



# Increased consumption despite fewer occasions: A longitudinal analysis of COVID-19 lockdown effects on soft drink consumption in England

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## ABSTRACT

We examined the impact of a COVID-19 lockdown in England on the frequency of consumption occasions and amount of soft drinks consumed. Beverage consumption is strongly associated with specific, often social, consumption situations (e.g., going out). We reasoned that lockdown would affect consumption behaviour because it removed typical soft drink consumption situations. Specifically, we hypothesised that soft drink consumption occasions and amount would be reduced during lockdown compared to before and after lockdown, especially in typical soft drink consumption situations. In two surveys (Dec. 2020 and May 2021) among the same participants ( $N = 211$ ,  $N = 160$ ; consuming soft drinks at least once/week), we assessed the frequency of soft drink and water consumption occasions before, during, and after the Nov./Dec. 2020 lockdown, across typical soft drink and water drinking situations. This presents a detailed picture of the situations in which participants drink soft drinks and water, and how this was affected by a lockdown. We also assessed the daily amount of soft drinks and water consumed in each period, and perceived habitualness of drinking soft drinks and water. As predicted, participants reported fewer occasions of drinking soft drinks during lockdown compared to before and after, especially in typical soft drink consumption situations. Unexpectedly, however, the daily amount of soft drinks consumed increased during lockdown, compared to before and after, especially among participants with stronger perceived habitualness of soft drink consumption. Exploratory analyses suggest that during lockdown, participants increased their soft drink consumption at home. Water consumption, on the other hand, was not systematically affected by the lockdown. These findings suggest that even if some typical consumption situations disappear, consumption may be hard to disrupt if the behaviour is rewarding.

## 1. Introduction

The consumption of soft drinks contributes to excess sugar intake and can lead to various health issues, such as diabetes (Imamura et al., 2015), dental caries (Moynihan & Kelly, 2014), and cardiovascular disease (Xi et al., 2015). It is therefore important to understand soft drink consumption in real-world settings and its underlying psychological processes, to inform the development of theories and effective interventions (Bringmann et al., 2022; Diener et al., 2002; Scheel et al., 2021). Previous research has shown that the consumption of soft drinks, like other beverages, is heavily tied to specific consumption situations (Papies et al., 2021; Rodger et al., 2021). Here, we examined how soft drink consumption was affected by a COVID-19 lockdown, which virtually removed some of the typical soft drink consumption situations

from citizens' daily lives (McNaughton et al., 2020). Examining shifts in soft drink consumption during a COVID-19 lockdown allows us to map and understand the behaviour of soft drink consumption in more detail, which has implications for informing behaviour change efforts.

Many consumption behaviours are heavily influenced by external situations. People think about foods and drinks in terms of typical consumption situations ('breakfast foods', 'with friends'; Keesman et al., 2018; Ross & Murphy, 1999), matching situations make foods more attractive (Papies, van Stekelenburg et al., 2022), and thinking about one's typical eating situations can increase cravings for a food (Kavanagh et al., 2005; Tatar et al., 2021). From a grounded cognition perspective on motivated behaviour (Papies et al., 2022; Papies et al., 2020; Papies & Barsalou, 2015), this can be understood as the result of rich, multimodal memory representations (so-called "situated

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conceptualizations”) learned during previous consumption experiences. Every time a food or drink is consumed, a memory representation of this experience is formed or updated, which includes for example information on the internal and external situation (e.g., feeling states, time, physical location), the actions performed (e.g., picking up a food or drink, chewing), sensory experiences (e.g., the taste, texture, temperature of the food or drink), and the immediate effects of consumption (e.g., feeling enjoyment, fullness, social connectedness). When one later encounters a feature of a consumption situation, a simulation, or re-experience, of other aspects of the multimodal representation can be triggered – including a simulation of the behaviour. In the domain of soft drinks, for example, this would mean that certain situations (e.g., feeling bored, being at a party) can trigger simulations of drinking soft drinks, along with possible consequences (e.g., enjoying the sweet and fizzy sensation). These simulations can then lead to that behaviour being performed, especially when the behaviour serves a current goal or is otherwise rewarding (see also Dutriaux et al., 2021; Kruglanski & Szumowska, 2020).

Previous research has shown that soft drink consumption situations are heavily social and often occur outside of the home (at the pub, in a restaurant, at a party, with friends; Keesman et al., 2018; McNaughton et al., 2020; Papies et al., 2021; Werner et al., 2022). We reasoned that because COVID-19 lockdowns led to the closure of pubs and restaurants and prohibited social gatherings, the situations leading to soft drink consumption would be encountered less often, reducing soft drink intake during a lockdown. This finding would be notable, because COVID-19 lockdowns have been associated with unhealthy dietary patterns in other studies (e.g., Buckland et al., 2021; Robinson et al., 2021). Here, we examined this issue in the context of a COVID-19 lockdown in England. We suggest that studying how a behaviour changes in response to external context shifts can increase the scientific understanding of the behaviour in natural settings, which will benefit theory formation and ultimately, public health interventions.

