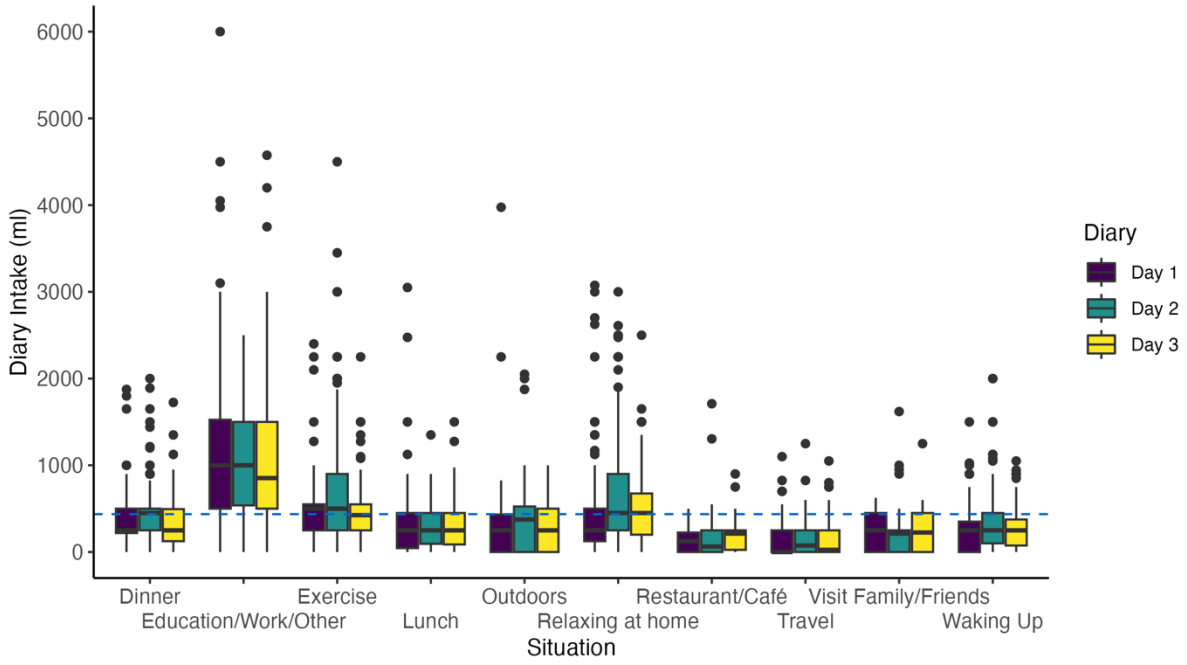



*Note.* The plots show the spread of typical intake using the following summary statistics: median, 25th and 75th percentiles, and 1.5*interquartile range. Observations outside of this spread are plotted individually by black dots. The horizontal blue dashed line shows the grand mean of typical intake. The situations are presented alphabetically.

For diary intake, participants reported drinking an average of 436.71 ml (SD = 535.28) of water during daily situations. The situational trends were the same as typical intake and, again, variable across participants (see Figure 18).

**Figure 18**

**Diary Water Intake Spread per Situation**




*Note.* The plots show the spread of diary intake per situation and diary day using the following summary statistics: median, 25th and 75th percentiles (lower and upper hinges), and 1.5*interquartile range (lower and upper whiskers). Observations outside of this spread are plotted individually by black dots. The horizontal blue dashed line shows the grand mean of diary intake. The situations are presented alphabetically.

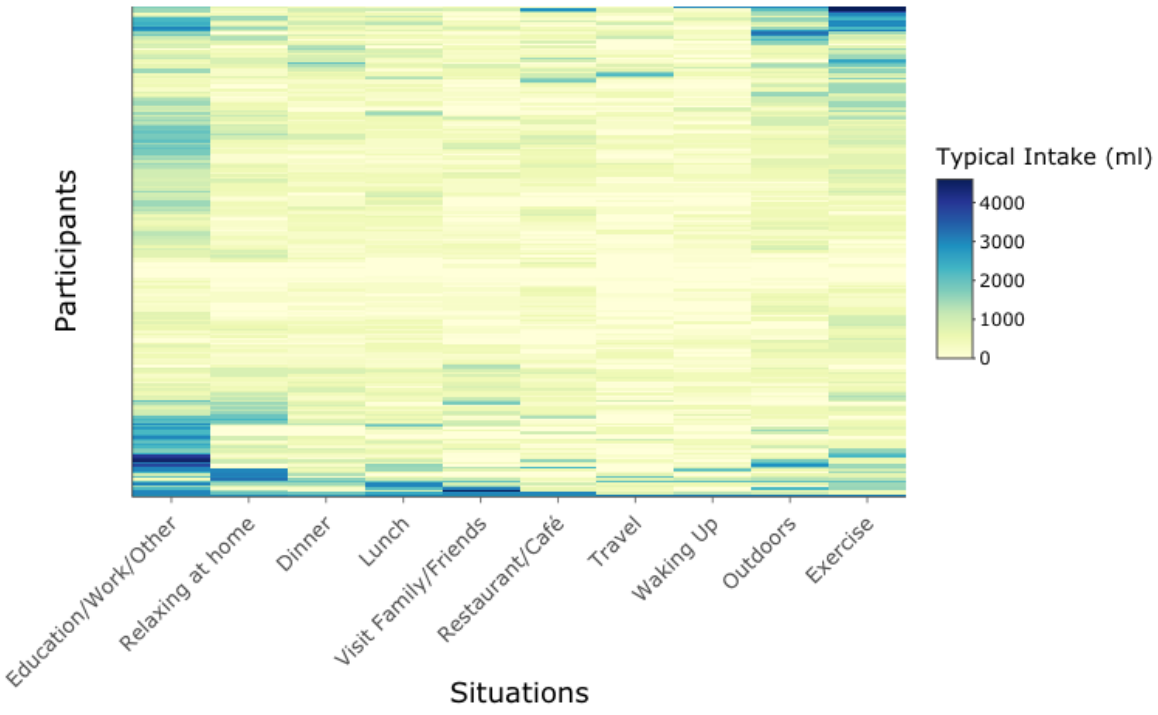
We used the ICC2 intraclass correlation coefficient (Shrout & Fleiss, 1979) to explore the variation in typical and diary intake across situations and participants in more detail. Briefly, the ICC2 estimates the average correlation in reported intake between all possible pairs of judges (i.e., the participants or situations). ICC2 values can reflect poor (< 0.5), moderate (0.5 - 0.75), good (0.75 - 0.9) and excellent agreement between judges (> 0.9) (Koo & Li, 2016). Finally, as ICC2 values account for random variation across participants and situations, they likely generalise to other samples from the same population.

For typical intake, inter-rater agreement between participants' typical intake was 0.18 across the ten situations. This indicates that situations have quite dissimilar typical intakes across the different participants. Inter-rater agreement between situations' typical intake was 0.25 across the 213 participants. This indicates that participants have quite dissimilar water intake across different situations. Participant and situation random effects (i.e., participant and situation means) explained 43% of typical intake variance. This indicates that individual and situational differences can explain a large proportion of the typical intake variation.

Figure 19 visualises the variation in typical intake across participants within each situation (see heatmap columns) and across situations within each participant (see heatmap rows).

**Figure 19**

**Typical Water Intake Heatmap: Participant by Situation**

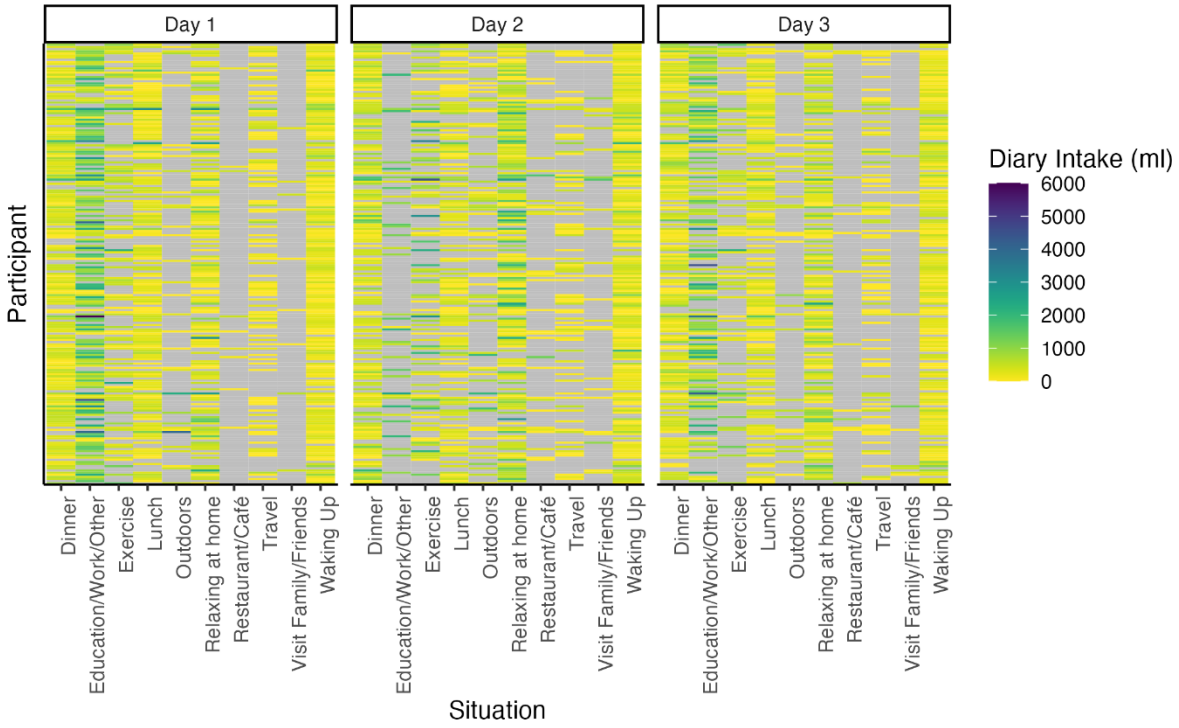



*Note.* Heat map displaying typical intake for the 213 participants in each of the ten situations (i.e., each cell represents the typical intake for one participant in one situation). As cells become darker blue, this indicates higher typical intake values. As they become lighter yellow, this indicates lower typical intake values. The participants and situations are ordered based on their similarity through hierarchical clustering (see Galili et al. (2018) for more information).

Figure 20 and Table 24 show that participants (ICC2 Range = 0.27 – 0.29) and situations (ICC2 Range = 0.16 – 0.21) also had a very low agreement in diary intake, indicating again that situations have dissimilar diary intake across the different participants, and participants have dissimilar diary intake across different situations. Additionally, participant and situation random effects also explained a large proportion of the variation in diary intake (43 – 50%).

**Figure 20**

**Diary Water Intake Heatmaps: Participant by Situation by Day**




*Note:* Heat maps displaying diary intake for the 206 participants in each of the ten situations over the three diary days (i.e., each cell represents the diary intake for one participant in one situation on one day). As cells become darker blue, this indicates higher diary intake values. As they become lighter yellow, this indicates lower diary intake values. Grey cells indicate that the situation did not occur. We note that Day 2 was a Saturday, so most cells for education/work/other are grey in this instance.

**Table 24**

**Diary Water Intake Participant and Situation ICC Values**

| **Participant ICC** | | | **Situation ICC** | | | **Proportion of** |
|---|---|---|---|---|---|---|
| **Day** | **ICC2** | **ICC2k** | **Day** | **ICC2** | **ICC2k** | **Variance Explained** |
| 1 | 0.29 | 0.99 | 1 | 0.21 | 0.72 | 0.50 |
| 2 | 0.27 | 0.99 | 2 | 0.24 | 0.76 | 0.51 |
| 3 | 0.27 | 0.99 | 3 | 0.16 | 0.66 | 0.43 |

*Note.* This table shows the ICC2 (inter-rater agreement) between participants and situations for the three days. It also shows the ICC2k (reliability of means) for participant and situation means. As well as the proportion of diary intake variance explained by the participant and situation random effects.

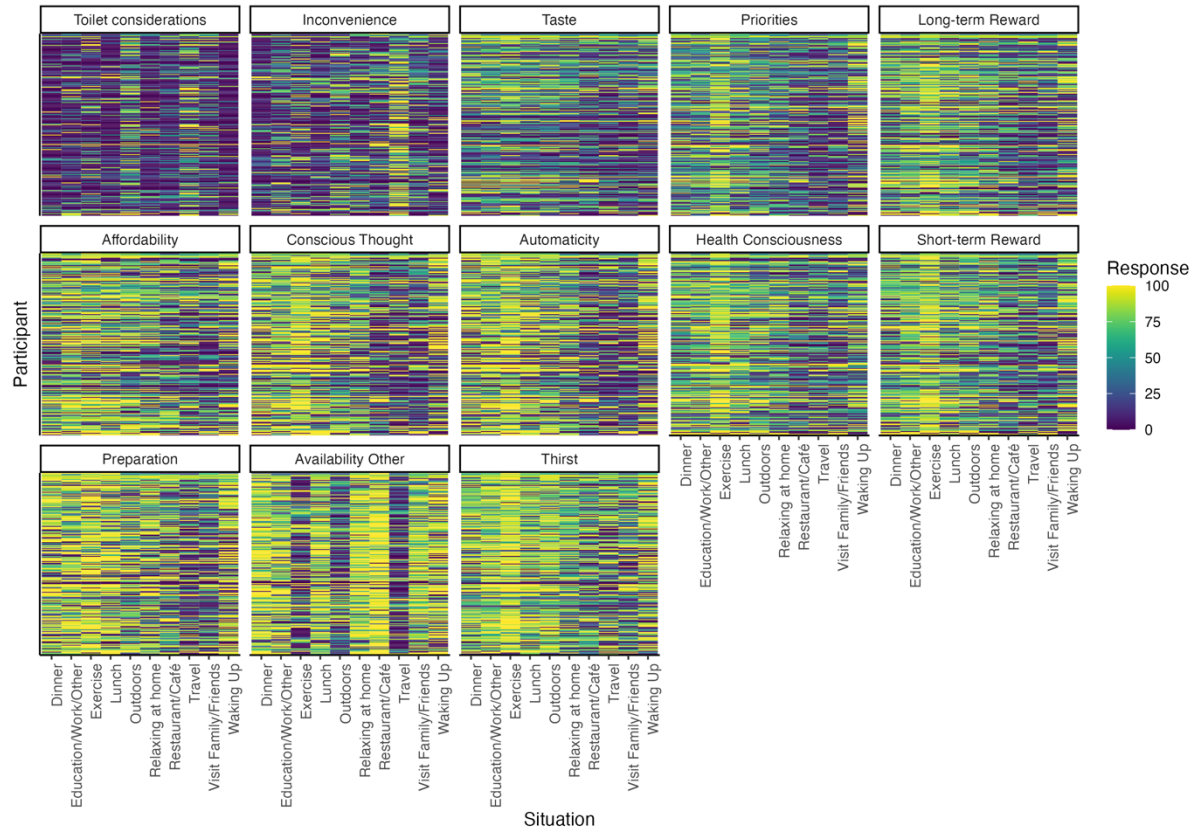
### *4.4.1.2 Predictor Responses*

Figure 21 visualises the variation in responses for each predictor across participants within each situation (see heatmap columns) and across situations within each participant (see heatmap rows). These heat maps show average trends

in predictor responses and how these vary across participants and situations. For example, while *toilet considerations* and *inconvenience* responses, were typically low, they were high during travel. Whereas *preparation* and *thirst* responses, typically high, were moderately low during travel. Additionally, all predictors with responses typically around the scale's midpoint (i.e., *long-term reward*, *affordability*, *health consciousness*, *short-term reward, conscious thought*, and *automaticity)* were moderate to extremely high during exercise. In contrast, *availability of other drinks* responses, typically high, was extremely low during exercise. A detailed overview of these trends is on the OSF (see supplemental results SR2).

**Figure 21**

**Predictor Response Heatmaps: Participant by Situation**




*Note.* Heat maps displaying predictor responses for the 213 participants in each of the ten situations (i.e., each cell represents the predictor response for one participant in one situation). As cells become bright yellow, this indicates higher predictor responses. As they become dark purple, this indicates lower predictor responses. The predictor heatmaps are presented in ascending order based on the grand mean response.

We used ICC2 to assess the inter-rater agreement between participants and situations regarding predictor responses. Table 25 shows that across all predictors, inter-rater agreement between participants was extremely low (Range = 0.04 –

0.28). This indicates that situations have very dissimilar predictor responses across participants. Inter-rater agreement between situations ranged from low to moderate (Range = 0.14 – 0.54). This indicates that participants have moderately dissimilar predictor responses across different situations.

**Table 25**

**Predictor Responses Inter-rater Agreement and Reliability of Means**

| **Participant ICC** | | | **Situation ICC** | | |
|---|---|---|---|---|---|
| Predictor | ICC2 | ICC2k | Predictor | ICC2 | ICC2k |
| Availability Other | 0.28 | 0.99 | Taste | 0.54 | 0.92 |
| Automaticity | 0.12 | 0.97 | Long-term Reward | 0.46 | 0.89 |
| Conscious Thought | 0.11 | 0.97 | Health Consciousness | 0.44 | 0.89 |
| Thirst | 0.11 | 0.96 | Affordability | 0.41 | 0.88 |
| Toilet considerations | 0.11 | 0.96 | Short-term Reward | 0.34 | 0.84 |
| Priorities | 0.10 | 0.96 | Priorities | 0.33 | 0.83 |
| Short-term Reward | 0.10 | 0.96 | Thirst | 0.30 | 0.81 |
| Health Consciousness | 0.09 | 0.96 | Toilet considerations | 0.27 | 0.79 |
| Inconvenience | 0.09 | 0.96 | Preparation | 0.27 | 0.79 |
| Preparation | 0.09 | 0.96 | Automaticity | 0.25 | 0.76 |
| Long-term Reward | 0.08 | 0.95 | Conscious Thought | 0.25 | 0.77 |
| Affordability | 0.05 | 0.92 | Inconvenience | 0.17 | 0.67 |
| Taste | 0.04 | 0.89 | Availability Other | 0.14 | 0.61 |

*Note.* This table shows the ICC2 (inter-rater agreement) between participants and situations. It also shows the ICC2k (reliability of means) for participant and situation means. The predictors are presented in descending order regarding the ICC2 value.