### 1.1. The current study

We investigated the effect of the November/December 2020 lockdown in England on soft drink consumption. Since soft drinks are often consumed in social situations which were restricted during lockdown, we predicted that people would experience fewer soft drink consumption occasions and would drink fewer soft drinks during than before and after lockdown.

We realise that for many people, soft drink consumption may be highly habitual, such that it occurs frequently and without much conscious deliberation and effort (De Houwer et al., 2022; Papies et al., 2022; Verplanken & Orbell, 2003). Research has shown that strongly habitual behaviour can become part of one’s self-identity, for example the identity of a “real water drinker” or a “healthy eater” (McCarthy et al., 2017; Rodger & Papies, 2022). In such cases, performing the habitual behaviour is less dependent on external triggers. In line with this, the frequently used self-report habit index (SRHI; Verplanken & Orbell, 2003) measures habitualness of a behaviour through its perceived automaticity and integration into one’s identity, rather than by referencing how consistently a behaviour occurs in a specific situation. Hence, shifts in the external context would be less likely to affect a strongly habitual behaviour. To address this possibility, we measured participants’ perceived habitualness of drinking soft drinks with the SRHI and assessed whether this moderated the effect of the lockdown on consumption.

An online survey was sent out during the lockdown (December 1, 2020) to assess soft drink consumption behaviours pre-lockdown (Time 1) and during lockdown (Time 2). We asked respondents to report the frequency of soft drink consumption occasions, as well as the daily amount of soft drinks consumed. We assessed water consumption in the same way, with results presented in the Supplementary Online Materials (SOM). Participants who had completed Survey 1 were sent a second

survey in May 2021 (from the 11th to the 25th of May), to examine post-lockdown (Time 3) consumption levels after the situations previously banned had been reinstated.

### 1.2. Hypotheses

**Survey 1.** We hypothesised that both the frequency of soft drink consumption occasions and daily soft drink consumption amount would be reduced during lockdown (Time 2) compared to pre-lockdown (Time 1; H1.1). Because those with high habitualness of soft drink consumption might drink soft drinks as part of their identity and less in response to external situations, we also predicted that the effect of lockdown would be weaker among participants with higher habitualness of soft drink consumption (moderation, H1.2). In addition, we predicted that frequency of soft drink consumption occasions specifically in 5 typical soft drink situations would be lower during than before lockdown (H1.3).

We further hypothesised an indirect (mediation) effect: lockdown would affect soft drink consumption amount through frequency of consumption occasions across 5 typical soft drink situations (H2). In other words, we expected that the amount of soft drinks consumed would be lower during lockdown because consumption occasions were reduced.

Concerning water, we hypothesised that water drinking habitualness, frequency of water consumption occasions, and daily amount of water consumed, would correlate with lighter urine colour, an objective, self-report indicator of hydration status (H3).

**Survey 2.** Hypotheses for Survey 2 were developed and pre-registered after the analysis of Survey 1. We predicted that the frequency of soft drink drinking occasions would increase again post-lockdown compared to during lockdown (H4.1), and that this effect would be stronger in 5 typical soft drink situations (H4.2).

The findings from Survey 1 showed that soft drink consumption amount increased, partially due to a higher frequency of consumption at home during lockdown. Hence, we predicted that soft drink consumption at home would remain the same post-lockdown compared to during lockdown (H5) due to participants now increasingly associating this situation to the consumption of soft drinks compared to pre-lockdown. We also hypothesised that soft drink consumption amount would be higher post-lockdown compared to during lockdown (H6.1), and that this effect would be stronger for those with higher habitualness of soft drink consumption (as measured in Survey 1; moderation, H6.2) because they also increased their consumption most during compared to pre-lockdown.

Furthermore, we again predicted an indirect (mediation) effect: Lockdown would increase soft drink consumption amount through an increase in the frequency of consumption occasions across 5 typical soft drink situations (H7).

Finally, we hypothesised that the increase in soft drink consumption amount from pre-lockdown to during lockdown (as measured in Survey 1) would be stronger for those with stronger hedonic drinking motives (moderation, H8).

The two surveys were pre-registered sequentially on the Open Science Framework, where all materials, data, and analysis scripts can be accessed ([https://osf.io/myb64/?view\\_only=f66607f100054ca28891fd6c82f276c3](https://osf.io/myb64/?view_only=f66607f100054ca28891fd6c82f276c3)).

## 2. Method

### 2.1. Participants

As no related previous research was available, we could not perform an *a priori* power analysis. However, with a within-subjects design we estimated that about 200 participants should provide sufficient power to detect an effect of lockdown on drinking occasions and amount. Participants were recruited through Prolific (<https://www.prolific.co>),

which resulted in a final sample of  $N = 211$  participants who completed the full survey (59% female, 40% male, 1% non-binary or other) for Time 1 and 2 (Survey 1). Inclusion criteria were being aged between 18 and 70 ( $M = 35.7$ ,  $SD = 11.0$  at Time 1 and 2), living in England, not being on a restrictive diet, and not having diabetes or allergies to any food or drink products. All participants successfully completed the two attention checks. Seventy-six percent of the original sample completed the second survey post-lockdown, leading to a sample of  $N = 160$  (57% female, 42% male and 1% non-binary or other) with a mean age of 37.4 ( $SD = 11.0$ ) for Time 3 (Survey 2). These participants did not differ significantly in terms of pre-lockdown soft drink consumption occasions and amount from the participants who dropped out (all  $p$ 's  $> .203$ ). The sample size was deemed sufficient to replicate the initial finding of the impact of lockdown on soft drink consumption occasions (see SOM).

## 2.2. Design

The design was a within-participants 3 (Time: pre-lockdown vs. during lockdown vs. post-lockdown)  $\times$  2 (Drink Type: soft drink vs. water) design. The dependent variables were frequency of consumption occasions and daily amount consumed. In Survey 1, participants rated these variables per drink type pre-lockdown and during lockdown (Time 1 and 2). In Survey 2, they rated the same variables post-lockdown (Time 3). Whether they first rated soft drink or water consumption was counterbalanced across participants.

## 2.3. Measures and procedure

### 2.3.1. Time 1 and 2 (survey 1)

**Frequency of consumption occasions.** Participants were asked how often they drank soft drinks and water in a number of situations. These situations were selected based on a previous study ( $N = 204$ ) where participants had been asked to list situations in which they typically drink soft drinks and water (Papies et al., 2021). The five most frequently mentioned situations for each drink type were chosen to create the ten situations for the current study, namely for soft drink consumption: on a day out, at home, at a party or when out with friends, on a holiday or when traveling, when eating out (including fast food). The situations for water consumption were: when out and about or shopping, with a meal, before bed or when waking up, at work, during or after exercise.

Frequency of soft drink consumption occasions pre-lockdown (Time 1) was measured by asking participants "First, please think carefully about your life before lockdown. For example, try to think of a typical week before lockdown. How often did this occur before the current lockdown?" Participants were then presented with the behaviour of having a soft drink in each of the ten situations: "I have a soft drink ... [situation]". (Cronbach's  $\alpha$  across the situations was 0.79). The frequency of drinking occasions during lockdown (Time 2) was measured by asking participants "Now, please think carefully about your life during lockdown. For example, try to think of a typical week during lockdown. How often does this occur during the current lockdown?" Again, the ten situations were presented ( $\alpha = 0.77$ ). Participants responded on a 0–100 VAS scale (0 = *never*, 50 = *sometimes*, 100 = *very often*). We specified that soft drinks included all non-alcoholic sugar-sweetened drinks (such as Regular Coca Cola, Fanta, Ginger Beer, Squash/Cordial, Lemonade), except for Diet drinks (e.g., Diet Coke), fruit juice, and sports and energy drinks, and that water included still and sparkling tap and bottled water.

**Amount consumed.** Participants were asked to report the total number of glasses of soft drinks and water they consumed on a typical day (ranging from 0 to 20 glasses) pre-lockdown (Time 1) and during lockdown (Time 2).

**Perceived habitualness.** Habitualness of drinking behaviour was measured through the 12-item self-report habit index (SRHI; Verplanken & Orbell, 2003) adapted for soft drinks and water. Participants answered

statements such as "Drinking soft drinks is something I start doing before I realise I'm doing it", on a 5-point Likert scale (1 = *strongly disagree*, 5 = *strongly agree*;  $\alpha = 0.94$  for soft drinks).

**Additional control measures.** We also included a measure to assess consumption frequency in an unsituated manner by asking participants about their frequency of consuming soft drinks and water regardless of the lockdown on a 0–100 VAS scale (anchors 0 = *never*, 50 = *sometimes*, 100 = *very often*). In addition, we measured participants' intentions to (1) increase their water consumption, (2) decrease their soft drink consumption, and (3) drink more water instead of soft drinks (0–100 VAS with anchors 0 = *strongly disagree*, 50 = *neither agree nor disagree*, 100 = *strongly agree*;  $\alpha = 0.81$ ). They were also presented with open-ended questions to assess whether they thought their drinking behaviour had changed due to lockdown.

Lastly, participants answered demographic questions including age, gender, and height and weight (from which we calculated Body Mass Index) and their hydration level was assessed with self-reported urine colour (Perrier et al., 2016). Urine colour has been recommended as a tool to monitor hydration by the general public (Perrier et al., 2021), and hence seemed appropriate as an approximation of hydration status in the context of this study.

### 2.3.2. Time 3 (survey 2)

**Main measures.** Participants answered the same consumption measures as in Survey 1. To assess post-lockdown frequency of consumption occasions (Time 3), participants were asked "Please think carefully about your life right now. For example, try to think of a typical week right now. How often does each of these situations occur?" ( $\alpha = 0.84$  for soft drinks).

In addition, participants were asked to rate their reasons for drinking soft drinks on a 0–100 VAS scale (anchors 0 = *not at all*, 100 = *completely*). This scale was created based on 5 hedonic drinking reasons (taste, energy, as a treat, boredom, bored of other drinks;  $\alpha = 0.57$ ) drawn from two previous studies in which we assessed general reasons for soft drink consumption (Papies et al., 2021), as well as the answers to the open-ended questions in Survey 1.