### 4.4.2 Exploratory Factor Analysis

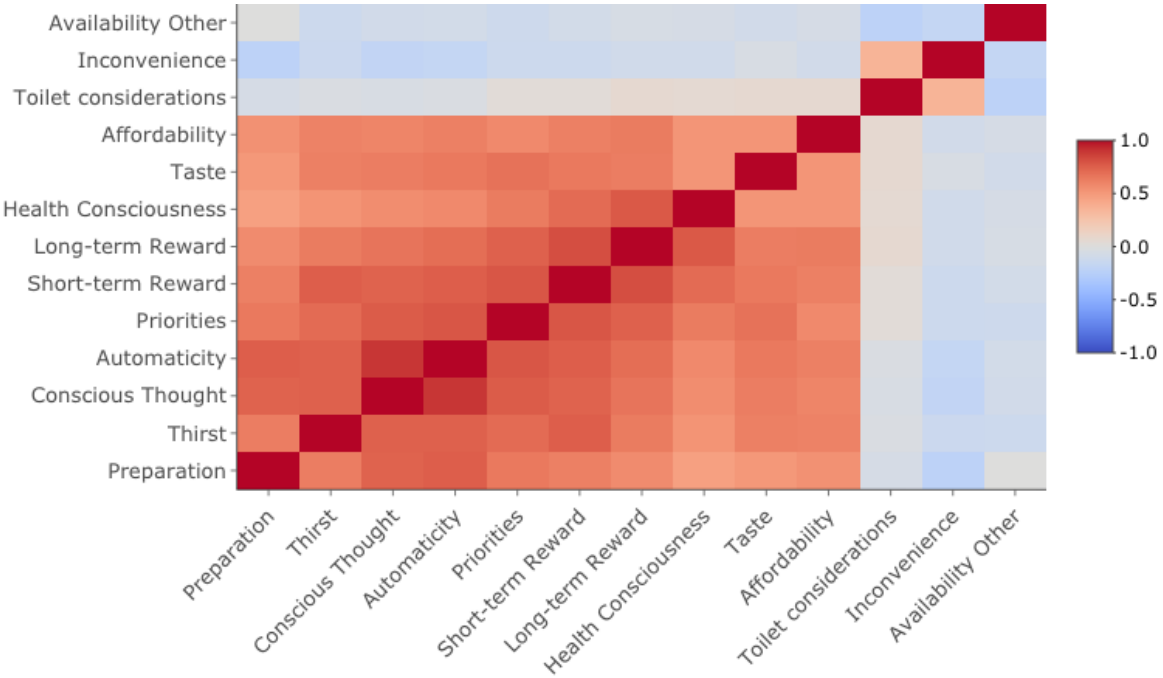
#### *4.4.2.1 Approach*

There was a moderate to strong correlation between two different clusters of predictors (see Figure 22 and supplemental results SR3 for an overview of these clusters). Therefore, we used exploratory factor analysis to assess whether there was an underlying set of latent constructs (i.e., factors) that the predictors loaded onto. This approach can help inform theory development, such as defining key constructs and establishing relationships between them, which is a key aim of the current research (Haig, 2005). Fabrigar & Wegener (2011) provide a detailed review of exploratory factor analysis, and we have outlined our approach on the OSF (see supplemental results SR4). Briefly, we used oblique rotation, allowing factors to correlate as this is recommended in social science, where everything measured is correlated to some extent (Meehl, 1990; Watkins, 2018). We also

present a four-factor solution as parallel analysis (Finch, 2020; Watkins, 2018) and comparison of fit indices (see Finch, 2020) suggested this was the most appropriate.

**Figure 22**

**Correlation Between Predictor Responses**




*Note.* Heatmap displaying the correlation matrix for the predictor responses. Each cell represents the Spearman correlation between two predictors. As cells become red, this indicates a strong positive correlation between predictor responses. As they become blue, this indicates a strong negative correlation between predictor responses. The predictors are ordered based on their similarity through hierarchical clustering (see Galili et al., 2018) for more information).

#### *4.4.2.2 Solution*

When referencing them in the manuscript moving forward, we italicise and bold ***factor names*** and italicise *predictor names*. The four-factor solution explained 64% of the variance in predictor responses and resulted in the following factors (see Figures 23 & 24):

(1) ***Habitualness*** was the first and most important factor, explaining 25% of the variance in predictor responses. It captured (in descending order of factor loading) the degree of *automaticity* and *conscious thought* needed to prepare and drink water, how often there was a glass/bottle of water within arm's reach (i.e., *preparation*), and how much water drinking is *prioritised*.

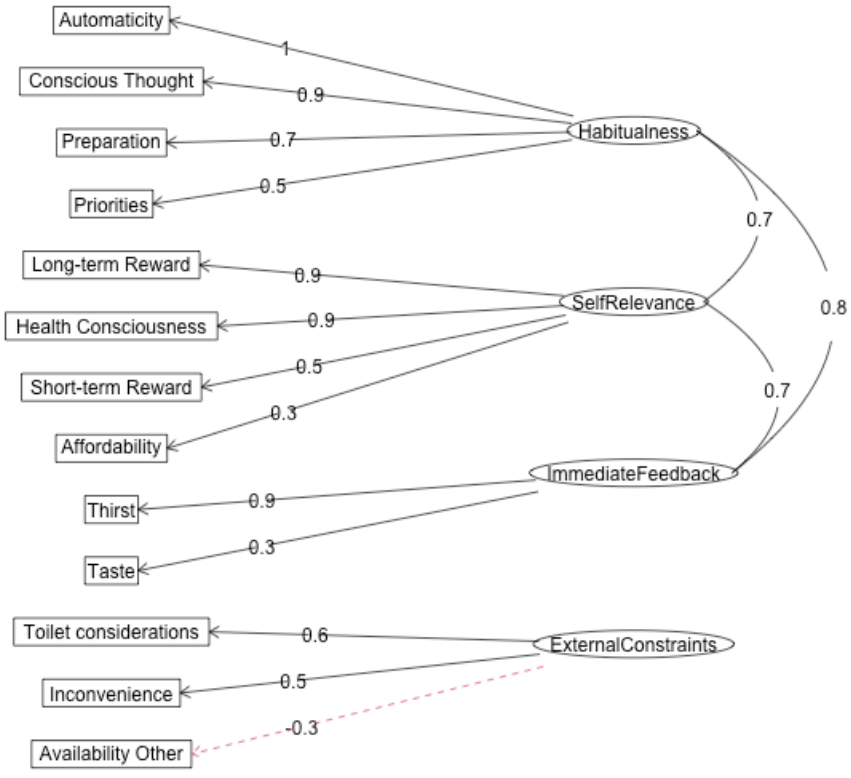
(2) ***Self-Relevance*** was the second most important factor, explaining 20% of the variance in predictor responses. It captured how motivated water drinking was by *long-term reward*, how much being healthy matters (i.e., *health consciousness)*, and how motivated water drinking was by *short-term reward* and *affordability* considerations.

(3) ***Immediate feedback*** was the third most important factor, explaining 12% of the variance in predictor responses. It captured how motivated water drinking was by its ability to quench *thirst* and positive *taste* expectations.

(4) ***Perception of external constraints*** was the final factor, explaining 6% of the variance in predictor responses. It captured the degree to which water drinking was impacted by *toilet considerations,* perceptions of *inconvenience*, and the *availability of other preferred drinks* in the immediate environment.

**Figure 23**

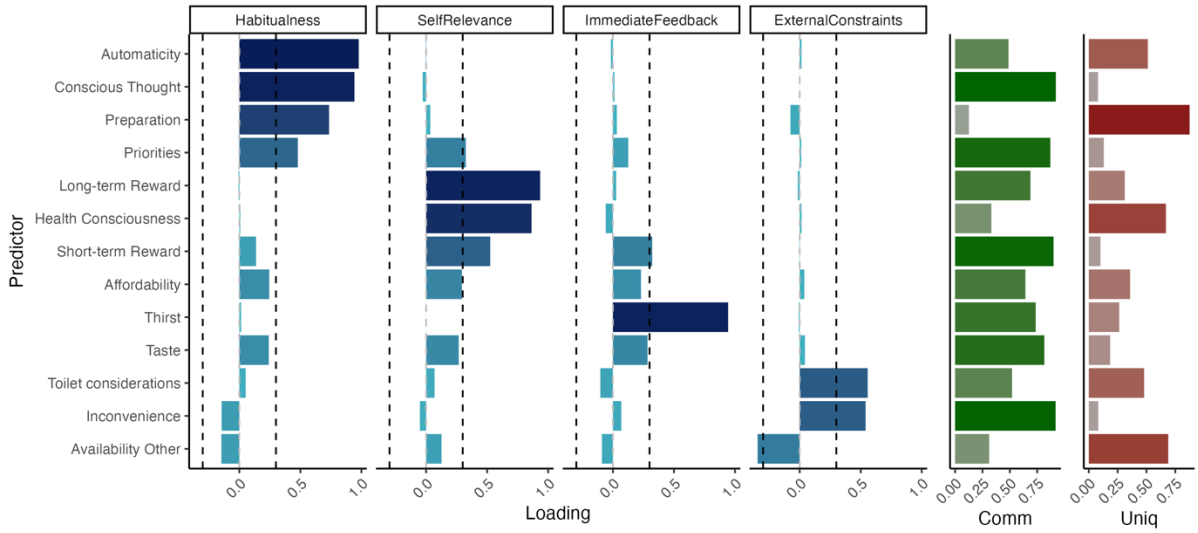
**Four-Factor Solution Diagram**




*Note.* This diagram illustrates the factor structure for the four-factor solution. Factors are listed on the right with curved lines denoting the correlation (if any) between each factor. The arrows show what predictors (listed on the left) load onto each factor with the predictors' factor loading.

**Figure 24**

**Four-Factor Solution Loading, Commonality, and Uniqueness Bar Plot**




*Note.* The first four bar plots (moving from left to right) show each predictor's loading across the four factors. Loadings show the influence of each factor on the predictor controlling for the effects of the other factors in the solution. The black dashed lines show the loading cut-off for inclusion (-0.3, 0.3). The fifth bar plot shows the commonality of each predictor (i.e., h2; the amount of variance in the predictor explained by four factors). The sixth bar plot shows the uniqueness of each predictor (i.e., u2; the amount of variance not explained by the four factors). The bars in each plot are coloured on a gradient, so darker bars mean higher values, and lighter bars mean lower values.

Figure 23 also shows that ***habitualness***, ***self-relevance***, and ***immediate feedback*** were positively correlated. However, ***perception of external constraints*** was uncorrelated with the other factors.

Figure 24 also shows that numerous predictors cross-load onto multiple factors. For example, *priorities* cross-loaded onto ***habitualness*** and ***self-relevance*** (Cross-loading = 0.33). Our research is more concerned with theory building than scale development, so cross-loadings are not problematic, and researchers should account for cross-loading in their factor interpretations (Fabrigar & Wegener, 2011, pg 139). For example, the *priorities* cross-loading makes conceptual sense, as *priorities* likely reflect the behaviours performed most regularly because they have the most ***self-relevance*** (i.e., aligned with goals, values, etc). These behaviours are also likely to exhibit a high degree of ***habitualness*** because they are repeatedly performed and rewarding behaviours (Wood & Rünger, 2016). We provide a more detailed overview of cross-loadings on the OSF (see supplemental results SR5).

### 4.4.3 Predicting Water Intake

We assessed how well each predictor predicts water intake by doing the following: (1) we correlated the predictor responses with typical intake and diary intake for one predictor and one situation at a time across all 213 participants using Spearman correlations, and (2) we ran a simple linear mixed effects model predicting typical intake and diary intake with the predictor responses for one predictor at a time accounting for the random effects of participant and situation. We used the following model for typical intake: typical intake ~ predictor + (1|ID) + (1|Situation). However, we used the following model for diary intake as participants only reported diary intake for situations that occurred for them (i.e., situations were nested within participants): diary intake ~ predictor + (1|ID) + (1| ID:Situation). DeBruine & Barr (2021) provide an overview of linear mixed effects models. These two analyses allowed us to assess the fixed effect (i.e., simple linear mixed effects) of the relationship between each predictor and the two water intake measures and how this relationship varied across situations (i.e., correlations). We used the same correlation and regression approach as outlined for the predictors for the factors. We used both the predictors and the factors to predict intake, given the potential instability of the four-factor solution (see supplemental results SR6).

#### *4.4.3.1 Typical Water Intake*

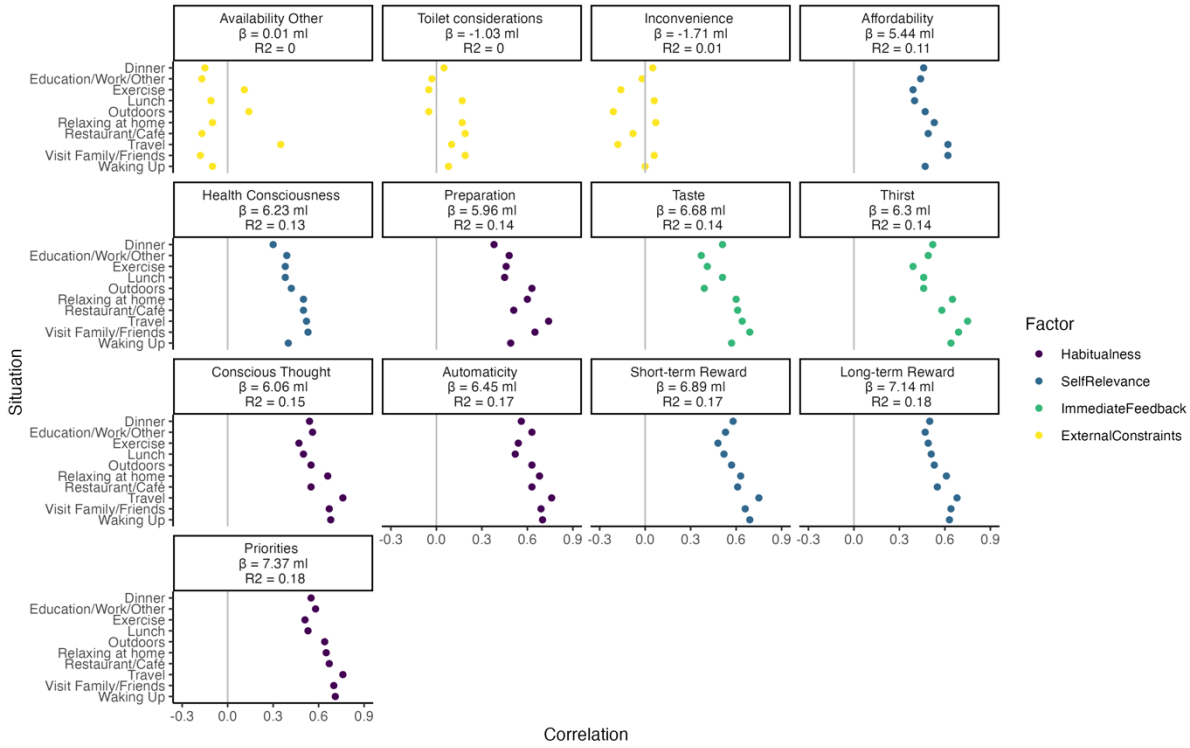
Figure 25 shows that every predictor was moderately positively correlated with typical intake, bar those related to the factor of ***perception of external constraints***, and that this trend is relatively consistent across situations. Depending on the situation, the predictors related to ***perception of external constraints*** have either positive or negative correlations with typical intake. However, most of these correlations are close to zero. The predictive profiles for each situation (i.e., the 13 predictor correlations for one situation compared to those for another) were very similar (ICC2 = 0.86), indicating a stable prediction pattern across situations.

The regression coefficients indicated that a unit increase in predictor responses for all predictors related to ***habitualness***, ***self-relevance***, and ***immediate feedback*** related to an increase in typical intake (β Range = 5.44 – 7.37 ml). These predictors explained 11 – 18% of typical intake variance. *Priorities, long-term reward,* and *short-term reward* related to the highest increase in typical intake. A unit increase in predictor responses related to ***perception of external constraints***

related to no change or a small decrease in typical intake (β Range = -0.01 – -1.71 ml). These predictors explained almost no typical intake variance (R2 Range= 0 – 1%). The 13 predictors and random effects collectively explained 53% of the typical intake variance.

**Figure 25**

**Predicting Typical Water Intake per Predictors**



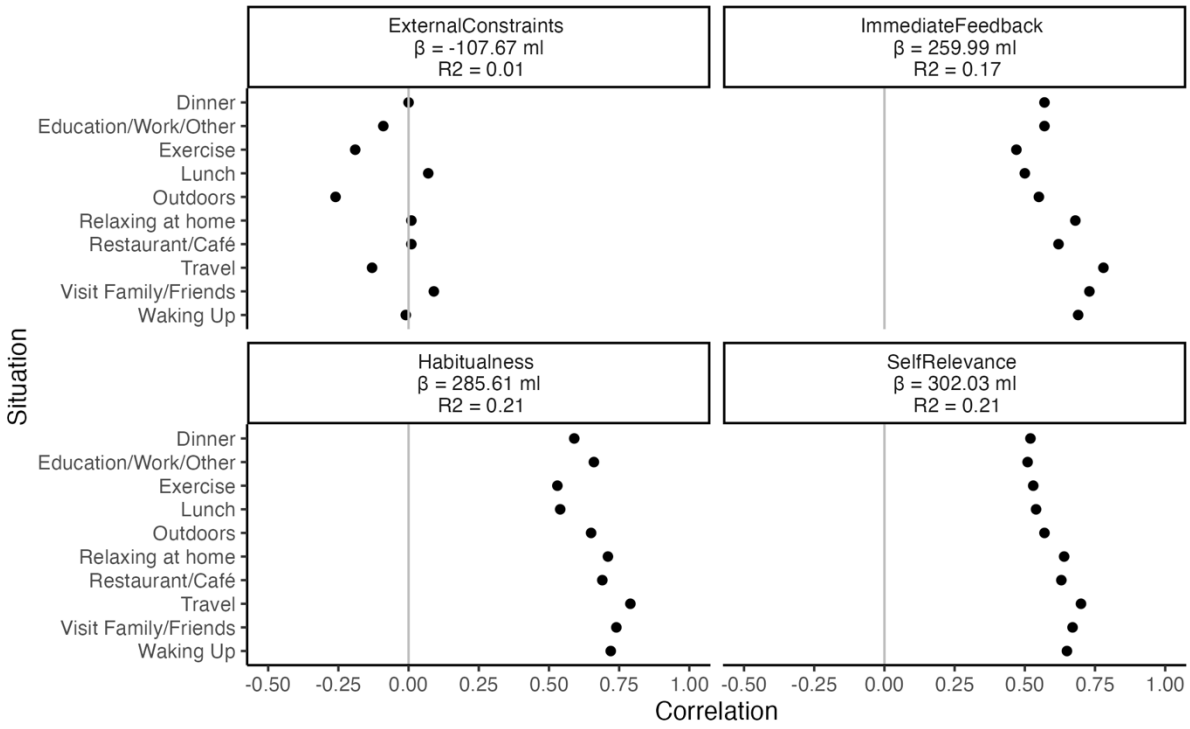

*Note.* Forest plots visualise the correlation between the 13 predictor responses and typical intake grouped by the predictor. They are ordered by R2. Each plot shows one predictor's correlation results across the ten situations. It also shows the increase in typical intake per unit increase in predictor response (i.e., regression coefficients; β) and the percentage of typical intake variance explained by the predictor (i.e., R2). The correlations are coloured per factor.

Figure 26 shows that ***self-relevance***, ***habitualness***, and ***immediate feedback*** strongly positively correlated with typical water intake, which is relatively consistent across situations. ***Perception of external constraints*** slightly negatively correlated with typical water intake. However, this correlation was zero and slightly positive in some situations. The regression coefficients indicated that a unit increase in ***self-relevance***, ***habitualness***, and ***immediate feedback*** factor scores related to an increase in typical water intake (β Range = 259.99 – 302.03 ml). These factors explained around 17% to 21% of the typical water intake variance. A unit increase in ***perception of external constraints*** factor scores related to a

decrease in typical water intake (β = -107.67 ml). This factor explained 1% of the typical water intake variance. The four factors and random effects collectively explained 53% of the typical water intake variance.

**Figure 26**

**Predicting Typical Water Intake per Factors**




*Note.* Forest plots visualise the results for correlations of factor scores from the four predictive factors with typical intake. They are ordered by R2. Each plot shows one factor's results across the ten situations. It also shows the increase in typical intake per unit increase in factor score (i.e., regression coefficients; β) and the percentage of typical water intake variance explained by the factor (i.e., R2).

### *4.4.3.2 Diary Water Intake*

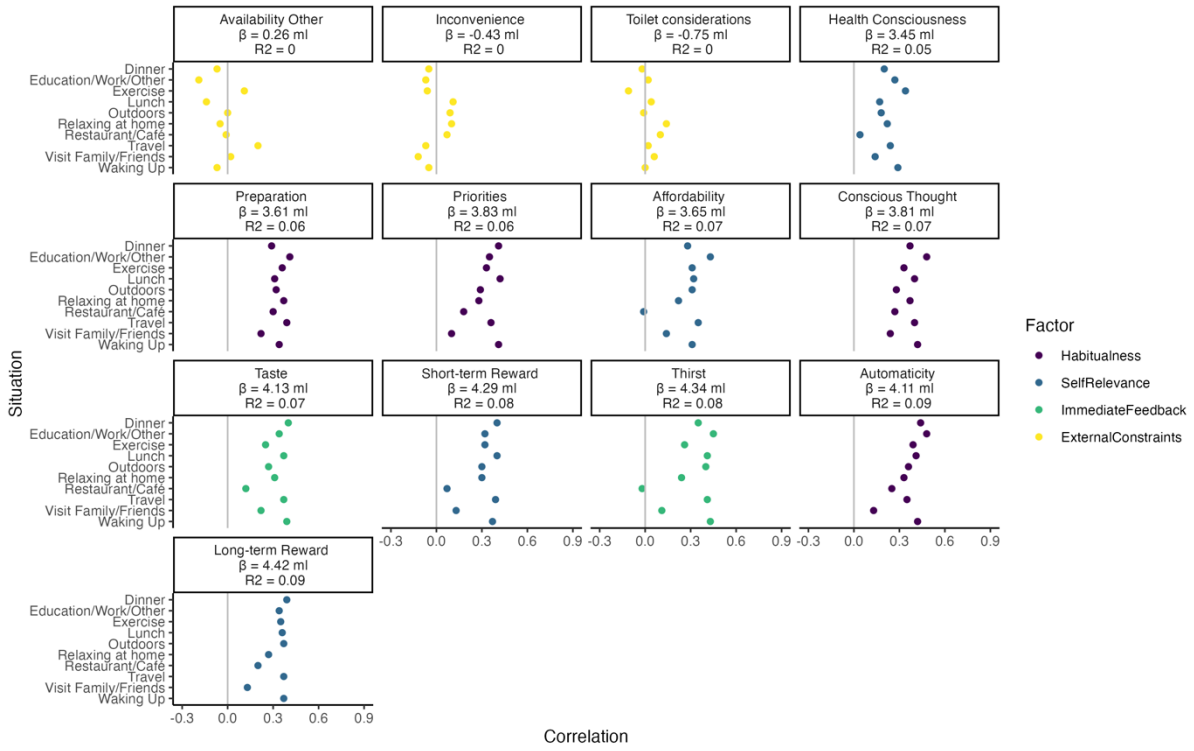
Figure 27 and 28 show that the predictors and factors had a very similar predictive pattern with diary intake as typical intake. Therefore, we do not outline the direction of these associations again. However, the predictive patterns had slight differences regarding the strength of these associations. All predictors and factors had slightly weaker correlations and regression coefficients for diary intake than typical intake. For example, a one-unit increase in the *priorities* predictor response related to a 7.37 ml increase in typical intake but a 3.83 ml increase in diary intake. A one-unit increase in the ***self-relevance*** factor score related to 302.03 ml increase in typical intake but a 175.19 ml increase in diary intake.

The predictors and factors also explained a smaller proportion of the variance in diary intake compared to typical intake. For example, *priorites* explained 18% of typical intake variation but 6% of diary intake variation, and ***self-relevance*** explained 21% of typical intake variation but 9% of diary intake variation. Additionally, when ordering the predictors based on the strength of their association, the order was slightly different compared to typical intake. For example, *priorities* and *long-term reward* had the strongest association with typical intake. However, *long-term reward* and *automaticity* have the strongest association with diary intake.

The 13 predictors and random effects collectively explained 66% of the diary intake variance. Interestingly, this was higher than the proportion of typical intake variance explained. However, this increase is likely due to the participant*situation interaction included in the diary intake but not the typical intake model (i.e., (1| ID:Situation)). The 4 factors and participant random effects collectively explained 44% of the diary intake variance above. This is lower than the proportion of typical intake variance explained, and this is likely due to us removing the participant*situation interaction from this model. We had to simplify the random effects structure per Barr et al.'s (2013) recommendation, as the full model was over-specified and failed to converge.

**Figure 27**

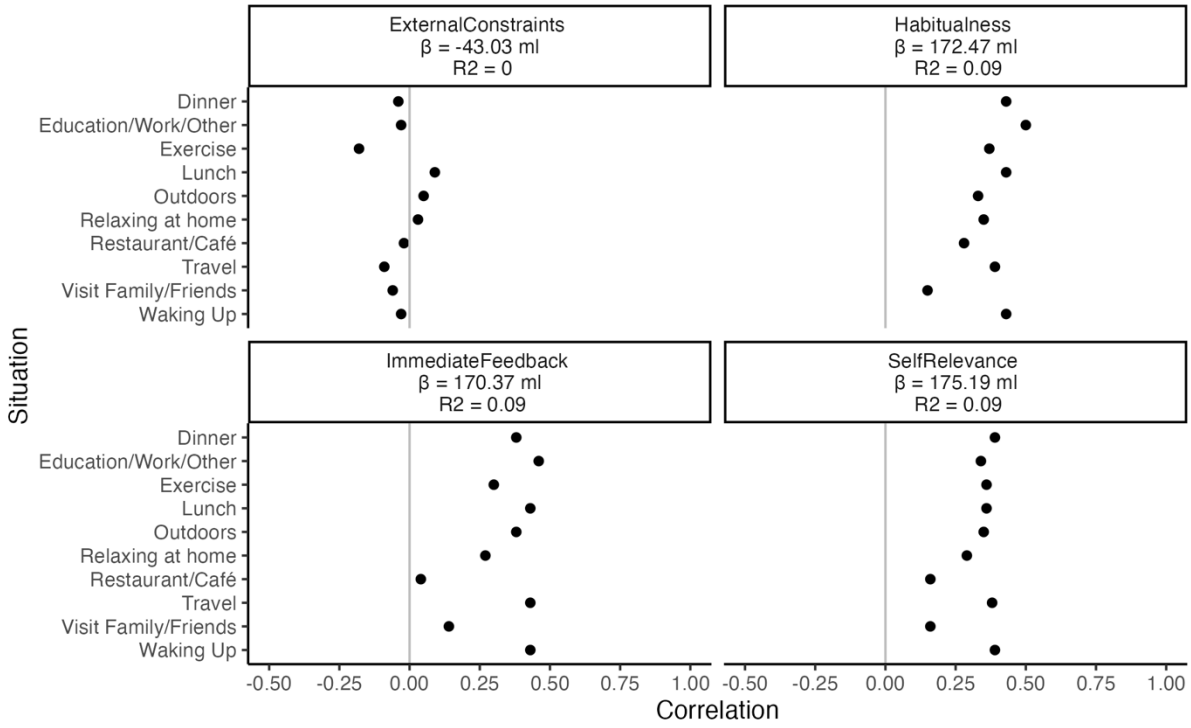
**Predicting Diary Water Intake per Predictor**




*Note.* Forest plots visualise the correlation between the 13 predictor responses and diary intake grouped by the predictor. They are ordered by R2. Each plot shows one predictor's correlation results across the ten situations. It also shows the increase in diary intake per unit increase in predictor response (i.e., regression coefficients; β) and the percentage of diary intake variance explained by the predictor (i.e., R2). The correlations are coloured per factor.

**Figure 28**

**Predicting Diary Water Intake per Factor**




*Note.* Forest plots visualise the results for correlations of factor scores from the four predictive factors with diary intake. They are ordered by R2. Each plot shows one factor's results across the ten situations. It also shows the increase in diary intake per unit increase in factor score (i.e., regression coefficients; β) and the percentage of diary water intake variance explained by the factor (i.e., R2).

### 4.4.4 High Versus Low Water Drinker Profiles

Underhydration has been linked to chronically low intake (< 1.2L/day) and adequate hydration to chronically high intake (> 2L/day) (Perrier et al., 2020). Although there are likely individual differences in the intake values related to under and adequate hydration, the current evidence can only make these broad categories (Perrier et al., 2020). Based on these insights, we categorised our sample into low (< 1.2), mid (1.2 – 2L), and high (> 2L) water drinkers using typical daily water intake from the SAM2 survey to assess whether these groups had qualitatively different predictor response profiles. See Table 26 for descriptive statistics regarding these groups. The demographic profiles of the three groups were similar (see supplemental results SR7).

Figures 29 shows the mean predictor responses per drinker type and illustrates the following trends: The high-water drinker group had higher responses regarding predictors related to ***habitualness*** than the mid-water drinker and low-

water drinker groups. A similar trend was seen for predictors related to ***self-relevance***. However, the difference between the high and mid-water drinker groups was smaller. The high and mid-water drinker groups had similar responses regarding predictors related to ***immediate feedback***, but both groups had higher responses compared to low-water drinkers. Finally, all three types of drinkers had similar responses regarding predictors related to ***perception of external constraints***.

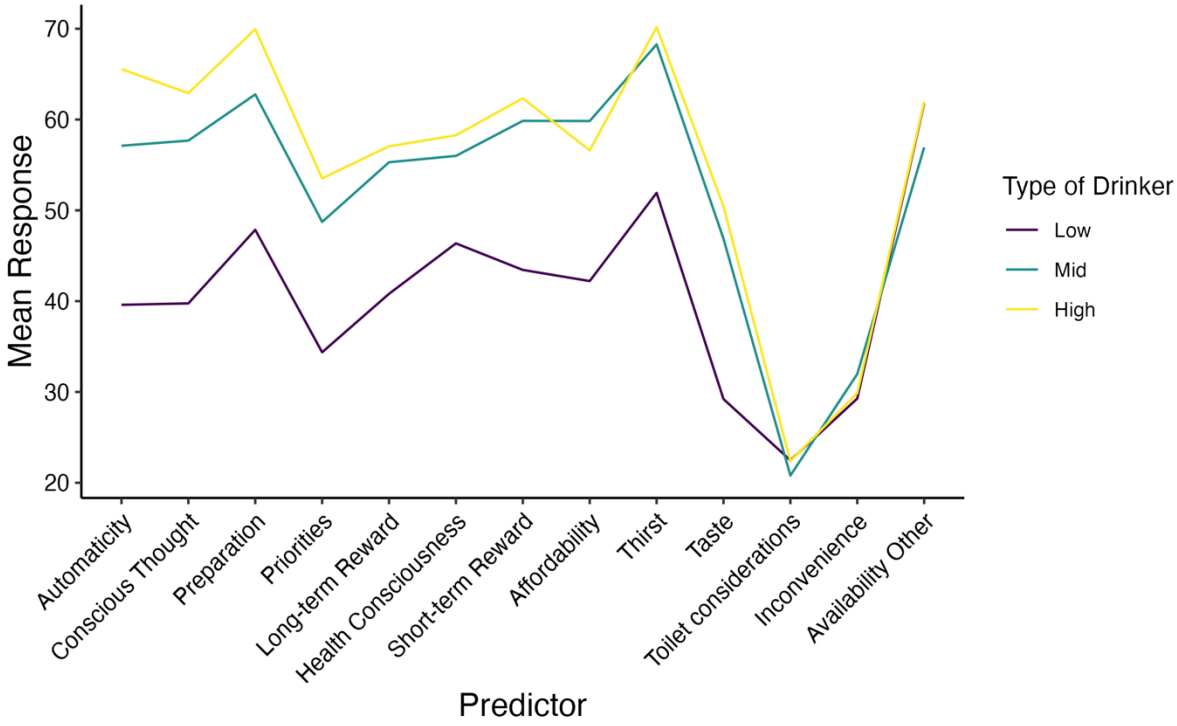
**Table 26**

**Descriptives Statistics Per Type of Drinker**

| Drinker Type | N | *M* (ml) | *SD* (ml) | Range (ml) |
|---|---|---|---|---|
| Low | 96 | 578.65 | 362.77 | 0 - 1200 |
| Mid | 53 | 1535.85 | 190.88 | 1250 - 1980 |
| High | 64 | 2787.81 | 707.90 | 2000 - 6000 |

**Figure 29**

**Mean Predictor Response Profiles Per Type of Drinker**




*Note.* This plot shows the mean predictor response profile per type of drinker. The predictors are ordered based on the four-factor solution: ***Habitualness*** (automaticity, conscious thought, preparation, priorities), ***Self-relevance*** (long-term reward, health consciousness, short-term reward, affordability), ***Immediate feedback*** (thirst, taste), and ***Perception of external constraints*** (toilet considerations, inconvenience, availability other).

### 4.5 Discussion

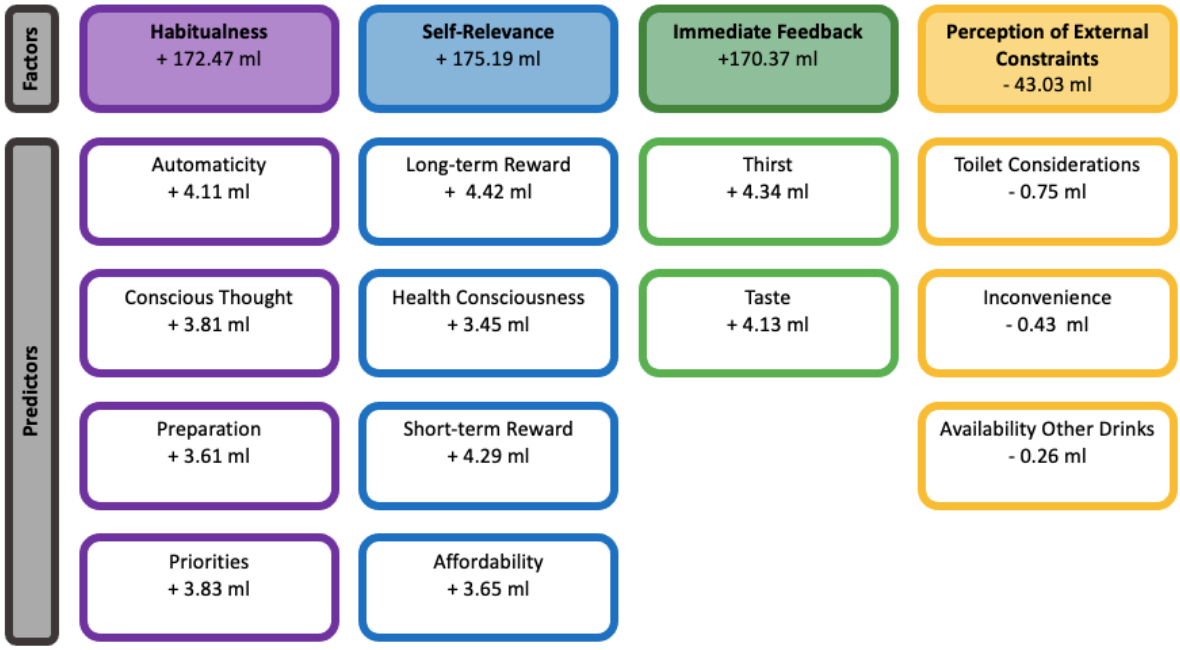
We used the Situated Assessment Method (Dutriaux et al., 2023) to explore (1) how water drinking behaviour (i.e., intake) and its underlying influences vary across individuals and daily situations and (2) the relationship between water drinking and potential underlying influences of this behaviour identified by previous research. Our research aimed to triangulate insights from previous qualitative and mixed-methods research on water drinking behaviour that highlighted the importance of individual and situation variation and identified potential constructs that may influence water intake.

Our approach was also informed by mounting calls for the field of psychology to use diverse research methods to inform theories of behaviour (Diener et al., 2022; Scheel et al., 2020).

We assessed 13 potential predictors of water intake using exploratory factor analysis to generate common constructs underlying these. There were four underlying constructs (i.e., factors): ***Habitualness***, ***Self-Relevance***, ***Immediate Feedback***, and ***Perception of External Constraints***. We then assessed the capacity of each predictor and factor to predict water intake and explain differences between high and low water drinkers' behaviour across 10 daily situations. Figure 30 summarises how each predictor and factor were associated with water intake (specifically, diary water intake).

**Figure 30**

**Predicting Water Intake: Factors & Predictor Summary**




*Note.* This figure presents the factors in order of importance determined by the exploratory factor analysis (i.e., % of predictor response score explained), with habitualness being the most and perception of external constraints being the least. It also presents the predictors in descending order of factor loading (e.g., automaticity had the highest and priorities had the lowest factor loading for habitualness). In each square, we present the simple linear mixed effects model regression coefficient of the predictive relationship between the respective factor/predictor and dairy water intake. The regression coefficient shows the increase in diary water intake per unit increase in factor score for the factors and the increase in diary water intake per unit increase in the predictor score, for the predictors.

Regarding our two areas of exploration, we found that water intake, predictor responses and factor scores varied greatly between individuals and situations and

within individuals across situations. We also found that the 13 predictors and 4 factors explained substantial proportions and the variance in water intake when paired with individual and situation random effects. Additionally, the associations the 13 predictors and 4 factors had with water drinking aligned with results from previous water drinking research. We discuss these results below, considering their theoretical and applied implications.

### 4.5.1 Individual and Situation Variation in Water Intake

Our research suggests that water intake varies greatly depending on who is drinking. This aligns with prior research illustrating vast individual differences in water intake and adherence to adequate intake guidelines (Drewnowski et al., 2013; Elmadfa & Meyer, 2015; Ferreira-Pêgo et al., 2015; Gibson & Shirreffs, 2013). Our research also suggests that water intake varies greatly depending on what situation a person is drinking in. This aligns with prior research illustrating that aspects of daily situations can impact an individual's water intake (Rodger et al., 2021). Additionally, participants typically drank water either 0% of the time or 100% of the time when a situation occurs, and there are fewer instances where water drinking frequency fell between these two extremes. This suggests that water drinking is either an established behaviour one performs in a situation, or it is hardly performed at all in a situation. This insight aligns with research illustrating that water drinking habits are formed and maintained within specific situations (Rodger et al., 2021; Rodger & Papies, 2022). This suggests that to increase water intake, water drinking behaviour would either need to be (1) performed in a new situation where it is not typically done, which has shown to be difficult for people to do in practice (see Rodger et al., 2023), or (2) performed more in an established water drinking situation, which may not lead to adequate intake if the situation covers a short time frame or occur infrequently throughout the day (see Rodger et al., 2021).