**Additional measures.** As additional control measures, participants indicated their employment status during the lockdown period assessed in Survey 1, how many days a week they spent at home in a typical lockdown week, two items on food security (e.g., "I was unable to obtain sufficient, nutritious, or personally acceptable foods") and three on stockpiling (e.g., "I would buy more products than I normally need for a week"), measured on a 0–100 VAS scale (0 = *never*, 50 = *sometimes*, 100 = *all the time*). Participants were also asked to report their highest education qualification and perceived wealth. We also assessed whether they shielded (i.e., stayed at home for health reasons) during lockdown and if so, whether they were still shielding at the moment of the survey completion (Yes-No questions). Findings regarding these measures are presented in the SOM. Lastly, participants were again asked about their intentions, hydration status and demographic information.

## 2.4. Data analysis procedure

Hypotheses, method and analytic plan were specified prior to data collection. In the reporting of the results, we clearly distinguish between confirmatory and exploratory analyses. Data analysis was conducted in R (<https://www.r-project.org/>, V.3.6). We conducted linear mixed effects regression analyses to account for variance across participants and situations by adding random intercepts and slopes for participants and/or situations, as suggested by Barr et al. (2013).  $P$ -values were obtained through Satterthwaite approximation with the 'lmerTest' package (Kuznetsova et al., 2017). Pseudo  $R$ -squared for Generalized Mixed-Effects models were calculated with the 'MuMIn' package (Bartoń, 2022). Simple slopes analyses were carried out using the 'interactions' package (Long, 2021) and effects plots were plotted using the 'effects' package (Fox & Weisberg, 2019). Furthermore, our mediation

analyses were tested using the ‘mediate’ package (Tingley et al., 2014) and correlations were assessed with Spearman’s rho ( $r_s$ ). We controlled for multiple tests by adjusting alpha levels, tested the influence of covariates (gender, age, BMI, counterbalancing block), and report these results in the text where relevant (see SOM).

2.5. Ethics statement

The research protocol was approved by the College of Science and Engineering Ethics Committee, University of Glasgow (application number: 300200055). All methods were carried out in accordance with relevant guidelines and regulations. Written informed consent was obtained from participants prior to participation.

3. Results

3.1. The effect of time on soft drink consumption

3.1.1. Time 1 and 2 (survey 1)

Results from Survey 1 showed that lockdown decreased the frequency of soft drink consumption occasions, but increased the amount consumed.

Specifically, in line with H1.1, we found that the average frequency of soft drink consumption occasions across all 10 situations decreased during lockdown (Time 2) compared to before lockdown (Time 1),  $b =$

**Table 1**  
The effect of time on soft drink consumption: model estimates and test statistics.

		Survey 1 (Time 1 and 2)		Survey 2 (Time 3)	
		Pre-lockdown vs. During lockdown		During lockdown vs. Post-lockdown	
		N = 211		N = 160	
Frequency of soft drink consumption occasions	10 situations	<i>b</i>	<b>-20.6</b> (5.89)	<b>13.9</b> (5.68)	
		(SE)			
		95% CI	-32.2, -9.10	2.76, 25.0	
		<i>t</i> ( <i>p</i> )	-3.50 (.005)	2.45 (.032)	
		AIC	39,960	30,384	
		$R_m^2$ $R_c^2$	0.08, 0.48	0.04, 0.47	
	5 typical soft drink situations	<i>b</i>	<b>-31.8</b> (8.73)	<b>24.1</b> (8.55)	
		(SE)			
		95% CI	-48.9, -14.6	7.34, 40.9	
		<i>t</i> ( <i>p</i> )	-3.64 (.014)	2.82 (.034)	
		AIC	20,000	15,222	
		$R_m^2$ $R_c^2$	0.19, 0.55	0.11, 0.54	
At home	<i>b</i>	<b>4.88</b> (1.82)	<b>-12.2</b> (2.50)		
	(SE)				
	95% CI	1.32, 8.44	-17.1, -7.35		
	<i>t</i> ( <i>p</i> )	2.69 (.008)	-4.90 (<.001)		
	AIC	3982	3064		
	$R_m^2$ $R_c^2$	0.01, 0.62	0.04, 0.48		
Daily soft drink consumption amount	<i>b</i>	<b>0.72</b> (0.14)	<b>-1.33</b> (0.23)		
	(SE)				
	95% CI	0.44, 0.99	-1.78, -0.87		
	<i>t</i> ( <i>p</i> )	5.17 (<.001)	-5.72 (<.001)		
	AIC	1895	1512		
	$R_m^2$ $R_c^2$	0.02, 0.74	0.06, 0.42		

Note.  $R_m^2$  (marginal) is variance explained by fixed effects and  $R_c^2$  (conditional) is variance explained by both fixed and random effects. Significant coefficients are presented in bold.

-20.6, see Table 1 and Fig. 1, left panel). And in line with H1.3, this effect was even stronger when only considering the average consumption frequency across the 5 specific soft drink situations, instead of all 10 possible situations ( $b = -31.8$ ).

However, contrary to H1.1, participants reported consuming a higher daily amount of soft drinks during lockdown than before lockdown,  $b = 0.72$ , amounting to an average increase of about 0.7 glasses of soft drinks per day (see Table 1 and Fig. 1, right panel).

3.1.2. Time 3 (survey 2)

Results from Survey 2 showed that the frequency of soft drink consumption occasions increased again after lockdown, but not when correcting for multiple testing. However, the frequency of consumption occasions at home decreased again after lockdown.

Specifically, in line with H4.1, the average frequency of soft drink consumption occasions increased post-lockdown compared to during lockdown,  $b = 13.9$ . This was also in line with H4.2, as this effect was even stronger in the 5 specific soft drink situations,  $b = 24.1$  (see Table 1). However, controlling for multiple tests, both these findings were no longer statistically significant. Looking at the CIs, we can conclude that consumption frequency increased but that the effect may be weaker or stronger (ranging from 7 to 41 on a 100-point scale; Johansson, 2011; Luke, 2017). In addition, while lockdown influenced consumption across situations and participants, a larger share of the variance in consumption occasions was explained by within-subject and within-situation variance (see SOM for additional analyses).

Contrary to our prediction (H5), the frequency of consumption occasions at home decreased post-lockdown compared to during lockdown,  $b = -12.2$ .

In addition, contrary to H6.1, participants reported consuming fewer glasses of soft drinks per day post-lockdown than during lockdown,  $b = -1.33$ , reflecting an average decrease of about 1.33 glasses (see Table 1 and Fig. 1).

In sum, the frequency of soft drink consumption occasions decreased during lockdown, while the daily amount consumed increased. After the lockdown, this pattern partly reversed again: consumption occasions slightly increased to almost pre-lockdown levels but with considerable uncertainty, while the daily amount consumed decreased again. However, consumption occasions at home decreased compared to during lockdown.

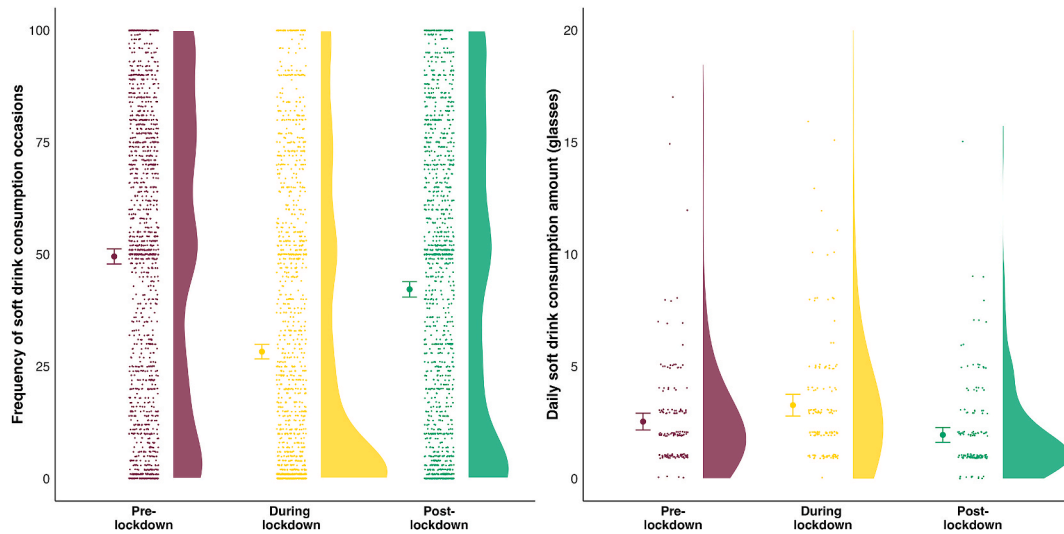
3.2. Moderation by perceived soft drink drinking habitualness

3.2.1. Time 1 and 2 (survey 1)

Results from Survey 1 showed that the increase in daily amount of soft drinks consumed was particularly pronounced among participants with high habitualness of soft drink consumption.

Specifically, perceived habitualness, as assessed by the SRHI, moderated the effect of time on daily consumption amount,  $b = 0.45$ . To investigate the nature of the interaction, we explored the effect of time on daily soft drink consumption amount for those with low (-1SD), average (M) and high (+1SD) habitualness (see Table 2 and Fig. 2). Simple slope analysis showed that participants with high habitualness increased their soft drink consumption by 1.18 glasses per day during lockdown compared to pre-lockdown and participants with average habitualness increased their intake by 0.73 glasses per day. On the contrary, participants with low habitualness did not significantly change their daily soft drink consumption amount,  $b = 0.28$ . Thus, contrary to our prediction (H1.2), participants with high habitualness of soft drink consumption increased their consumption during lockdown, and more so than participants with weaker habits.