Water intake also varies within individuals across different situations. Therefore, accounting for who is drinking and what situation they are drinking in can explain around half the variation in water intake. However, despite the explanatory power of individual and situation information, most water-drinking research neglects to account for it, as does most other research on appetitive behaviours, for example eating behaviour (for exceptions, see Bauer, Nielsen, et al., 2022; Laffan et al., 2023; Werner, Kloidt, et al., 2022). Water drinking research

typically measures unsituated daily water intake. Additionally, water drinking interventions typically report group-level differences in water intake with limited insight into variation of the intervention effect across individuals and situations (Kwasnicka & Naughton, 2020).

### 4.5.2 Underlying Influences of Water Intake

Our research established the relationship the 13 potential influences of water drinking behaviour and their four underlying factors had with water intake.

The results suggest that reward (e.g., ***self-relevance*** and ***immediate feedback***) and ***habitualness*** are positively associated with water drinking behaviour. The positive prospective association ***self-relevance***, ***immediate feedback,*** and ***habitualness*** had with diary water intake suggests that as water intake is perceived as more rewarding and performed with a higher degree of habitualness, water intake increases. The cross-sectional association between these factors and typical water intake supports this interpretation but also suggests that as people drink more water, they perceive water drinking as more rewarding and perform it with a higher degree of habitualness. The trend that high-water drinkers had higher predictor responses related to ***self-relevance***, ***immediate feedback*** and ***habitualness*** predictors supports both interpretations regarding the cross-sectional association.

Both interpretations align with mounting evidence that reward *and* habitualness are crucial constructs for understanding why people do or do not drink water (Papies et al., 2020; Rodger et al., 2021; Rodger & Papies, 2022; Werner, Papies, et al., 2022). For example, perceiving water drinking as rewarding was associated with drinking higher amounts with a higher degree of automaticity (Rodger & Papies, 2022). These interpretations also align with research on other consumption behaviours, such as healthy eating, where reward *and* habitualness facilitate food intake (Di Maio et al., 2022; McCarthy et al., 2017; Wiedemann et al., 2014). Finally, these interpretations align with broader theories of behaviour which suggest that as rewarding behaviours are performed in similar situations, aspects of the situation, behaviour, and outcomes are encoded in memory, and these representations make performance more likely to reoccur with a high degree of habitualness (Hommel, 2021a; Kruglanski & Szumowska, 2020; Papies et al., 2022).

Interestingly, our results indicate that ***self-relevance*** typically had a slightly stronger positive association with water drinking than ***immediate feedback***. The direction of these associations aligns with prior research. However, our results suggest that short-term reward, long-term reward, and health consciousness influences may have a stronger impact on water intake and drinking frequency than thirst and taste influences. Alternatively, quenching thirst and liking taste (i.e., ***immediate feedback***) are typically the most salient and commonly reported influences underlying drinking water (Rodger et al., 2023; Rodger & Papies, 2022). This insight also suggests that drinking water is associated with a multifaceted set of potential rewards. Researchers and intervention developers should not assume that accounting for one or two well-established rewards (e.g., quenching thirst) provides a comprehensive insight into water drinking behaviour. In other words, people could have different reasons for drinking water (i.e., different rewards associated with water drinking) in different situations and those situated reasons could be primed in the relevant situation to help facilitate drinking (see Papies, 2016). However, accounting for the numerous and situated rewards potentially associated behaviour is uncommon in some research domains. For example, Stimulus-Response (S-R) habit theory research typically accounts for only one rewarding outcome of the target behaviour (Kruglanski & Szumowska, 2020; Mazar & Wood, 2022).

Finally, our results suggest that ***perceptions of external constraints*** are typically negatively associated with water drinking. The prospective association between and predictive ability of ***perceptions of external constraints*** regarding diary water intake suggests that as the perceived inconvenience of drinking water, lack of suitable toilet options, and availability of other preferred drinks increase, water intake decreases. The cross-sectional association between this factor and typical water intake supports this interpretation but also suggests that as people drink less water they perceive higher levels of external constraints regarding water drinking. This aligns with prior research suggesting that low and infrequent water drinkers are more likely to report being hindered by these types of external constraints (Rodger et al., 2021; Rodger & Papies, 2022).

It is important to note that the association between ***perceptions of external constraints*** and water intake was weaker than that of ***self-relevance***, ***immediate***

***feedback*** and ***habitualness***. This indicates that this factor and its related predictors may not have as much influence on water drinking behaviour. The trend showing high-water drinkers had similar predictor responses and factor scores regarding perceptions of external constraints support this interpretation. This is unexpected, given that these external constraints were reported as common and salient barriers to water drinking. This difference could reflect participants in prior research overestimating the influence of these external constraints when communicating their lay theories of what motivates their water drinking (e.g., see Mazar & Wood, 2022). However, this difference could also reflect that our operationalisation (i.e., predictor wording) of these external constraints did not capture this association accurately. For example, the inconvenience predictor aims to capture a broad and nuanced issue: performing other, more valued behaviours hinders water intake (Rodger et al., 2021, 2023; Rodger & Papies, 2022). The weak negative association of this predictor with water drinking may reflect that our wording of this question does not capture this barrier rather than this barrier not influencing water drinking.

#### *4.5.2.1 Influence Across Individuals and Situations*

The associations discussed above were similar across situations, individuals, and types of water drinkers. This indicates that the influence of these predictors and factors on water intake is stable across these facets. However, the predictors and factors' ability to influence water drinking was highly varied, as our results show that predictor responses and factor scores vary widely across participants and situations. For example, thirst is often theorised as the main underlying influence of water drinking (Carroll, 2020; Ferrar, 2018), and prior research suggests quenching thirst is a very common and salient reward associated with this behaviour (Rodger & Papies, 2022). However, there was extremely low agreement between individuals and within individuals across situations on how motivated they were to drink water to quench their thirst. Therefore, water drinking's ability to quench thirst is likely not always capable of inducing or increasing intake, as certain individuals in certain situations are not motivated by this. This aligns with prior research advocating that thirst is not always a reliable cue for water drinking, as it can be easily blunted, suppressed or ignored (Bhanu et al., 2020; Rodger et al., 2021; Rosinger et al., 2022; Stevenson et al., 2015). Although we used thirst to illustrate this insight, it holds for all other predictors.

This insight aligns with theoretical perspectives that suggest a construct's ability to influence behaviour depends on its presence or degree of presence in each situation. For example, habitualness develops when performing rewarding behaviour repeatedly within a specific situation (Papies et al., 2022). Therefore, habitualness is not guaranteed in other situations, especially those with no similarities to the original situation. As such, habitualness's ability to influence behaviour depends on whether habitualness has been developed and the extent to which it has been developed in the situation the individual is drinking water. Similar theorising is seen for other constructs, such as self-identity, which is thought to vary depending on the situation, meaning its ability to influence behaviour varies depending on the situation (Hommel, 2021a, 2021b; Oyserman, 2009).

#### *4.5.2.2 Predictive Capability*

The 13 predictors and 4 factors explained substantial proportions and the variation in typical intake (Predictors & Factors = 53%), typical frequency (Predictors = 83%, Factors = 82%), and diary intake (Predictors = 66%, Factors = 44%) when paired with individual and situation random effects. The predictive capability of these models suggests that prior research has identified an extensive set of constructs that potentially influence water drinking. However, this set is incomplete, as large proportions of variance remain unexplained.

### 4.5.3 Theoretical Implications

Our results suggest that water drinking likely has multiple underlying lying influences, including but not limited to individual differences, features of external situations, reward, self-identity, and habitualness. As such, the theories researchers use to guide research in this domain should be able to account for these various influences. This insight aligns with calls for more comprehensive theories of behaviour, as behaviour in real-world settings is likely governed by a complex interplay of multiple processes and constructs rather than a single process or construct (Barsalou, 2019). For example, comprehensive theories such as the Grounded Theory of Motivated Behaviour and Desire and GOALLIATH provide theoretical frameworks that account for and explain the interplay between most, if not all, of the potential constructs we have identified as influencing water drinking (see Hommel, 2021a; Papies et al., 2022). However, popular psychology theories, such as S-R habit theory (see Wood et al., 2022), provide simplistic theoretical

frameworks involving one or few constructs. Theoretical and empirical research now provides compelling arguments and evidence suggesting these theories are likely too simplistic (De Houwer, 2019; De Houwer et al., 2018; Du et al., 2022; Hommel, 2021a; Kruglanski & Szumowska, 2020). Indeed, our results also suggest this. For example, the variation in water intake unaccounted for suggests the need for more constructs in our theoretical framework of water drinking behaviour, not less.

Our results also provide insight into the debate regarding the role of reward in regulating habitual behaviour (see Kruglanski & Szumowska, 2020; Wood et al., 2022). S-R habit theory advocates that habitual behaviour is a learned, automatic response to an external stimulus that is performed *independent of reward* (Wood et al., 2022; Wood & Rünger, 2016). However, our results show a strong positive association between habitualness and reward at both the predictor and factor levels. For example, ***habitualness*** is strongly positively associated with ***self-relevance*** and ***immediate feedback***. Additionally, automaticity and conscious thought are commonly used as measures of habit (Gardner et al., 2012; Mazar & Wood, 2022) and are strongly positively associated with reward-related predictors (e.g., short-term and long-term reward). These associations challenge the S-R habit theory perspective and suggest that as water drinking becomes more rewarding, it becomes more habitual. Therefore, water drinking is more likely a goal-driven behaviour that is habitual to some degree. In other words, reward is involved in forming and maintaining habitual water-drinking behaviour (Rodger & Papies, 2022). This insight replicates results from previous SAM$^2$ research on common daily habits (Dutriaux et al., 2023) and aligns with mounting theoretical arguments and empirical evidence for reward regulating habitual behaviour (De Houwer, 2019; De Houwer et al., 2018, 2022; Du et al., 2022; Dutriaux et al., 2023; Hommel, 2021a; Kruglanski & Szumowska, 2020; Yin & Knowlton, 2006).

### 4.5.4 Applied Implications

Our SAM$^2$ results could inform personalised intervention strategies (Werner, Papies, et al., 2022), which may be more effective than conventional approaches, although more evidence is needed (Mathers, 2019; Ordovas et al., 2018). Individual-level predictive profiles could inform interventions related to influences most relevant to an individual's water drinking. For example, if external constraints hinder an individual's water drinking, the intervention may provide

strategies to overcome these, for example, through creating implementation intentions (Bieleke et al., 2021) not to buy sugary drinks during their weekly shopping to reduce their availability at home. However, if external constraints do not influence an individual's water drinking and long-term rewards instead facilitate it, the intervention may aim to induce the influence of these rewards in drinking situations, for example through priming (Papies, 2016) long-term rewards when an individual is making drink choices.

The situated water intake and frequency data could be used to identify situations where increased water intake is needed. However, the intervention developers or participants would likely need to assess the feasibility of these situations for increased intake. An intervention study evidenced that one of the most common barriers to increased intake was that participants felt it was infeasible to drink water in their planned situation during the follow-up (Rodger et al., 2023). To combat this, an intervention could help participants map out their typical routines in low water intake situations, identifying potential barriers and opportunities to act (e.g., script elicitation; Mohideen et al., 2023). For example, our results suggest that education and workplaces are key water drinking situations. These situations also typically account for large proportions of people's days and occur most days a week, if someone is in education or employment. Therefore, water drinking should be facilitated in these situations as it could facilitate people reaching adequate intake throughout the day. However, these situations may also have barriers to water drinking that need to be addressed. For example, many people reported forgetting to drink water or remembering but not doing so while working because they were busy and had to prioritise behaviours related to their jobs (Rodger et al., 2021; Rodger & Papies, 2022).

Prior research suggests that knowledge regarding water drinking's importance and potential rewarding outcomes is low (Rodger et al., 2021, 2023; Veilleux et al., 2020). Hence, education is likely a necessary but insufficient component of interventions aiming to increase water intake (Carrero et al., 2019; Rodger et al., 2023; Vercammen et al., 2018). Given that short-term *and* long-term rewards influence water drinking, our results suggest that education should cover both. This is especially important given that pursuing long-term rewards is unlikely in the presence of competing short-term rewards (Bauer et al., 2022; Papies, 2016). For example, someone may want to increase their water intake to improve their

health (long-term reward) but choose a sugary drink over water while dining out because they think it is the tastier option (short-term reward).

### 4.5.5 Strengths, Limitations & Future Directions

A key strength of our research was the SAM$^2$ approach. Our results show that water drinking and its underlying influences vary considerably across individuals and situations. SAM$^2$ allowed us to capture this variation and conduct a more comprehensive exploration of water drinking than traditional measurement approaches would have allowed. It also allowed us to explain large proportions of the variation in water drinking behaviour and predict future water intake, further highlighting its usefulness. However, there is still a substantial proportion of water drinking variation that remains unexplained. Therefore, future research should identify constructs not currently considered in the water drinking literature that could influence intake. For example, given the limited variance explained by the predictors related to perceptions of external constraints, more research may be needed to understand how perceived barriers in people's external environments influence water drinking. This may involve conducting more exploratory research (e.g., observational and qualitative research) to identify relevant constraints within people's external environments and establish their association with remembering to drink water, performing preparation behaviours related to water drinking, and drinking water (i.e., intake).

A key limitation of our research approach is that the results are correlational and should not be used in isolation to inform causal explanations of water drinking behaviour. Although observational data can be used to inform causal explanations, it should be done with extreme caution (Diener et al., 2022; Grosz et al., 2020; Rohrer, 2018). For example, correlational research can aid in accumulating evidence for causal explanations by evidencing consistent or inconsistent associations (Dutriaux et al., 2023). Indeed, our research aimed to triangulate evidence for explanations of the underlying influences of water drinking from prior research. Our results do not provide insight into the mechanisms by which these influences affect water drinking or how water drinking affects these influences. However, our results provide further evidence that these influences are likely relevant to our theoretical understanding of water drinking.

Further research should use diverse methods to continue providing evidence for the relevance and underlying mechanisms these influences have regarding water drinking. Researchers could expand on our findings by manipulating these influences and observing the effect, if any, it has on water drinking. These manipulations could be exploratory or hypothesis testing depending on the extent of prior research on the target influence. For example, researchers could assess education interventions with different content (e.g., short-term reward coverage, long-term coverage, or both) to assess the impact that knowledge of different types of reward has on water drinking. Additionally, researchers could attempt to alter taste perceptions (e.g., attempt to improve liking by adding natural flavourings or through repeated exposure) and observe how this impacts water drinking.

Another key strength of our research was the representative sampling strategy. However, given the potential instability of the exploratory factor analysis, this analysis would have likely benefitted from a larger sample size. Additionally, our research is situated within the UK context, so it may have limited insight into different contexts. Additionally, we conducted our research during a period of warmer weather (Met Office, 2023). Thus, the climate may have impacted participants' water drinking behaviour and underlying influences (Rodger et al., 2021, 2023).

A final limitation of this research is the likelihood of measurement error in our water intake measures. Accurate water intake measurement is an ongoing issue researchers need to tackle as most intake measures are validated for energy or nutrient intake but not fluid (Rogerson et al., 2023). There are likely two sources of measurement error in our water intake measures: error due to participants having to estimate their intake and error due to the sliding scale we used to capture participants' responses (i.e., a few participants reported that this feature led to incorrect responses). We included a diary measure for intake to try and combat the first of these error sources, as this typically involves less estimation than the typical intake approach. However, there was a moderate association between typical and diary water intake, and the key interpretations of the results from both measures were very similar. This suggests that typical intake may provide in-depth, accurate insights into water drinking. However, our results suggests that the strength of these associations may be overestimated. Future research should assess the validity of different water intake measures against an objective marker of fluid intake and

recommend the most objective approach (Rogerson et al., 2023). This would improve the quality of more theoretical and applied research on water drinking.

# 5. Chapter 5: Towards a Theory of Water Drinking: The Essential Health Behaviour

This chapter is an exact copy of the following pre-print:

Rodger, A., Barsalou, L., & Papies, E. K. (2023). *Towards a Theory of Water Drinking: The Essential Health Behaviour*. PsyArXiv. https://doi.org/10.31234/osf.io/fys86

## 5.1 Abstract

Water intake is a vital aspect of health, yet a comprehensive theoretical understanding of this behaviour has been lacking, hindering efforts to increase people's intake. Recent advances in psychology research methodology stress the importance of theory development for understanding and changing behaviour. Specifically, poor theory development practices are considered partly responsible for current issues, such as the replication crisis and ineffective interventions. Therefore, we aimed to develop a theoretical framework of water drinking behaviour informed by current best practice recommendations on theory development. We reviewed emerging water drinking research to (1) define water drinking behaviour, and (2) identify and establish how various constructs influence water drinking in daily life, which are key activities in the theory development process. Our framework suggests researchers should account for the complexities of water drinking, including the different steps involved, how they vary between people and situations, and the relative time and effort needed for each step. Moreover, it underscores the intricate interplay between internal and external factors influencing water drinking behaviour. External influences include constructs like water security, tap water quality, and toilet facilities, while internal influences include individual attributes like thirst, knowledge, habitualness, and reward. Our framework implies that comprehensive theories of behaviour are essential to comprehend the complex interplay of influences underlying water drinking. Additionally, it suggests that a complex intervention approach, targeting both individual and systemic-level influences, is likely needed to address inadequate water intake. We also discuss research from other consumption behaviour domains, evidencing that aspects of this framework may apply to consumption behaviour more broadly. This paper does not aim to establish a definitive theory of water drinking behaviour but offers a current snapshot of our understanding to inform future research and intervention efforts.

## 5.2 Introduction

Recent literature on best practices in psychology research methodology advocates that psychology must better engage with theory development to understand and change behaviour (Barsalou, 2019; Eronen & Bringmann, 2021; Oberauer & Lewandowsky, 2019; Proulx & Morey, 2021; Scheel et al., 2020). Specifically, this literature advocates for developing comprehensive theories that explain how behaviour is performed in real-world settings and what influences its performance. According to Scheel et al., (2020), psychology too often incorrectly prioritises testing predictions over earlier stages of theory development, such as observing and describing behaviour in real-life settings and defining constructs regarding its influences. As a result, mere descriptions of highly controlled experimental effects, unlikely to generalise to real-world settings, are being passed off as theories (Meehl, 1978, 1990; Proulx & Morey, 2021), and the field is facing issues such as the replication crisis (Scheel et al., 2020). To tackle these issues, the psychology research methodology literature suggests that psychology researchers must spend more time developing theories than testing them (Scheel et al., 2020). The current paper aims to review emerging water drinking research to develop an initial theoretical overview of this behaviour regarding which constructs *may* be relevant and should be *considered* when designing theoretical and intervention-focused water drinking research, using best practice recommendations from the wider methodology literature.

We focus on water drinking as this is an important health behaviour essential for survival that impacts physical health and psychological function, as we will describe in more detail below (Kavouras & Anastasiou, 2010; Perrier et al., 2020; Seal et al., 2019). Additionally, water drinking research is well placed to inform theory development work as there is now considerable research describing how water drinking is performed in naturalistic settings, establishing what constructs are relevant for understanding this behaviour, and assessing how these constructs influence this behaviour. These research activities are fundamental to developing well-specified comprehensive theories (Bonetto et al., 2023; Scheel et al., 2020). However, to our knowledge, no recent works have reviewed water drinking research intending to present an initial theoretical overview of how water drinking is performed in real-life settings and what influences its performance. Before further outlining this paper's aims and approach, it is important to establish why water drinking is an important health behaviour and why the domain of water drinking research would benefit from theory development work.