Perceived habitualness of soft drink consumption did not moderate the effect of time on frequency of soft drink consumption occasions,  $b = -1.17$ , not even when exploring this effect considering only the average consumption frequency across 5 specific soft drink situations,  $b = -1.87$ ,  $p = .232$ .



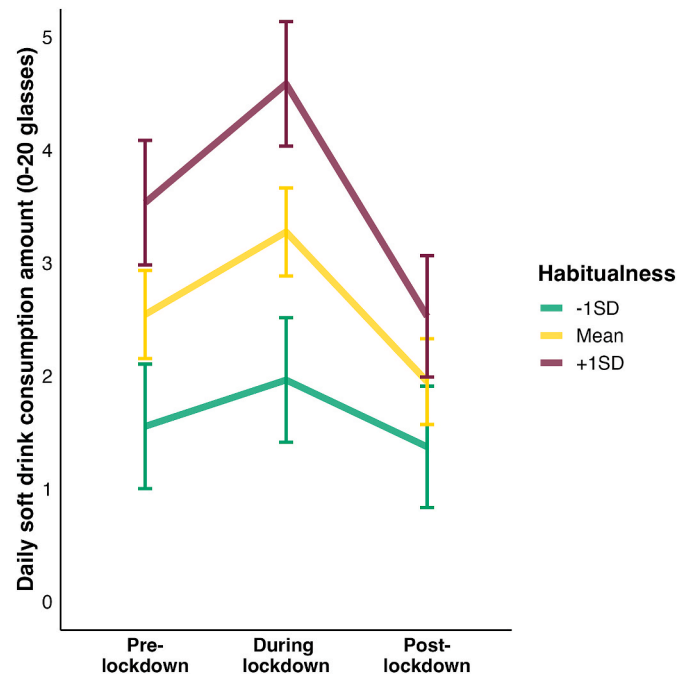
**Fig. 1.** Frequency of soft drink consumption occasions across all 10 situations (left panel); daily amount of soft drinks consumed (right panel) pre-, during and post-lockdown.

*Note.* Points represent raw observations, density plots represent the distribution, large points and error bars represent the means and 95% confidence intervals.

**Table 2**  
Moderation by perceived soft drink drinking habitualness: model estimates and test statistics.

		Survey 1 (Time 1 and 2)		Survey 2 (Time 3)	
		Pre-lockdown vs. During lockdown		During lockdown vs. Post-lockdown	
		N = 211		N = 160	
<b>Frequency of soft drink consumption occasions</b>	Time × soft drink habitualness	<i>b</i> (SE)	-1.17 (1.13)	-1.53	
		95% CI	-3.39, 1.05	-4.61, 1.54	
		<i>t</i> ( <i>p</i> )	-1.03 (.304)	-0.99 (.329)	
		AIC	39,702	30,358	
		$R_m^2$ , $R_c^2$	0.14, 0.49	0.07, 0.47	
<b>Daily soft drink consumption amount</b>	Time × soft drink habitualness	<i>b</i> (SE)	<b>0.45</b> (0.14)	-0.73 (0.22)	
		95% CI	0.19, 0.72	-1.17, -0.29	
		<i>t</i> ( <i>p</i> )	3.34 (<.001)	-3.27 (.001)	
		AIC	1822	1474	
		$R_m^2$ , $R_c^2$	0.22, 0.75	0.20, 0.46	
Simple slopes of soft drink habitualness					
Low (-1SD)	<i>b</i> (SE)	0.28 (0.19)	-0.59 (0.32)		
	<i>t</i> ( <i>p</i> )	1.45 (.150)	-1.86 (.060)		
Average (M)	<i>b</i> (SE)	<b>0.73</b> (0.13)	-1.32 (0.22)		
	<i>t</i> ( <i>p</i> )	5.40 (<.001)	-5.91 (<.001)		
High (+1SD)	<i>b</i> (SE)	<b>1.18</b> (0.19)	-2.06 (0.32)		
	<i>t</i> ( <i>p</i> )	6.18 (<.001)	-6.49 (<.001)		

*Note.*  $R_m^2$  (marginal) is variance explained by fixed effects and  $R_c^2$  (conditional) is variance explained by both fixed and random effects.



**Fig. 2.** Effects plot showing predicted daily amount of soft drinks consumed (95% CI) for participants with low, average, and high perceived habitualness of soft drink consumption, pre-, during, and post-lockdown.

**3.2.2. Time 3 (survey 2)**

Results from Survey 2 showed that the decrease in amount consumed after lockdown ended was particularly pronounced among participants with strong habitualness of soft drink consumption.

Specifically, in line with H6.2, perceived habitualness of soft drink consumption (measured in Survey 1) moderated the effect of time on daily soft drink consumption amount,  $b = -0.73$ . Simple effects analysis showed that participants with high (+1 SD) habitualness had the largest decrease in daily soft drink consumption, namely by 2.06 glasses, followed by those with average (M) habitualness who reduced their intake by 1.32 glasses, and, lastly, those with low (-1 SD) habitualness whose intake was not significantly reduced,  $b = -0.59$  (see Table 2 and Fig. 2).

Thus, again, participants with high consumption habitualness changed their intake more compared to participants with average and low habitualness.

In sum, participants with higher habitualness of soft drink consumption increased their consumption amount during lockdown the most, and again decreased it the most after the end of the lockdown.

### 3.3. The mediating role of soft drink consumption at home

#### 3.3.1. Time 1 and 2 (survey 1)

Results from Survey 1 showed that the increase in daily amount of soft drinks consumed was driven by increased consumption frequency at home.

Specifically, as we did not find the expected decrease in daily amount consumed during lockdown compared to pre-lockdown, the pre-registered analysis (H2) examining whether daily consumption amount is mediated by the frequency of consumption occasions across the five typical soft drink situations, was not performed. Instead, we explored whether the increase in daily consumption amount could be explained by an increase in the amount consumed in a particular situation. Examining the effect of time on each of the ten drinking situations separately revealed only one situation for which frequency of consumption occasions increased, namely consumption at home ( $b = 4.88$ ,  $SE = 1.82$ ,  $p = .008$ , 95% CI [1.32, 8.44]; see Fig. 3 and SOM for analyses per situation). We ran a mediation analysis to explore whether the increase in the frequency of consumption at home explained the increase in daily consumption amount during lockdown.

Indeed, 18% of the effect of time on daily soft drink consumption was mediated by frequency of soft drink consumption at home (see Table 3). The direct effect remained significant which, together with the wide CIs, suggests that consumption at home only partially mediated the influence of time on consumption amount.

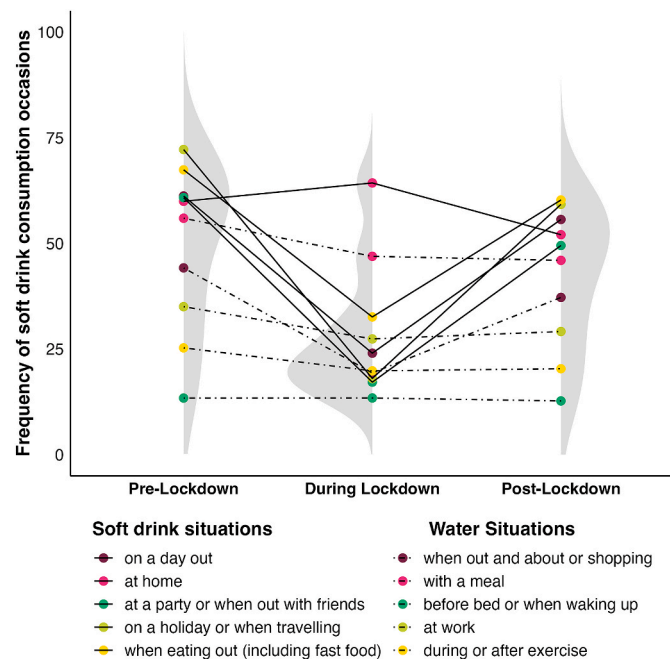


Fig. 3. Mean frequency ratings for drinking soft drinks in situations pre-, during, and post-lockdown.

Note. The density plots represent the distribution. Each average score for a situation is represented by a dot and connected by a line between the three time points. The straight lines represent 5 typical soft drink consumption situations, the dotted lines represent 5 typical water consumption situations. Please note that the frequency of consumption occasions of each drink type was assessed for all 10 situations.

Table 3

Consumption at home mediates the effect of time on daily soft drink consumption amount: model estimates and test statistics.

	Survey 1 (Time 1 and 2)		Survey 2 (Time 3)	
	Pre-lockdown vs. During lockdown		During lockdown vs. Post-lockdown	
	N = 211		N = 160	
	b (95% CI)	p	b (95% CI)	p
Total effect	0.71 (0.43, 0.98)	<.001	-1.32 (-1.80, -0.84)	<.001
Direct effect	0.58 (0.32, 0.85)	<.001	-0.88 (-1.32, -0.41)	<.001
Indirect effect	0.13 (0.03, 0.23)	.006	-0.45 (-0.68, -0.25)	<.001
Proportion mediated	0.18 (0.05, 0.33)	.006	0.34 (0.19, 0.55)	<.001

#### 3.3.2. Time 3 (survey 2)

Results from Survey 2 showed that the decrease in daily amount of soft drinks consumed after lockdown ended was driven by decreased consumption frequency at home.

Again, as we found a decrease in daily consumption amount but increase in overall frequency of consumption occasions post-lockdown, we could not test our pre-registered mediation analysis (H7). Examining the effect of time on each situation separately, we found that the only drinking situation whose frequency decreased significantly post-lockdown compared to during lockdown was again the situation "at home" ( $b = -12.2$ ,  $SE = 2.50$ ,  $p < .001$ , 95% CI [-17.1, -7.35]; see Fig. 3). Thus, we explored whether the decrease in frequency of consumption at home explained the decrease in daily consumption amount post-lockdown.

The decrease in daily soft drink consumption amount was mediated by a decrease in the frequency of soft drink consumption at home. More specifically, 34% of the relationship was explained by frequency of consumption at home but the significant direct effect suggests a partial mediation (see Table 3).