### 5.2.1 Water Drinking is an Essential Health Behaviour

Adequate fluid intake is essential for human health as water sustains all physiological functions (Jéquier & Constant, 2010; Kavouras & Anastasiou, 2010). Inadequate intake can lead to underhydration, which is linked to adverse health outcomes such as chronic kidney disease, diabetes, and urinary tract infections (Armstrong & Johnson, 2018; Perrier et al., 2020; Seal et al., 2019). Despite this, large proportions of industrialised nations' populations do not meet adequate intake guidelines (Drewnowski et al., 2013; Ferreira-Pêgo et al., 2015; Gibson & Shirreffs, 2013). For example, 60% of men and 40% of women did not meet adequate intake guidelines in a survey across 13 countries and three continents (Ferreira-Pêgo et al., 2015). Increased fluid intake could be an effective prevention strategy against the adverse health outcomes linked to underhydration (Perrier et al., 2020).

Drinking water is one of many means of obtaining adequate fluid intake, as food and other drinks also contribute. However, obtaining adequate intake is unlikely solely through eating, as drinking accounts for most daily water intake (Elmadfa & Meyer, 2015). Additionally, water is the optimal drink choice because it is healthier (Perrier, 2017) than other drinks (e.g., sugar-sweetened beverages) associated with adverse health outcomes (e.g., all-cause mortality; Anderson et al., 2020). Therefore, obtaining fluid intake through water drinking, specifically, is important.

### 5.2.2 Water Drinking Research Needs Theory Development

Water drinking intervention research provides a key example of the need for a better theoretical understanding of water drinking behaviour. Specifically, water drinking interventions are typically ineffective (Franse et al., 2020; Vargas-Garcia et al., 2017) or lead to small increases in intake that are unlikely to address the adverse outcomes associated with underhydration (Rodger et al., 2021). For example, a meta-analysis of water drinking interventions found that intervention groups only drank an average of 67 ml more water than control groups (Vargas-Garcia et al., 2017). However, larger increases in water intake are needed to regain adequate hydration status and address potentially adverse outcomes (e.g., 1500 ml; Johnson et al., 2020; Pross et al., 2014). Therefore, the potential of increased water

intake as a prevention strategy is unlikely to be realised, given the small effects of current intervention efforts.

Water drinking interventions may be ineffective because they are informed by broader research on health and consumption behaviour rather than domain-specific research on water drinking (Rodger et al., 2021). Although water drinking may share similarities with these broader domains (e.g., it is a desire and reward-driven behaviour; Papies et al., 2022), it also has unique features regarding how it is performed and what influences its performance (e.g., the types of reward that motivate it, such as thirst; Rodger et al., 2021). Therefore, applying interventions developed in other domains to increase water intake may not be effective as they do not account for domain-specific water drinking considerations. For example, product descriptions containing language regarding rewarding consumption experiences effectively increase plant-based eating, but this approach does not seem effective for water drinking (Claassen et al., 2022). This is potentially due to people having relatively stable and neutral representations of reward (e.g., taste) related to water drinking, which differs from people's less stable representations of plant-based foods, given their larger variety and novelty (Claassen et al., 2022). This suggests effective interventions from broader health and consumption domains may not generalise to water drinking. Therefore, more research on the underlying influences of water drinking behaviour is needed to inform water drinking interventions.

However, water drinking is a notoriously under-researched behaviour (Rush, 2013), so there has been limited domain-specific research to inform intervention development. Most early water drinking research has focused on demographic trends in water intake (Elmadfa & Meyer, 2015; Ferreira-Pêgo et al., 2015; Gibson & Shirreffs, 2013). Although this research provides insights into potentially at-risk groups needing water-drinking interventions, it is uninformative regarding the underlying influences causing these trends. For example, this research shows older people are less likely to meet adequate intake guidelines than other demographic groups. However, age alone, if at all, is unlikely the underlying cause of this trend. Indeed, this trend can be partially explained by barriers to water drinking that are specific to or particularly prevalent for older people (e.g., urinary incontinence concerns; Bhanu et al., 2020).

In recent years, novel research has emerged on how water drinking is performed and what constructs influence performance in real-life settings, aiming to inform a more comprehensive theoretical understanding of this behaviour. Specifically, we have conducted numerous qualitative and mixed-methods research studies in this domain (Rodger, Barsalou, et al., 2023; Rodger et al., 2021; Rodger, Vezevicius, et al., 2023; Rodger & Papies, 2022). However, it is important to consistently and meaningfully discuss how current evidence in a research domain relates to relevant constructs and wider theories of behaviour, including emerging research domains (Maatman, 2021; Meehl, 1978, 1990; Oberauer & Lewandowsky, 2019; Proulx & Morey, 2021; Scheel et al., 2020). Therefore, this domain needs theoretical work on the collective implications of emerging water drinking research.

### 5.2.3 The Current Paper

In this theoretical paper, we review emerging water drinking research insights to generate an initial theoretical overview of water drinking and discuss its implications. To achieve this, we structure the paper into the following sections:

First, we narratively review emerging research on water drinking to (1) define water drinking behaviour (i.e., what steps are involved in drinking water) based on how it occurs in daily life, and (2) identify constructs (e.g., knowledge, reward, etc.) that influence the performance of water drinking and explain how these constructs influence (i.e., hinder and facilitate) this behaviour in daily life. We structure our narrative review around relevant constructs and their role in water drinking, as constructs are the building blocks of theory (Scheel et al., 2020).

Second, we discuss the theoretical implications regarding important discussions in the wider psychology literature, such as the role of reward in regulating habitual behaviour (see De Houwer et al., 2022; Kruglanski & Szumowska, 2020; Wood et al., 2022).

Third, we discuss the applied implications of trying to increase water intake.

Lastly, we outline the strengths and limitations of current water drinking research and potential future directions.

We do not aim to cement a causal explanation of water drinking in developing this initial theoretical overview. Instead, we aim to use the in-depth insights from emerging water drinking research to inform suggestions regarding which constructs and broader theories of behaviour *may* be relevant and should be *considered* when designing theoretical and intervention-focused water drinking research. Our overview is a starting point, which can and *should* be continually improved upon through future research.

#### *5.2.3.1 Theoretical Perspectives Informing Our Approach*

Water drinking is an emerging research domain in the earlier stages of theory development, which is best informed by observational, qualitative, and exploratory methods (Scheel et al., 2020). As such, we predominantly review research using these methods to inform the explanations of water drinking in our theoretical overview. Our approach may seem to conflict with dominant positivist-informed perspectives in psychology that advocate confirmatory experimental methods are the sole "gold standard" for informing causal explanations. Therefore, we outline some key theoretical perspectives that informed our approach.

First, there are numerous, long-standing calls within the philosophy of science and methodology literature for psychology to use a more balanced array of diverse research methods to inform theory development (Diener et al., 2022; Grosz et al., 2020; Rohrer, 2018). Although experimental research has strengths (e.g., internal validity), it also has *substantial* weaknesses that other methods do not have (e.g., a lack of external and construct validity; Diener et al., 2022; Vazire et al., 2022). However, these weaknesses are often poorly acknowledged (Diener et al., 2022; Scheel et al., 2020; Wadhwa & Cook, 2019).

Second, positivist perspectives typically advocate that only quantitative experimental methods can inform causal explanations (Willis, 2023). Positivism treats causal influence as an unobservable 'black box' focusing solely on establishing regular associations between observable events (Ryba et al., 2022; Willis, 2023). In contrast, our approach aligns with our critical realist perspective, which advocates that quantitative and qualitative methods can and should inform causal explanations (Ryba et al., 2022; Willis, 2023). Critical realism takes a more complex view of causal influence. It assumes all entities (i.e., all objects from abstract social and psychological constructs to concrete physical things) have the

capacity for causal influence, which emerges under certain conditions, giving rise to observable events (e.g., behaviour; Willis, 2023). Here, causality is not gleaned solely by assessing associations between observable events but by explaining the causal influences that emerge and give rise to observable events under certain conditions (Ryba et al., 2022; Willis, 2023). Evidence from diverse methods is needed to inform this explanatory work (Ryba et al., 2022).

## 5.3 Initial Theoretical Overview

In this section, we review research on water drinking behaviour in real-world settings to establish (1) how this behaviour should be defined and (2) what constructs influence its performance. We then present case studies to further illustrate how this definition and these constructs can be used to understand the water drinking behaviour of real individuals. To inform these sections, we relied predominantly on recent qualitative, observational, and field intervention research, including our prior research and other research identified through database searches and citation chaining. We also used prior reviews of water drinking research, which focused on specific constructs, contexts, or participant groups. Finally, we used research on water drinking across contexts and participant groups to present a theoretical overview of water drinking that is likely transferable across these facets (Korstjens & Moser, 2018). However, where possible, we outline potential context or participant-specific considerations that should be accounted for when defining water drinking and describing which constructs influence its performance. Appendix A, available through the Open Science Framework (see https://osf.io/hnyzq/), provides an overview of the research we used to inform our theoretical overview, including the research aim, method, context, participant group, and key insights from each article.

### 5.3.1 How Should Water Drinking Be Defined?

A key component of theory development is defining the behaviour of interest, which has various implications, such as how the behaviour is measured (Scheel et al., 2020). Defining behaviour involves asking the following: what do we mean by water drinking behaviour? Answering this question may seem simple, but as this section will illustrate, current definitions of water drinking do not accurately reflect how this behaviour is performed in real-life settings, potentially impeding empirical research and intervention efforts.

Water drinking is typically defined as a simple behaviour, especially compared to other consumption or health behaviours. This is because other behaviours, such as healthy eating and exercise, have a higher degree of complexity, most simply defined as the number of lower-order behaviours facilitating a higher-order behaviour and the relative time needed to engage in these (Phillips & Mullan, 2022). However, just because water drinking is simpler than other behaviours does not mean it is inherently simple for people to perform.

First, water drinking behaviour is more than solely the motor act of drinking water, encompassing other essential lower-order behaviours that facilitate drinking (Rodger, Vezevicius, et al., 2023). Water drinking is contingent on remembering; most simply defined as the ability to remember to drink or prepare water when these behaviours are feasible and desired (i.e., prospective memory; Cole & Kvavilashvili, 2021; Kvavilashvili & Rummel, 2020). For example, UK-based adults with low water intake struggled to increase their water intake during an intervention follow-up because they did not remember to drink it during the day (Rodger, Vezevicius, et al., 2023). Water drinking is also contingent on preparation: most simply defined as any behaviour that makes water available to drink and, therefore, applies to a diverse range of behaviours. For example, seeking out a water source, filling up a glass or bottle of water, ensuring a glass or bottle of water is within arm's reach, carrying a water bottle, and buying bottled water (Hess et al., 2019; Kaushik et al., 2007; Rodger, Vezevicius, et al., 2023; Rodger & Papies, 2022). Water drinking is facilitated or hindered depending on whether or not these behaviours have been performed (Rodger, Vezevicius, et al., 2023). For example, UK-based adults with high water intake were more likely to engage in preparation behaviours, such as carrying a water bottle or ensuring a glass or bottle of water is within arm's reach, than those with low intake (Rodger, Barsalou, et al., 2023; Rodger & Papies, 2022).

Importantly, preparation behaviours vary across contexts. For example, in contexts with undrinkable tap water, boiling or filtering drinking water is necessary to facilitate water intake, or at least healthy water intake (Duan et al., 2022). Additionally, barriers to preparation behaviours vary across participants. For example, adolescents' water drinking often depends on whether adults aid adolescents in preparing water or do it for them (Chouraqui, 2023; Franse et al.,

2019): Students and parents in rural New Mexico reported that parents' preparation behaviours (e.g., ensuring bottled water is in the fridge) facilitated water intake (Hess et al., 2019). Schools not providing water at lunch or teachers restricting preparation behaviours (e.g., keeping a bottle of water on the desk) hindered water intake (Hess et al., 2019; Kaushik et al., 2007).

Second, water drinking can be a relatively time-consuming behaviour to engage in. Although one instance of water drinking may span mere seconds, numerous instances across various situations throughout the day are needed to achieve adequate water intake. For example, UK-based adults with high water intake were more likely to have more drinking instances and drink in more situations than those with low intake (Rodger & Papies, 2022). Additionally, depending on their nature, preparation behaviours must be repeated throughout the day (e.g., refilling a bottle). This increases the time needed to facilitate adequate water intake. For example, UK-based adults perceived water drinking, particularly the preparation behaviours involved, as time-consuming in situations where they did not typically drink water (Rodger, Vezevicius, et al., 2023; Rodger & Papies, 2022).

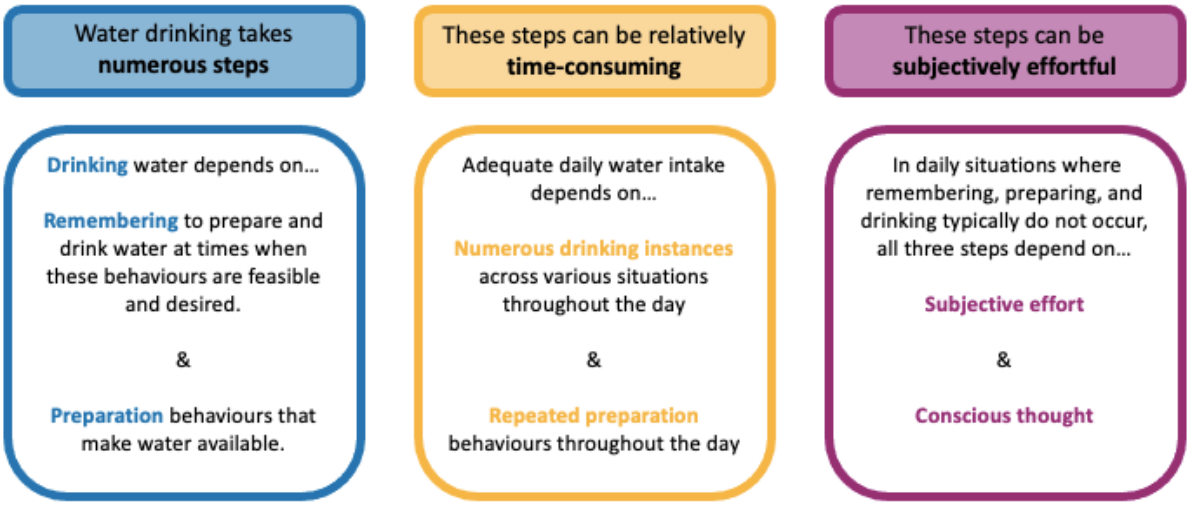
Finally, people may typically hold abstract representations that water drinking is a simple behaviour. However, for some people, when they think about performing it within the rich contexts of their daily routines, this behaviour can be complex. Water drinking and preparation behaviours are perceived as subjectively effortful in situations where water drinking is not typically performed (Rodger et al., 2021). This is evidenced by adults with low water intake (Rodger, Barsalou, et al., 2023; Rodger & Papies, 2022) and older people (Bhanu et al., 2020), who reported that effortful preparation behaviours were a key barrier to water intake. It is important to caveat that water drinking can be perceived as simple for some (Rodger et al., 2021), and we will discuss this in more detail in the preceding sections (see Habitualness).

We have shown, regarding complexity, that there are numerous steps an individual must engage in for water intake to occur, which can be relatively time-consuming and subjectively effortful. Complexity is, therefore, a key construct that should be accounted for when defining water drinking behaviour. Specifically, water drinking is best defined as a higher-order behaviour that can be separated into

lower-order behaviours: remembering, preparing, *and* drinking (all defined above). Additionally, water drinking's perceived complexity varies greatly depending on the individual and the situation. Therefore, conceptualising water drinking as a simple behaviour for all individuals to perform in all daily life situations does not align with people's lived experience of this behaviour. Water drinking definitions should also account for these aspects of variation. Figure 31 provides a summary of the key constructs covered in this section.

**Figure 31**

**Defining Water Drinking: Accounting for Complexity**




Note: Complexity is most simply defined as the number of lower-order behaviours facilitating a higher-order behaviour and the relative time needed to engage in these (Phillips & Mullan, 2022).

### 5.3.2 What Influences Water Drinking's Performance?

Another key component of theory development is defining constructs that influence the behaviour of interest and establishing how these constructs influence the behaviour (Scheel et al., 2020). Below, we define 12 constructs relevant to understanding water drinking behaviour and review evidence regarding how these constructs hinder and facilitate this behaviour. We have grouped these constructs into external influences, focusing on aspects of the external environment that influence water drinking behaviour, and internal influences, focusing on aspects of individuals that influence water drinking behaviour. We separately discuss the construct of situatedness and how this relates to water drinking, as it is relevant to external and internal influences.

#### *5.3.2.1 External Influences*

**Availability.** The extent to which a context's infrastructure provides readily available access to drinkable water (i.e., water security) impacts water drinking (Miller et al., 2021). Context can relate to anything from an entire country to a specific building or room, and low water security is associated with lower water intake across various contexts (see Miller et al., 2021; Nounkeu et al., 2022). Conversely, installing appealing water bottle filling stations in recreation centres in low-income communities in Philadelphia increased the number of adolescents drinking water (Patel et al., 2020). Low water security also means more time must be invested in preparation behaviours. For example, in three rural communities in Cameroon with low water security, women spent an average of three hours fetching water approximately every four days (Nounkeu et al., 2022). Low water security could also impact remembering, as UK-based adults reported relying on external cues (e.g., water fountains and bottle refill stations) to aid remembering (Rodger et al., 2021; Rodger, Vezevicius, et al., 2023). Finally, we note that availability is heavily intertwined with policy, which has the power to mandate certain levels of access within various contexts. For example, a California state policy requiring childcare centres to make drinkable water available to adolescents led to increased water offerings (Patel et al., 2020).

On a more individual level, barriers in the immediate external environment can hinder people's ability to engage in preparation behaviours that increase water's availability. For example, UK-based adults reported not drinking water in certain situations (e.g., work) because external barriers (e.g., nature of their job) prevent them from engaging in preparation behaviours (e.g., carrying a water bottle) that would have made water readily available (Rodger et al., 2021; Rodger, Vezevicius, et al., 2023; Rodger & Papies, 2022). Additionally, older people reported not drinking enough due to reduced mobility and external barriers that made preparation difficult (e.g., stairs; Bhanu et al., 2020). In both examples, the external environment does not facilitate the preparation of water, meaning water is not readily available when an instance of drinking is desirable.

**Quality & Safety.** Perceptions of poor tap water quality and safety are typically negatively associated with water intake (Barrett et al., 2017; Geerts et al., 2020; Hess et al., 2019; Onufrak et al., 2014). For example, in Flanders, Belgium, these perceptions led to people not drinking tap water, despite having a drinkable water supply (Geerts et al., 2020). Therefore, actual tap water quality and safety is

a necessary but insufficient condition for (tap) water intake (Geerts et al., 2020). These perceptions also affect people's preparation behaviours (e.g., buying bottled water versus filling a bottle from the tap). However, they do not necessarily lead to inadequate water intake if bottled water is drunk instead. Indeed, research evidences that these perceptions lead to increased bottled water intake (Geerts et al., 2020; Onufrak et al., 2014). Substituting tap with bottled water creates an interesting tension for researchers to consider: This substitution may be desirable from a health perspective if adequate intake is the goal, especially in contexts where tap water is undrinkable and preparation behaviours to make it drinkable are a barrier to healthy intake. However, this substitution is not desirable from an environmental perspective if adequate *and* sustainable intake is the goal, especially where tap water is drinkable. This is due to the adverse environmental impacts of bottled water manufacturing, transport, and single-use plastic (Geerts et al., 2020). Additionally, this substitution may not be affordable for certain individuals or groups.

**Affordability.** Free access to drinkable water facilitated water intake across various demographic groups and contexts (Block et al., 2013; Geerts et al., 2020; Hess et al., 2019; Werner et al., 2022). For example, UK-based adults' baseline water affordability ratings were positively associated with water intake over a three-day follow-up (Rodger, Barsalou, et al., 2023). However, when water is perceived as a free resource, people typically have negative attitudes towards paying for bottled water. For example, US-based college students reported a low tolerance for paying for water, unlike other drinks (Block et al., 2013). Additionally, US-based adults across various demographic groups perceived the high cost of bottled water as a key barrier to water drinking (Wippold et al., 2020).

**Toilet Facilities.** Access to sanitary toilet facilities facilitates water drinking, but lack of access to toilet facilities and access to unsanitary toilet facilities hinders water drinking (Michels et al., 2019; Rodger et al., 2021; Rodger, Vezevicius, et al., 2023; Venugopal et al., 2023). For example, female police officers in South India reported being unable to drink water when thirsty due to a lack of access to sanitary, private, or conveniently located toilets when working offsite (Venugopal et al., 2023). UK-based adults with low water intake reported increased trips to the toilet as a barrier to increasing their water intake (Rodger, Vezevicius, et al., 2023). Older people practised highly restrictive fluid intake due

to fear of urinary incontinence and lack of access to public toilets (Bhanu et al., 2020). Finally, adolescent's hydration was better in schools with policies that gave them regular access to well-maintained toilets (Michels et al., 2019).

**Availability of other drinks.** This can hinder water drinking, as adults and adolescents often report not drinking water because other preferred drinks are available (Álvarez-Sánchez et al., 2022; Hess et al., 2019; Rodger & Papies, 2022). For example, UK-based adults with low water intake reported that the availability of other preferred drinks hindered their attempts to start drinking water in new situations (Rodger, Vezevicius, et al., 2023). Additionally, construction workers in Mexico partially attributed their high consumption of SSBs over water to the widespread availability of these drinks in most situations (Álvarez-Sánchez et al., 2022).

**Weather & Indoor Climate.** Warm weather or indoor climates facilitate, but cold weather and indoor climates hinder water drinking. For example, construction workers in Mexico, who prefer and typically drink sugar-sweetened beverages, reported increasing their water intake in very warm weather (Álvarez-Sánchez et al., 2022). UK-based adults reported preferring warm drinks such as tea during winter but drinking water on warmer summer days (Rodger et al., 2021). Finally, adolescents typically report drinking more in warm than cold weather (Barrett et al., 2017; Hess et al., 2019).

Figure 32 provides an overview of the key considerations regarding each external influence construct and its potential negative impact on water drinking. For readability, we chose to highlight the negative impact that each construct has on water drinking as a key aim of this paper is to inform intervention efforts that mitigate barriers to water drinking behaviour, increasing water intake. Additionally, focusing on one type of impact (i.e., negative versus positive) allowed for a more detailed summary of impacts in the figure. However, we note that for most constructs there is also evidence of positive impacts. For example, regarding availability, effective policy and infrastructure leading to readily available drinkable tap water facilitates people's ability to remember, prepare, drink water. We also note that for all these constructs, both an objective and subjective framing likely should be considered. For example, imagine a researcher is assessing availability within an office, and there is a bottle refill station on one floor of the

building. They may view water as readily available in this context (objective framing). However, a worker one floor above the refill station may perceive this as far away and too much effort to use (subjective framing).

**Figure 32**

**External Influences of Water Drinking: Key Constructs**

| External Influence | Negative Impact on Water Drinking |
|---|---|
| **Availability:** To what extent does the current context have infrastructure that provides readily available access to drinkable water? And policy that mandates effective infrastructure, which aids water drinking? | **A lack of policy and infrastructure** that lead to readily available drinkable water hinder people's ability to remember, prepare, and drink (e.g., external water sources, such as water fountains, are used as cues for remembering and can aid preparation when conveniently located). |
| **Quality & Safety:** To what extent does the current context have infrastructure that provides access to quality and safe water? | **Low-quality and unsafe water** hinders people's ability to prepare and drink an adequate water amount. This can also lead to the use of unsustainable and inequitable alternatives (e.g., bottled water). |
| **Affordability:** To what extent does the current context have infrastructure that provides free or affordable access to drinkable water? | **Unaffordable water options** hinder people's preparation and drinking. This relates to purchasing bottled water and improving tap water quality (e.g., through filters). |
| **Toilet facilities:** To what extent does the current context have infrastructure that provides access to sanitary, private, and conveniently located toilets? | **Poor toilet infrastructure** restricts people's water drinking practices (e.g., not preparing or drinking even upon remembering and being thirsty). |
| **Availability of other drinks:** To what extent does the current context have infrastructure that provides access to other drinks options? | **Access to other drinks** hinder preparing and drinking if the other drinks are preferred. |
| **Weather & indoor climate:** What is the temperature in the current context? | **Cold weather and indoor climates** hinder remembering, preparing and drinking. |

### *5.3.2.2 Internal Influences*

**Thirst.** Thirst facilitates water drinking, which is unsurprising given that the adaptive function of thirst sensations creates the desire to consume water to restore the body's hydration state (Stevenson et al., 2015). Specifically, thirst sensations are a common cue for water drinking, and not experiencing them is a common reason for not drinking water across various contexts and participants (Barrett et al., 2017; Bhanu et al., 2020; Block et al., 2013; Hess et al., 2019; Rodger et al., 2021; Rodger & Papies, 2022; Werner et al., 2022). For example, UK-based adults reported relying on thirst sensations, such as having a dry mouth, to prompt water drinking throughout the day (Rodger et al., 2021). Additionally, UK-based adults' ratings of the extent to which thirst motivated water drinking across ten daily situations predicted future water intake in these situations (Rodger, Barsalou, et al., 2023).

However, relying solely on thirst sensations is unlikely an effective way of obtaining adequate water intake because perceptions of thirst sensations are highly variable and unreliable (Adams et al., 2022; Rosinger et al., 2022; Stevenson et al., 2015). For example, UK-based adults also reported suppressing, ignoring, and not perceiving thirst sensations throughout the day, especially when they felt hydration was not a key priority compared to other goals (e.g., completing their work; Rodger et al., 2021). Additionally, older people may suffer from blunted thirst sensations in later life (Miller et al., 2021). Finally, other influences, such as the external environment, can impact thirst sensations' capability to facilitate water drinking. For example, we evidenced earlier that female police officers in South India did not act on thirst sensations due to a lack of appropriate toilet facilities (Venugopal et al., 2023). This illustrates that thirst sensations *can* facilitate water drinking, but they are unlikely a sufficient influence.

**Knowledge.** Research across various contexts and participant groups (e.g., adults, adolescents, athletes, older people) highlights that many people lack hydration knowledge (Bhanu et al., 2020; Brownbill et al., 2020; Rodger et al., 2021; Song et al., 2022; Veilleux et al., 2020). Hydration knowledge relates to people's understanding of, for example, the need for water intake, adequate intake guidelines, and the health benefits of drinking water (see Veilleux et al., 2020). The lack of hydration knowledge indicates the need for education. However, education-based water drinking interventions are typically ineffective (Franse et al., 2020; Vargas-Garcia et al., 2017), indicating that acquiring hydration knowledge is insufficient to facilitate water drinking. Indeed, in a recent intervention study, hydration education motivated UK-based adults with low water intake, providing a reason to drink water and the potential rewards they may experience (Rodger, Vezevicius, et al., 2023). However, participants did not always drink water during the follow-up, as they struggled with barriers (e.g., effortful preparation) or did not experience the anticipated rewards. Therefore, knowing the importance and benefits of hydration is potentially necessary but insufficient for facilitating water intake in cases where hydration knowledge is lacking.

**Habitualness.** Water drinking appears habitual to some degree (Veilleux et al., 2020), as it is typically performed consistently in similar situations with a high degree of automaticity (Rodger et al., 2021; Rodger & Papies, 2022). Regarding drinking, some UK-based adults struggled to describe the thought process

underlying their water drinking as this behaviour was highly automatic (Rodger et al., 2021). However, these adults also reported drinking water inconsistently, relying on conscious thought and subjective effort outside of habitual situations (i.e., situations were they consistently drank water with little consious thought and subjective effort; Rodger et al., 2021). Similar patterns were evidenced for remembering and preparing. For example, UK-based adults with high water intake reported remembering and performing preparation behaviours with a high degree of automaticity (Rodger et al., 2021; Rodger & Papies, 2022). Specifically, they reported engaging in preparation with little conscious thought and subjective effort. Conversely, those adults with low water intake reported that preparing and drinking water was a deliberate action that took time, effort, and conscious thought (Rodger, Vezevicius, et al., 2023; Rodger & Papies, 2022).

Highly habitual water drinking is not necessarily conducive to high daily water intake. For example, an individual may only have highly habitual water drinking behaviour in situations that occur infrequently throughout the day (e.g., upon waking up Rodger et al., 2021). However, people with high daily water intake typically have highly habitual water drinking behaviour across various situations (Rodger et al., 2021; Rodger & Papies, 2022), suggesting that having habitual water drinking in numerous situations is necessary for high water intake. For example, UK-based adults with high water intake reported preparing and drinking water with higher levels of automaticity than those with low intake across ten daily situations (Rodger, Barsalou, et al., 2023).

**Reward.** Reward is a desired outcome of consumption behaviour that motivates performance (Shiota et al., 2021). Water drinking behaviour is typically performed when it is associated with rewarding outcomes and not when it is associated with unrewarding outcomes (Rodger, Vezevicius, et al., 2023; Rodger & Papies, 2022). For example, UK-based adults with highly habitual water drinking behaviour reported drinking water because they find it rewarding (Rodger & Papies, 2022). Additionally, US-based adolescents reported drinking water because it was refreshing and energising (Barrett et al., 2017). Conversely, water drinking is not typically performed when associated with no or unrewarding outcomes. For example, adults and adolescents reported not drinking water because they associate it with outcomes such as experiencing a disliked taste (Hess et al., 2019; Rodger et al., 2021; Rodger, Vezevicius, et al., 2023; Rodger & Papies, 2022), spending

money (Wippold et al., 2020), and an increased need to urinate (Bhanu et al., 2020; Rodger, Vezevicius, et al., 2023; Rodger & Papies, 2022). The latter two unrewarding outcomes highlight that reward perceptions are interrelated to external influence constructs such as availability and toilet facilities.

The reward associated with water drinking ranges from shorter-term rewards (e.g., taste) to longer-term rewards (e.g., improved health), and both predict future water intake (Rodger, Barsalou, et al., 2023). Water's ability to quench thirst is the most common and salient reward (Barrett et al., 2017; Block et al., 2013; Rodger et al., 2021; Rodger & Papies, 2022). However, as previously discussed, thirst's ability to motivate water drinking may be unreliable. Indeed, UK-based adults with highly habitual water drinking across various situations did not rely solely on thirst to initiate drinking and associated water drinking with multiple rewards (Rodger & Papies, 2022). The diverse rewards associated with water include liking the taste (Bhanu et al., 2020; Geerts et al., 2020; Rodger & Papies, 2022; Wippold et al., 2020), experiencing tangible well-being benefits (e.g., improved mood and energy levels), and preventing adverse dehydration outcomes (e.g., fatigue) (Barrett et al., 2017; Block et al., 2013; Lilo & West, 2022; Rodger, Vezevicius, et al., 2023; Rodger & Papies, 2022). For example, after exposure to a healthy hydration campaign, high school students' water drinking seemed partly motivated by reward experiences (e.g., weight loss, increased energy levels, and reduced dehydration symptoms; Lilo & West, 2022). However, awareness of these potential rewards is not always sufficient to influence water drinking (Douglas et al., 2015). Instead, water intake is associated with experiencing or believing in certain actual or perceived rewards (Block et al., 2013; Etale et al., 2018; Rodger & Papies, 2022; Vézina-Im & Beaulieu, 2019).

Finally, the reward associated with water drinking varies across situations, such that people associate water drinking with reward in some situations but not others (Rodger, Vezevicius, et al., 2023; Rodger & Papies, 2022). For example, UK-based adults' ratings on whether a range of rewarding outcomes motivated water drinking was extremely varied across ten daily situations (Rodger, Barsalou, et al., 2023). Therefore, reward seems to motivate the repeated performance of water drinking in certain situations (Rodger, Vezevicius, et al., 2023). This could explain why people have highly habitual water drinking in certain situations but not in others.

**Self-Relevance.** The research on reward suggests that people perform water drinking in situations when it supports the pursuit of self-relevant outcomes. Research on self-identity and social norms also illustrates the influence of self-relevance, as water drinking outcomes that align with one's identity or with social norms motivate water drinking.

Strong health consciousness is associated with finding water drinking highly rewarding and habitual (Rodger & Papies, 2022). For example, UK-based adults' ratings of health consciousness positively predicted future water intake (Rodger, Barsalou, et al., 2023). However, these associations are weaker when people prioritise other aspects of self-identity, which are not aligned with water drinking. For example, a student who drank water habitually when studying, did not do so during Ramadan, when their salient religious identity motivated fasting (Rodger & Papies, 2022). Therefore, the influence of self-identity seems to vary depending on what aspects of self-identity are salient in each situation (Oyserman, 2015).

Water drinking also appears associated with social norms. For example, UK-based adults reported perceiving water drinking as rewarding because it had a social signalling function (e.g., signalling that they are healthy; Rodger & Papies, 2022). Additionally, using peer influence to increase adolescent water intake (Smit et al., 2016) was the most effective intervention strategy in a recent meta-analysis (Franse et al., 2020). Conversely, construction workers in Mexico continued to drink sugar-sweetened beverages (SSBs) over water due to social norms, despite increased taxes on SSBs and knowing the health risks (Álvarez-Sánchez et al., 2022).

The influence of self-relevance is also further illustrated by commonly reported barriers to water drinking. Specifically, performing other, more valued behaviours that water drinking would interrupt (Rodger et al., 2021; Rodger, Vezevicius, et al., 2023), and the availability of other, preferred drinks (Rodger, Vezevicius, et al., 2023; Sylvetsky et al., 2020; Wippold et al., 2020). For example, perceived control over the availability of other preferred drinks predicted US-based college students' intentions to initiate drinking water over SSBs (Sharma et al., 2017). These barriers indicate that water drinking is not performed when another

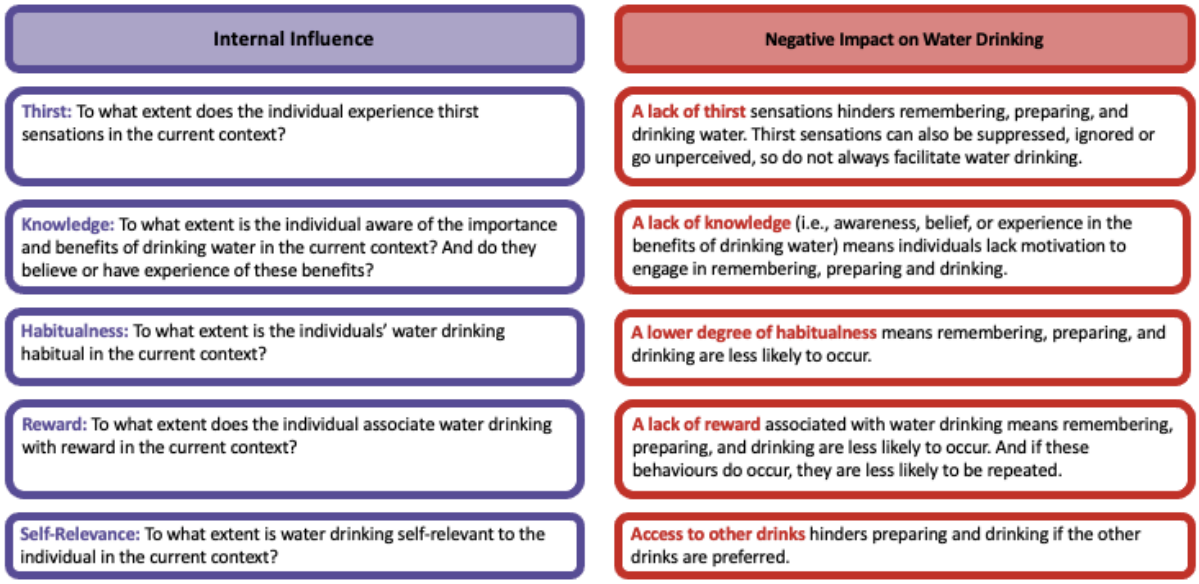
behaviour is more self-relevant or rewarding. Additionally, these barriers were common in UK-based adults with high water intake, who exhibited habitual water drinking (Rodger & Papies, 2022). Therefore, even highly habitual water drinking associated with reward, self-identity, and social norms, may not occur if another behaviour is more self-relevant.

Finally, these barriers indicate that the self-relevance of water drinking fluctuates throughout the day. For example, UK-based adults' ratings on where water drinking placed on their list of priorities was extremely varied across ten daily situations (Rodger, Barsalou, et al., 2023).

Figure 33 provides an overview of the key constructs regarding internal influences and their potential negative impact on water drinking. It is presented in the same format and has the same considerations as outlined for the external influences summarised in Figure 32.

**Figure 33**

**Internal Influences of Water Drinking: Key Constructs**




### *5.3.2.3 Situatedness*

Situatedness is the idea that behaviour and the processes regulating behaviour are situation-specific, so vary widely across situations (Barsalou, 2019; Dutriaux et al., 2021). For decades, research in personality and social psychology has demonstrated the profound effects of situations on behaviour. Indeed, the preceding sections of this paper show that water drinking behaviour and the

influence of relevant constructs regulating this behaviour seem to vary across situations. A prime example is research on UK-based adults that measured water intake and various influential constructs across ten daily situations, showing all these measures varied substantially across individuals, across situations, and within individuals across situations (Rodger, Barsalou, et al., 2023). Therefore, it is important to account for situatedness when defining constructs related to water drinking and establishing how they influence water drinking behaviour.

### *5.3.3* Initial Theoretical Overview in Practice: A Case Study Illustration

This section presents a comparative case study of interviews with two real UK-based participants from our prior research to illustrate that accounting for the definition and various influential constructs in the overview above can provide an in-depth understanding of water drinking behaviour.

The first case is Matilda, a university student with a high daily water intake who reported drinking water consistently throughout the day across most situations (e.g., at home, university, and work). The second is Ted, an office worker with a low daily water intake who reported drinking water inconsistently throughout the day across most situations, bar during exercise. Matilda and Ted are participants in a qualitative interview study (N = 60) that aimed to broadly scope the motivations underlying UK-based adults' water drinking behaviour throughout the day. We reanalysed their interview transcripts (available through the published paper; Rodger et al., 2021) to reiterate the relevance of our theoretical overview for understanding why water drinking does or does not occur in real-life settings. Specifically, in Figure 34, we show that Matilda conceptualises the steps, time, and effort needed to engage in water drinking as simple, unlike Ted conceptualises water drinking with a higher degree of complexity. In Figure 35, we show that Matilda does perceive any salient external barriers (e.g., water availability and toilet facilities) to drinking, unlike Ted, who reported being hindered by or not facilitated by all the external influences in our overview. Finally, in Figure 36, we show Matilda had internal influences that facilitated water drinking, unlike Ted whose water drinking behaviour was hindered by influences such as a lack of perceived rewarding outcomes and habitualness associated with water drinking.

**Figure 34**

**Water Drinking Complexity: The Case of Matilda & Ted**

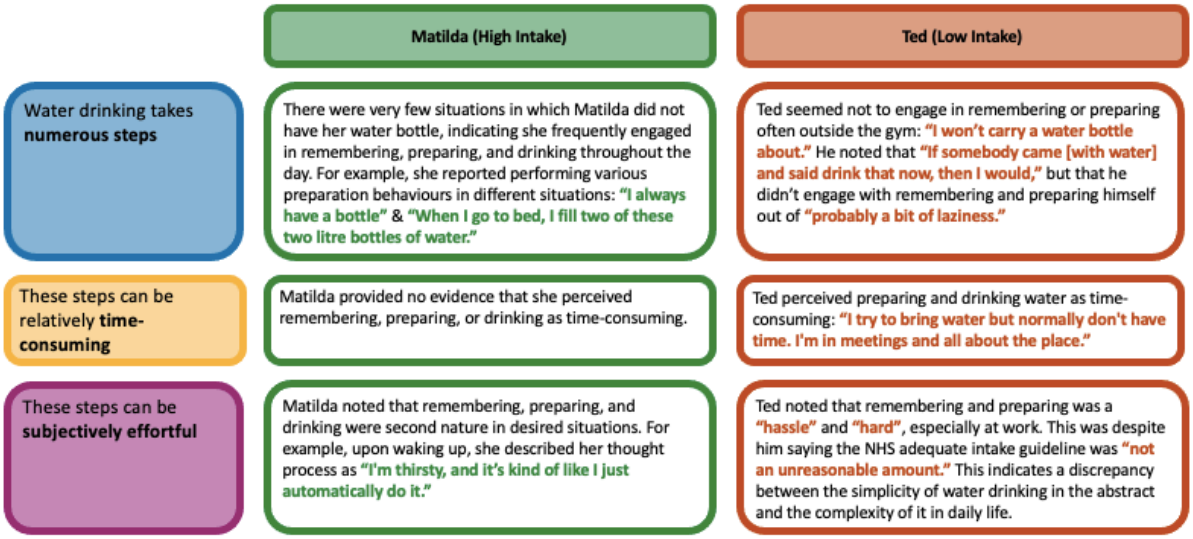



**Figure 35**

**External Influences: The Case of Matilda & Ted**

| Influence | Matilda (High Intake) | Ted (Low Intake) |
|---|---|---|
| Availability | Matilda discussed drinking water in most situations (e.g., at home, university, work) and did not mention access as a barrier in any. Instead, she frequently engaged in preparation that made water readily accessible when she wanted to drink: "I always have a bottle." | Ted did not perform preparation behaviours that made water readily available. For example, he relied on others to prepare his drinks at work: "My only fluids are if somebody is kind enough to offer." This was despite the fact he noted "there's water dispensers" at his office. |
| Quality & Safety | Matilda had positive perceptions of the available water: "We live in Scotland, there's clean water." | Ted had rather neutral perceptions of tap water "I don't take too much consideration for quality [...] it's quite fresh and cold." |
| Affordability | Matilda bought bottled water only when she forgot her water bottle, but had sustainability concerns: "I drink so much getting a bottle of water is just a waste [of plastic]." | Ted bought bottled water if he was buying a lunch deal that included a drink but viewed this as "a waste of money" in other contexts. |
| Toilet Facilities | Matilda did not perceive any toilet-related barriers to drinking: "I care more about the water going in than the water going out." | This was a key barrier for Ted. For example, in meetings, "You can't just go to the toilet" and at night "It disturbs your sleep." |
| Availability of other drinks | Matilda's default choice was water, even when other options were available. However, she noted she drank soft drinks at work for a short period "just because they're free." | In most situations, Ted opted for drinks other than water. For example, when socialising after work, "water could be an option, but it will not cross my lips." |
| Weather & indoor climate | Matilda noted her water intake was "probably a bit more in summer, but just because I'm sweaty." | Ted noted that his water intake "would be the same" in the summer. |

**Figure 36**

**Internal Influences: The Case of Matilda & Ted**

| Influence | Matilda (High Intake) | Ted (Low Intake) |
|---|---|---|
| Thirst | Matilda noted that instances of drinking were motivated by feeling **"a dry mouth"** or because **"I'm thirsty."** | Ted noted that he was **"not one for always feeling thirsty,"** indicating thirst sensations were not salient for him. |
| Knowledge | Matilda evidenced some knowledge of adequate guidelines: **"I believe it's two litres"**. However, she was also unsure of the long-term health implications, indicating this was an insufficient influence: **"does it have any long term health issues? Is it a big deal? I don't know."** | Ted seemed to be aware of the importance of hydration, noting, **"I don't drink as much as I should"** and that the little water he did drink was motivated by **"health implications."** However, his intake was low outside of exercise, indicating health was an insufficient influence. |
| Habitualness | Matilda drank from her water bottle **"automatically"** in various situations: **I'll just be like (picks up bottle and takes a sip)"**. However, preparing was not always habitual: **"I leave it [her bottle] in work quite a lot."** | Ted noted some degree of habitual drinking in his old job: **"When I was in class teaching, it was easy."** However, when he gained a new role with more **"frantic and erratic"** days, he said his water drinking dropped off **"almost immediately."** |
| Reward | Matilda associated water drinking with various rewards: **"If I don't have water, I will just feel really unhydrated, tired, and crap."** Even her highly habitual drinking was rewarding: she reported drinking **"automatically"** in the morning because it quenched her thirst (**"I'm thirsty"**). | Ted associated water drinking with reward: **"You feel the difference in terms of tiredness at work."** However, this was associated with drinks more generally (e.g., tea and coffee). He only drank water habitually in the gym, where he only associated water with the reward of getting **"the best workout."** |
| Self-Relevance | Matilda also associated water drinking behaviour with her self-identity and social norms: **"I like that aspect of my identity that I keep hydrated,"** and **"everyone [her friends] was very fixated on their body and health [...] water is just a part of that."** | Ted's identity and social norms did not align with water drinking: he **"won't carry a water bottle"** in schools out of **"professionalism"** and felt there was a **"social aspect"** to hot drinks at meetings. He also perceived a lot of barriers. |

Considering Matilda and Ted's water drinking behaviour within our theoretical overview helps us understand why Matilda has a high daily water intake, and Ted doesn't. It also illustrates the diverse array of influences likely underlying these individuals' water drinking through the day.

## 5.4 Theoretical Implications

### 5.4.1 Acknowledge the Complexity of Water Drinking

Conceptualising water drinking as a simple behaviour could impede water drinking research. Theoretical frameworks used for comparatively more complex consumption and health behaviours may be incorrectly perceived as inappropriate in this domain. For example, breaking down complex behaviours into chunks (i.e., into lower order behaviours and instigation versus performance) to inform theory and intervention development has been effectively applied to more complex health behaviours, such as healthy eating and exercise. However, advocates of this approach noted that it may not be relevant for water drinking as it is a simple behaviour (Gardner, 2015; Gardner et al., 2016). Conversely, our theoretical overview would suggest chunking may be an informative approach for water drinking research.

Additionally, acknowledging the complexity of water drinking will likely improve intervention development. For example, a key limitation of a planning-based water drinking intervention was that participants made plans for *drinking* in new situations (Rodger, Vezevicius, et al., 2023). This intervention did not account for *preparation behaviours*, which were needed to ensure water was readily available for participants to drink in these situations. Additionally, participants struggled to *remember* their plans during the follow-up. As a result of these issues, the intervention was ineffective compared to the control. Therefore, it is crucial to account for remembering and preparation behaviours when defining water drinking.

### 5.4.2 Use Comprehensive Theories of Behaviour to Guide Research

Our theoretical overview suggests that water drinking is likely influenced by a complex interplay of various internal and external constructs. Therefore, it is important to use theories of behaviour that account for these constructs.

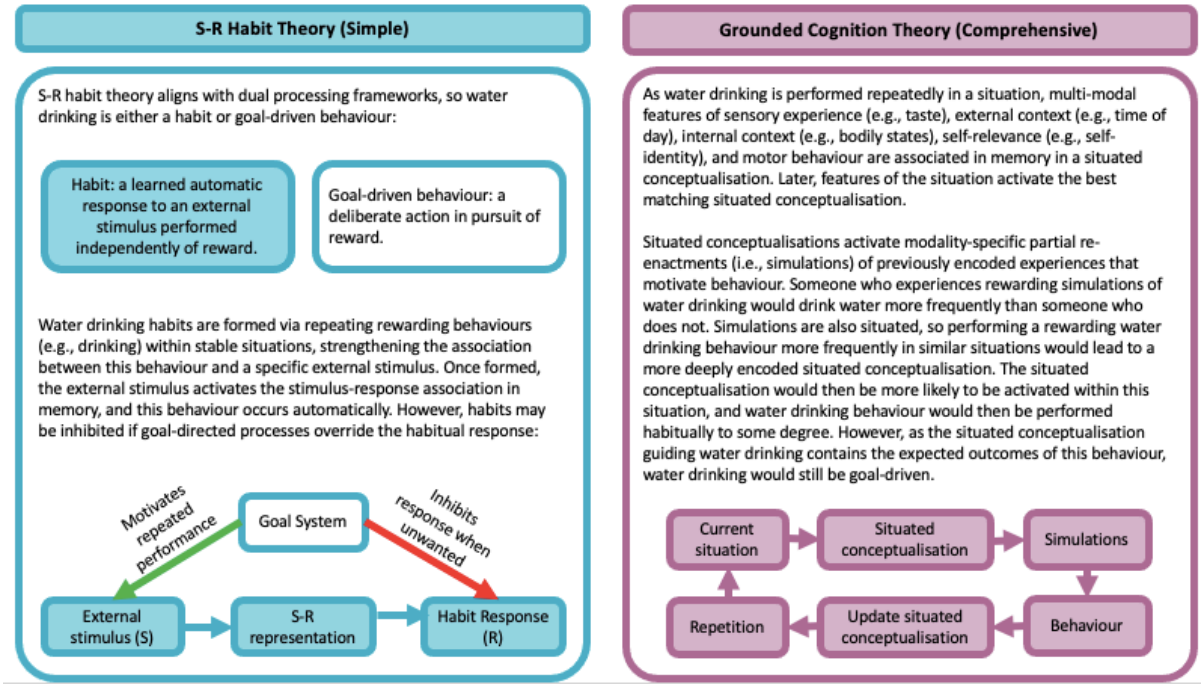
To illustrate this point, we consider the usefulness of a relatively simple versus a relatively more comprehensive theory of behaviour to account for the various influences of water drinking. Specifically, we consider the usefulness of Stimulus-Response (S-R) habit theory (see Wood et al., 2022; Wood & Rünger, 2016) and the grounded cognition theory of desire and motivated behaviour (see Papies et al., 2022). We selected these two theories as they frequently guide consumption behaviour research and intervention development. However, this is not an exhaustive discussion of theories that could help explain water drinking behaviour. For example, goal-directed behaviour theory (Hommel, 2021), value-based decision-making (Berkman, 2018), and the COM-B model (Michie et al., 2011) present other potentially helpful perspectives. A complete discussion of all these theories is outside the scope of this paper. However, the principle of comprehensive theories being more informative applies to the other theoretical perspectives noted above. Readers can use the following section as an example of how they might assess whether their chosen theory of behaviour comprehensively accounts for the constructs influencing water drinking.

To evaluate a theory's usefulness in explaining behaviour, researchers must first establish each theory's assumptions clearly (Eronen & Bringmann, 2021; Scheel et al., 2020). Hence, in Figure 37, we outline how each theory would

assume water drinking is performed, given their core assumptions. This figure shows that S-R habit theory and grounded cognition theory have different explanations of what influences water drinking. For example, S-R habit theory assumes reward does not influence habitual water drinking behaviour; however, grounded cognition theory assumes it does. This figure also shows that S-R habit theory identifies fewer constructs influencing water drinking than grounded cognition theory. For example, S-R habit theory relies on four key constructs: goals, habit, external stimuli, and repeated performance. However, grounded cognition theory relies on various constructs, including but not limited to sensory experience, external context, internal context, and more. Each of these constructs relates to various sub-constructs. For example, internal context relates to constructs such as physiological states (e.g., thirst) and psychological states (e.g., motivation). As such, we conceptualise S-R habit theory as a relatively simple theory of behaviour and grounded cognition theory as a relatively comprehensive one.

**Figure 37**

**Simple vs Comprehensive Theory's Assumptions on Water Drinking Influences**




Having established what each theory assumes influences water drinking, we now discuss how well these assumptions account for the influences established in our theoretical overview. We use the case of Matilda to ground our discussion, showing each theory has a different explanation of what regulates Matilda's water drinking and differs in its ability to map its assumptions onto the various influences

of Matilda's water drinking. We focus on Matilda as she had highly habitual water drinking (unlike Ted), which allows us to access the usefulness of S-R habit theory's definition of habits.

#### *5.4.2.1 Can S-R Habit Theory Account for Matilda's Water Drinking?*

As habitualness seems to be a relevant construct of water drinking, it could be helpful to conceptualise this behaviour as an S-R habit response. This conceptualisation could apply to lower-order behaviours (i.e., drinking), for certain individuals, in specific situations (Phillips & Mullan, 2022). For example, Matilda described her thought process underlying her water drinking at university by simply picking up and drinking from her bottle, indicating that drinking, for Matilda, in this situation, might be an S-R habit response.

However, conceptualising these types of observations as S-R habits could be misleading. One cannot assume that a behaviour is an S-R habit response simply by observing a high degree of automaticity and the apparent association between a behaviour and a stimulus (De Houwer, 2019b; Trofimova, 2022). These observations could also be made for goal-driven behaviour (De Houwer et al., 2022; Hommel, 2021; Kruglanski & Szumowska, 2020; Papies et al., 2022). For example, thirst, reward, and self-relevance seem to regulate Matilda's highly habitual water drinking, which does not align with S-R habit theory unless her drinking is conceptualised as being in the process of habit formation. We note that S-R habit theory would suggest that people provide reward-driven explanations of S-R habits (Mazar & Wood, 2022; Wood et al., 2022), which could explain participants' reporting habitual water drinking being rewarding. However, we suggest that this perspective provides a convenient rather than comprehensive explanation for the substantial evidence suggesting reward may regulate highly habitual water drinking and habitual behaviour more generally (Kruglanski & Szumowska, 2020; Trofimova, 2022).

Additionally, various external influences seem to regulate Matilda's drinking, not merely a sole external stimulus as assumed by S-R habit theory. For example, Matilda consistently had a water bottle in sight and within reach while working at her desk at university. In other words, she was consistently exposed to this stimulus. She nevertheless could go for periods without drinking from her water bottle at university while doing her work. S-R habit theory would suggest that this observation is due to goal-driven behaviour (e.g., completing coursework)

inhibiting the default S-R habit response (Wood et al., 2022). However, the constant need to inhibit the default habit response calls into question a core assumption of S-R habit theory: defaulting to S-R habit responses in most instances of behaviour is the most efficient means of behavioural control. For Matilda, it does not seem efficient to default to water drinking when she sees her bottle while working at her desk. A more comprehensive explanation is that reward-driven behaviour is the default (see De Houwer, 2019a) and therefore, a range of external and internal influences are needed for Matilda's highly habitual drinking to occur (Hommel, 2021; Kruglanski & Szumowska, 2020; Papies et al., 2022).

If Matilda's water drinking were conceptualised as being in the process of habit formation, this would allow various influences to regulate this behaviour (Verplanken & Orbell, 2022; Wood et al., 2022). Indeed, habit formation seems to account for many of the potential influences of water drinking (Phillips & Mullan, 2022; Verplanken & Orbell, 2022; Wood et al., 2022). Therefore, it could be an informative perspective for understanding and changing water drinking behaviour. However, habit formation assumes that an S-R habit response will eventually develop, and influences other than the external stimulus will not regulate its maintenance (Fontanet et al., 2021; Wood et al., 2022). These assumptions potentially limit the use of habit formation to understand water drinking and maintain established water drinking behaviour, as previous research has questioned whether the extensive overtraining involved in forming S-R habits is replicable in real-life settings (Kruglanski & Szumowska, 2020). For example, Matilda's highly habitual water drinking in the morning still seemed to be regulated by reward (i.e., quenching thirst), even though she has been doing this for years, which should be long enough for this behaviour to develop into an S-R habit response.

Finally, S-R habit research mainly focuses on simplified behaviours in highly controlled experimental settings (Kruglanski & Szumowska, 2020; Marien et al., 2019). Therefore, this theory may not generalise to higher-order behaviours in real-word settings (Marien et al., 2019; Verplanken & Orbell, 2022), such as those requiring preparation in changing external circumstances. Additionally, S-R habit research in real-world settings relies on continuous self-report measures of habit (Gardner et al., 2012; Verplanken & Orbell, 2003), which do not align with this theory's dichotomous distinction between S-R habits and goal-driven behaviour. This distinction may also not be appropriate (De Houwer, 2019b;

Hommel, 2021; Hommel & Wiers, 2017; Kopetz et al., 2018), as there is both empirical and theoretical evidence that habitual and goal-driven behaviour could result from the same underlying mechanisms, namely associations in memory that contain information regarding features of the situation, behaviour *and* rewarding outcomes (De Houwer, 2019b; De Houwer et al., 2022; Kopetz et al., 2018; Kruglanski & Szumowska, 2020). Finally, research using these continuous habit measures suggests that habitualness *and* other influences may regulate behaviour (Phillips & Mullan, 2022). For example, habitualness *and* reward (e.g., the experience of reducing fatigue) predict coffee drinking (Mazar & Wood, 2022).

#### *5.4.2.2 Can Grounded Cognition Theory Account for Matilda's Water Drinking?*

It may be more useful to conceptualise water drinking as stimulus-driven to some degree while also being influenced by other external and internal influences. Grounded cognition theory assumes that internal and external influences are part of the learned associations in memory (i.e., situated conceptualisation) that guide even highly habitual behaviour (Hommel, 2021; Papies et al., 2022). As such, any of these features can initiate water drinking, meaning water drinking behaviour can occur in response to external influences while also being regulated by internal influences (Papies et al., 2022). This theory also predicts that individuals' water drinking behaviour varies between different situations *and* within the same situation (Barsalou, 2020; Papies et al., 2022).

For example, Matilda would drink water at her desk at university when internal (e.g., dry mouth), external (e.g., her water bottle), or sets of both internal and external influences activate her situated conceptualisation of drinking water. This would lead to rewarding simulations of water drinking and in turn, the performance of drinking behaviour (Papies, 2020; Papies et al., 2022). As Matilda has repeatedly performed this behaviour at university, her situated conceptualisation of drinking in this situation is likely deeply encoded (Barsalou, 2020). Consequently, her drinking would exhibit features of habitualness (Barsalou, 2020; Papies et al., 2022). Still, Matilda would not drink water, even in the presence of relevant external influences (e.g., her water bottle), if the best matching situated conceptualisation activated (e.g., by an email notification) did not relate to water drinking behaviour (e.g., responding to an email) (Papies, 2020; Papies et al., 2020, 2022). Similarly, she would not drink water when simulations

of other drinks or activities are more rewarding (e.g., she prefers to drink orange juice when she is hungover) (Papies, 2020; Papies et al., 2020, 2022).

Matilda's highly situation-dependent water drinking does not seem to be accounted for by a simple S-R habit theory account. Instead, the emerging research suggests that the learned associations that guide water drinking likely contain information on the situational context in which a behaviour is performed (i.e., both external and internal influences), the behaviour itself (i.e., motor or mental actions involved in remembering, preparing and drinking), *and* its outcomes (Trofimova, 2022). Grounded cognition theory accounts for this, allowing external stimuli and other external and internal influences to regulate even highly habitual water drinking behaviour.

Grounded cognition theory's conceptualisation of water drinking seems to have utility in accounting for most of water drinking's potentially relevant influences, but it also has theoretical and empirical problems. Specifically, proponents of S-R habit theory have noted that claiming all behaviour is goal-driven to some degree (e.g., claiming water drinking is always partially influenced by thirst, reward, or self-relevance) is not falsifiable (see Wood et al., 2022). However, De Houwer et al., (2022) have noted that this criticism does not provide sufficient grounds for dismissing goal-driven theories of behaviour for the following reasons: (1) The assumption that behaviour can be goal-driven is well evidenced and accepted within psychology. Therefore, the burden of proof remains with those trying to evidence that behaviour is driven by S-R habit associations, as current evidence has substantial limitations (e.g., proxy measures for S-R habits typically lack validity). (2) While the goal-driven perspective may be unfalsifiable in theory, it can be falsified (or accepted as falsified) in practice by evidencing that a *comprehensive* set of relevant goals does not drive a specific behaviour. However, S-R habit theory research typically only falsifies one relevant goal, while ignoring alternative goal-driven explanations.

Overall, this discussion illustrates that comprehensive theories of behaviour are likely more useful in accounting for the complex interplay of influences that underly water drinking behaviour in daily life. Specifically, theories that can account for the empirical research on water drinking so far suggesting the following:

1. External and internal influences underly habitual water drinking,
2. The contexts in which water drinking is performed, and the performance of water drinking itself are highly variable and complex, and
3. Various contextual (internal and external), behaviour, and outcome constructs seem to influence water drinking rather than solely external stimuli or reward.

This discussion aligns with a growing literature advocating that S-R habit theory currently provides a limited framework for understanding and changing behaviour in real-world settings (De Houwer, 2019b; De Houwer et al., 2022; Du et al., 2022; Hommel, 2021; Hommel & Wiers, 2017; Kruglanski & Szumowska, 2020; Papies et al., 2022; Trofimova, 2022). This recommendation is also important as researchers' choice of guiding theory will substantially influence their research question, study design, and how they interpret and discuss their results. Therefore, researchers should carefully and explicitly consider the appropriateness of their selected theory; can it comprehensively explain water drinking behaviour in real-life settings?

### 5.4.3 Relevance to Other Consumption Behaviours

Water drinking differs from other consumption behaviours in some key ways. For example, water drinking is less complex than eating behaviour, as it takes relatively fewer steps to facilitate intake and time to engage in these steps than, say eating a plant-based meal. In addition, it is drunk in different situations and for other purposes than other drinks such as alcohol, which has different rewarding outcomes associated with it (e.g., relaxing, socialising) (Rodger, Vezevicius, et al., 2023). However, if research from other consumption domains indicated that influences similar to the constructs in our theoretical overview motivate these behaviours, water drinking research could also be used to inform research in wider consumption domains (Busse et al., 2017). Although a review of consumption behaviour research is outside the scope of this paper, we highlight examples of research from other consumption domains that indicate similar influences are evidenced in these domains.

First, our definition of water drinking aligns with research that highlights the importance of including preparation within conceptualisations of eating behaviour. For example, meal preparation (Wijayaratne et al., 2021) and

interventions targeting meal preparation (Fraser et al., 2022; Mendez et al., 2021) facilitate healthy eating. Additionally, the external influences we outline align with wider consumption behaviour research evidencing the influence of constructs such as availability and affordability. For example, adolescents' unhealthy snacking at home depended on what was available (i.e., what their parents bought for them) (Gangrade et al., 2022). Maintaining transitions to sustainable diets was hindered by the cost of buying vegan food (Williams et al., 2023). Finally, the internal influences we outline align with wider consumption behaviour research, evidencing the influence of constructs such as habitualness, reward, and self-relevance. For example, habitualness is associated with the consumption of coffee (Mazar & Wood, 2022), soft drink (Kulbida et al., 2022), and alcohol (Albery & Spada, 2021; Cooke et al., 2021) (Werner et al., 2022), as well as fruit and vegetable intake (Craveiro et al., 2021), snacking (Rose et al., 2022), and young adults' diet quality (Baldwin et al., 2022). Reward motivates unhealthy snacking behaviours (Rose et al., 2022) and aids transitions to sustainable diets, specifically forming habitual preparation behaviours (Wehbe et al., 2021). Finally, Self-identity is associated with habitual healthy eating (McCarthy et al., 2017; Ryan et al., 2022). For example, framing a healthy eating goal as a self-identity change, rather than a behavioural change, leads to healthier food choice (Dominick & Cole, 2020).

Therefore, our theoretical overview and its implications may also be relevant to other consumption behaviours. However, researchers should carefully consider the extent to which each influence or wider implication can be generalised to wider consumption domains.

### 5.5 Applied Implications

Developing a better theoretical understanding of water drinking behaviour can help inform applied research as comprehensive theory provides insights into what influence(s) the intervention should target and how best to target that influence, as we illustrate next.

Given the complex interplay of influences underlying water drinking, interventions that target one sole influence may not be effective. Regarding internal influences, a prime example is the potentially necessary but insufficient influence of knowledge. For example, for individuals who lack knowledge of the importance and benefits of hydration, education is likely a necessary intervention component to create

a motivation to drink water (Rodger, Vezevicius, et al., 2023). However, education is insufficient on its own as even motivated individuals report issues related to constructs such as complexity, lack of availability, lack of reward, and availability of preferred drinks, all which hinder them from drinking more water in daily life. Regarding external influences, a prime example of the limitations of targeting a sole influence is the impact of public disapproval towards policy and infrastructure plans to tackle low water security by using recycled wastewater as a drinking water source (Tortajada & van Rensburg, 2020). Although this recycled wastewater is objectively safe to drink as it is subjected to stricter regulations, public scepticism has seen many projects to introduce recycled wastewater as a source of tap water in local communities go unimplemented (Tortajada & van Rensburg, 2020).

Effective interventions will, therefore, likely need to take a complex intervention approach that targets multiple influences in a staged or tandem manner. Interventions may be considered complex in two ways: (1) because of certain properties the intervention has, such as the number of components, number of target behaviours, skills and expertise needed for delivery, and the flexibility of the intervention delivery, and (2) because it there unlikely a simple linear relationship between intervention components and their influence on behaviour change in the target context (i.e., complex mechanisms of change exist such as feedback loops). Skivington et al. (2021) provide an in-depth framework for complex intervention development and evaluation.

Going back to the education example, education likely needs to be done in tandem with other intervention activities that help individuals, for example, identify daily situations where it would be feasible to drink more (e.g., script elicitation; Mohideen et al., 2023), combat the competing influence of short-term reward associated with preferred alternatives (e.g., goal priming or health warning labels; Bauer et al., 2022; Miller et al., 2022; Papies, 2016), combat social norms for preferred alternatives (e.g., peer influence; Smit et al., 2016), or promote the repeated performance of lower-order behaviours that facilitate drinking (e.g., reminders; Rodger et al., 2023). Regarding the wastewater example, this policy and infrastructure change likely needs to come after concerted efforts to change public acceptance (e.g., public engagement & education; Tortajada & van Rensburg, 2020). In both examples, the interventions are complex because they have certain properties, such as multiple

components that target different influences (e.g., knowledge and reward) of different lower-order water drinking behaviours (e.g., remembering, preparing, drinking).

Additionally, it is likely that a combination of individual and system-level (e.g., policy change) intervention is needed to tackle inadequate water intake. A study of stakeholders' perspectives on increasing water intake across academia, government and education showed stakeholders' perceived system-level interventions (e.g., improving individuals' access to drinkable water via infrastructure changes, such as recycled wastewater) as more effective, indicating a shift in focus away from individual-level interventions (e.g., education; Vercammen et al., 2018). However, this dichotomous distinction that pits top-down system and bottom-up individual-level change against one another ignores the fact that individual actions are central to any system (Sniehotta et al., 2017). For example, regarding recycled wastewater, we illustrated that individuals have the agency to hinder top-down efforts. Water drinking research also shows individuals have the agency to ignore top-down efforts (e.g., public health communication) and perform behaviours that do not align with top-down changes. For example, implementing a sugar tax in Mexico did not effectively combat constriction workers' deep-seated social norms that drove their preference for sugar-sweetened beverages over water (Álvarez-Sánchez et al., 2022).

Therefore, a complex intervention approach to water drinking that acknowledges that water drinking is performed within a system is likely the most effective approach moving forward. This is because a system acknowledges that behaviour is dynamically influenced by a myriad of interconnected components (e.g., individuals, immediate external environments, policy, etc) is likely the most effective approach moving forward. This approach embraces complexity by accepting that a system can never be fully mapped or predicted, but there are research methods allowing researchers to assess why the system produces certain behavioural tendencies and how it may be changed to produce more desirable behavioural tendencies, such as adequate water intake (McGill et al., 2021; Sniehotta et al., 2017). This aligns with recommendations from research in other domains, such as health and sustainable behaviour (Jarman et al., 2022; Papies et al., 2023). For example, a recent systematic review of influences underlying adolescent dietary intake concluded that applying systems thinking to understand and change this behaviour was a crucial next step to improve upon the study's social-ecological modelling perspective (Jarman et al., 2022). The authors advocated that systems thinking (a perspective within the complex

intervention approach) and its associated methods would allow researchers to explore complex and dynamic relationships between consumption behaviour and its various influences across various levels. McGill et al (2021) provide an overview of key concepts involved in systems thinking and a systematic review of the different research methods used to assess complex interventions in the public health domain.

### 5.6 Strengths, Limitations and Future Directions

A strength of this paper is that it is foregrounded by current best practice recommendations on theory development from the wider psychology research methodology literature. As such, our theoretical overview was informed by diverse methods providing rich insights into describing and understanding how water drinking occurs in naturalistic settings. It is not hindered by the various limitations of overreliance on experimental research that typically dominates psychology and impedes the development of comprehensive theories of behaviour (Diener et al., 2022; Scheel et al., 2020). Drawing on varied research methods will likely create the richest understanding of water drinking and broader consumption behaviours (Barsalou, 2019). For example, cross-sectional research showing a positive association between a specific influence (e.g., thirst) and water drinking was informative for establishing the relationship between water drinking and its potential influences. However, other more in-depth methods, such as qualitative interviews, were able to establish when and for whom this influence leads to water drinking throughout the day (i.e., boundary conditions; Busse et al., 2017). Finally, we note our and others' critiques of experimental hypothesis-driven research are not advocating for the discontinuation of this method, merely a more balanced and appropriate use (Diener et al., 2022; Scheel et al., 2020). This recommendation is important as water drinking is an emerging domain, likely in the early stages of theory development, which benefits from exploratory rather than hypothesis-driven research methods.

Another strength of this paper is that it is informed by water-drinking research in various contexts on various groups (see Appendix A), meaning the influences and implications we covered have the capacity to transfer across these dimensions (i.e., transferability; Korstjens & Moser, 2018). However, it is essential to carefully consider the relevance of these influences and how they emerge across these dimensions. For example, water availability might be conceptualised differently in a school compared to an office context as researchers have to contend with adults (e.g., teachers) having control over adolescents' water availability, unlike with office workers. Water

availability is likely important in both cases, but there will be context and participant-specific considerations regarding this influence. Researchers should use prior research and familiarity with their target context and participant groups to inform these considerations. Where this cannot be done, this likely indicates a need to better understand how those specific participants perform water drinking in that specific context. For example, researchers could use naturalistic observation or qualitative research to explore these gaps in knowledge (Bonetto et al., 2023; Scheel et al., 2020).

On the transferability of our theoretical overview and its implications, we caveat that the research we reviewed was predominantly Western, specifically situated within the UK and the US. This means further work must be done to consider how likely these insights will transfer to other cultural contexts. For example, Duan et al. (2022) conducted cross-sectional research on middle-aged and elderly residents' willingness to use water filters in rural Tengchong, China, where water quality is a concern. The authors noted that although their results showed similarities to Western countries, there were differences that could be partially accounted for by Chinese tradition. For example, older residents were less willing to use filters than middle-aged residents, partly due to their traditional life practices promoting other preparation behaviours such as boiling tap water. Researchers aiming to understand water drinking in this context or develop an intervention must consider our theoretical overview regarding Chinese traditions. For example, preparation behaviour, including filtering or boiling tap water, seems to be a key facilitator of healthy water intake in this context. However, interventions in this context may wish to promote one or the other depending on the residents' age group and how traditional their lifestyle is.

Another key limitation of this paper is that water-drinking research is relatively novel, so this literature is not yet comprehensive. Future research is *essential* to substantiate, challenge, and build on the influences and implications we have covered. However, we advocate that our paper is informative for this work as it establishes influences and their relationship to water drinking and broader theoretical considerations that researchers can use to inform their research. For example, access to other preferred drinks is a common barrier to water intake. However, more research is needed to establish the dynamics of drink choice when competing options exist. This is especially true in intervention contexts where the availability of other preferred drinks can hinder the effect of intervention components (i.e., implementation intentions) that do not address this issue (Rodger, Vezevicius, et al., 2023). Additionally, we highlight

examples of research on other consumption behaviours suggesting these behaviours may have similar influences as water drinking. To better substantiate whether the insights from this paper apply to these behaviours, researchers should consider this literature in more depth.

Another key issue researchers must contend with moving forward is measuring water drinking behaviour and its underlying influences. Measurement development is a key stage of theory development (Flake & Fried, 2020; Scheel et al., 2020). Regarding water drinking behaviour, nearly all the research we reviewed measured drinking and did not capture other lower-order components such as preparation. Specifically, this research relied on retrospective self-report measures, such as measures of typical daily intake or daily drinks diaries. These measures likely involved measurement error, as participants needed to estimate their intake. Many of these measurement approaches have also been validated for food, not fluid intake (Rogerson et al., 2023). To gain an accurate measure of intake, researchers could use more advanced technology, such as bottles that measure exact intake amounts (e.g., Pül Hydration's Smart Cap; www.pulhydration.com). However, access to this type of technology may not be feasible regarding cost or desirable given the research aims and design. Additionally, water bottles can act as an intervention tool, therefore, unless participants already had these bottles available in their daily life, providing them would potentially alter their water intake. Therefore, more research is needed to validate accessible water intake measures against an objective marker of fluid intake (Rogerson et al., 2023). Additionally, measures of important lower-order behaviours, such as preparation, must be developed and used in future research to better understand how lower-order behaviours facilitate intake.

Regarding measuring underlying influences, there is some initial research developing quantitative items for some of these influences (see Rodger, Barsalou, et al., 2023; Veilleux et al., 2020). However, more work must be done to develop and validate more comprehensive measures. Flake & Fried (2020) present a framework to help researchers establish valid measurements and avoid common questionable measurement practices within psychology. Additionally, more work should be done to consider when these measures should be taken, especially given how variable these influences are across different daily situations. In the wider field of psychology, there is an uptake in the advocation and use of methods that allow researchers to account for this variability. Ecological Momentary Assessment (EMA) and the Situated

Assessment Method ($SAM^2$) have been used in the domain of eating and drinking to better understand what influences these behaviours through the day, and how these influences fluctuate across different individuals and situations over time (Dutriaux et al., 2023; Perski et al., 2022). Specifically, an EMA study on eating motives showed that typical motive ratings overestimated actual in-the-moment motives (Wahl et al., 2020). Therefore, water drinking research will likely benefit from using newer measurement approaches in tandem with more traditional methods.

Finally, as previously discussed, we advocate future researcher should use a complex intervention approach to guide their research and intervention development. An overview of this approach and methods is outside the scope of this paper. However, we provide an example of research that could be done using this approach, as illustrated by other domains. For example, a useful first step in this approach is to map out the system in which a behaviour occurs, considering who and what is part of that system and how they interact. These maps can be developed based on prior literature and co-production with relevant stakeholders (Cavill et al., 2020; Waterlander et al., 2021). They can also inform many lines of inquiry, including but not limited to identifying opportunities to change the system, stakeholders needed to effect change in the system, the best means of changing the system, and the type of data that should be collected to evaluate changes within the system (Allender et al., 2019; Cavill et al., 2020; Moore et al., 2019). For example, Gerritsen et al. (2019) used this system mapping approach to co-produce an in-depth understanding of the systemic barriers to fruit and vegetable intake with members of a low-income community in New Zealand. From this mapping exercise, they established that fast-food availability and marketing needed to be reduced. However, community members struggled to determine how to do this, indicating a need for additional stakeholder involvement (e.g., policymakers). Regarding water drinking, researchers could work with a school community (e.g., students, teachers, and parents) to map out the underlying influences of water drinking behaviour in the school setting. This map could be used to identify a range of potentially effective intervention components that aim to facilitate water intake and the key stakeholders needed to make these feasible. For example, support from senior management may be needed for enacting policy and infrastructure changes (e.g., increasing water availability, decreasing availability of other drinks, and improving toilet facilities), and advocacy from parents and students that these changes are desirable may facilitate senior management's support.

We note a key improvement that may need to be made to a systems thinking approach moving forward is integrating individual psychological theories of behaviour into this perspective (e.g., how do individuals perceive different systems features and how does impact the features influence on their behaviour).

## 5.7 Conclusion

The purpose of this paper was not to cement a theory of water drinking but to provide a snapshot of our current understanding of this behaviour. Water drinking is a relatively new and emerging research domain, so we cannot conclude with certainty which constructs and theories are relevant for understanding and changing water drinking. However, this research's in-depth insights into the core influences of this behaviour informed our theoretical overview regarding which constructs and theories should be considered when designing theoretical and intervention-focused water drinking research. Specifically, conceptualising water drinking as a simple behaviour does not align with people's lived experience and will likely impede research in this domain. Water drinking conceptualisations should instead account for the complexity of water drinking regarding the lower-order behaviours, relative time, and subjective effort underlying water intake. Additionally, given the complex interplay of external and internal influences underlying water drinking, researchers should use comprehensive theories of behaviour to guide their research.

We hope this work can be used to inform further research building on this understanding of water drinking by challenging, supporting, or adding to our theoretical overview. We also hope this work can be used to inform more effective water drinking interventions. Finally, we hope researchers in other domains can learn from the case of water drinking behaviour and apply relevant insights to their research. As such, we leave readers with the following questions:

1. Are you accounting for the complexity of performing the target consumption behaviour in daily life?
2. Are you using theoretical frameworks that comprehensively account for the complex interplay of influences that likely underlie your target consumption behaviour in daily life?

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