### 3.4. Moderation by hedonic drinking motives

We examined whether hedonic motives moderated the increase in daily soft drink consumption amount from pre-to during lockdown found at Time 1 and 2 (H8 for Survey 2 in which hedonic motives were measured). However, neither the main effect of hedonic motives ( $b = 0.01$ ,  $SE = 0.01$ ,  $p = .395$ , 95% CI [-0.01, 0.03]) nor the interaction with time ( $b = 0.01$ ,  $p = .339$ , 95% CI [-0.01, 0.03]) were significant. We should note that the reliability of the hedonic drinking motives scale was low ( $\alpha = 0.57$ ) which may have affected these results.

Exploratory analyses showed that hedonic motives correlated with higher perceived habitualness of soft drink consumption,  $r_s$  (158) = 0.23,  $p = .003$ .

### 3.5. Water drinking behaviour correlations with urine colour

Results from Surveys 1 and 2 showed that higher water consumption and lower soft drink consumption were associated with healthier urine colours.

Specifically, in line with our hypothesis in Survey 1 (H3), higher water consumption (both frequency of consumption occasions and daily consumption amount) and higher perceived habitualness of water drinking correlated positively with hydration status as measured by urine colour (see Table 4).

In contrast, exploratory correlations showed that soft drink consumption (both frequency of consumption occasions and daily consumption amount), correlated negatively with urine colour, with more negative scores indicating darker urine colour and hence an unhealthier

**Table 4**

Correlations between water and soft drink drinking behaviours and hydration status<sup>a</sup> during (Time 2) and post-lockdown (Time 3).

		Urine colour			
		Survey 1 (Time 2)		Survey 2 (Time 3)	
		$r_s$ (df)	$p$	$r_s$ (df)	$p$
<b>Water</b>	Frequency of consumption occasions	.13 (2108)	<.001	.11 (1598)	<.001
	Daily amount consumed	.30 (219)	<.001	.22 (158)	.006
	Habitualness	.30 (219)	<.001	.19 (158)	.019
<b>Soft drinks</b>	Frequency of consumption occasions	-.07 (2108)	<.001	-.07 (1598)	.008
	Daily amount consumed	-.27 (219)	<.001	-.21 (158)	.009
	Habitualness	-.26 (219)	<.001	-.05 (158)	.495

Note.

<sup>a</sup> Hydration status was assessed with urine colour: the higher the rating, the lighter the colour and the better the hydration status.

hydration status. In sum, a healthier urine colour was associated with higher water intake and with lower soft drink intake.

Lastly, the percentage of underhydrated participants (with scores above 5 on the 8-point urine colour scale, [Perrier et al., 2021](#)) was 39% during lockdown and 28% post-lockdown.

### 3.6. Analyses of responses to open questions

In both surveys, participants responded to open-ended questions in which they were asked to describe whether their drinking habits had changed during lockdown (Time 2) and post-lockdown (Time 3). Answers were brief and did not allow for formal qualitative analysis, but several themes were identified with an informal content analysis. We included a theme if it was mentioned by at least 10% of the participants across the two time points. Common themes for both time points are outlined in [Table 5](#).

## 4. Discussion

This study examined the effect of a COVID-19 lockdown on the consumption of soft drinks and water in England through two surveys completed during the November/December 2020 lockdown, and 5 months later. The results showed that the frequency of occasions in which participants consumed soft drinks decreased during lockdown, especially in situations typical for soft drink consumption, whereas the

**Table 5**

Summary of responses to open-ended questions about changes to soft drink and water consumption during (Time 2) and post-lockdown (Time 3).

Accessibility	Some participants reported having easier access to soft drinks during lockdown at their homes while others reported more difficulty accessing soft drinks in lockdown, as they were not going to restaurants and eating out. Similar experiences were noted for water, such that some participants consumed less water with restricted access to water coolers, while others consumed more due to being at home.
Taste	Individuals chose to drink more soft drinks to alleviate boredom, as a treat or due to their sweet taste.
Physical health	Participants reported choosing water in order to improve their physical health during lockdown, and reported drinking fewer soft drinks post-lockdown in order to reduce their sugar intake or lose weight.
Habit maintenance	Some participants did not report any change in their soft drink or water drinking behaviour at any time point. This was most pronounced post-lockdown when participants reported still spending a lot of time at home.

number of daily glasses of soft drinks consumed increased. In other words, a higher amount of soft drinks was consumed despite fewer consumption occasions.

After lockdown, the frequency of situations in which participants drank soft drinks increased again, albeit with less certainty, while the daily amount of soft drinks consumed decreased. Participants largely returned to their pre-lockdown consumption patterns across situations but drank a smaller amount of soft drinks per day. Speculatively, this may be due to attempts to limit consumption for health concerns after lockdown, and intake might return to pre-lockdown levels with a longer follow-up. Both changes in the daily amount of soft drinks consumed during and post-lockdown were largely, but not fully, due to changes in consumption at home, as this was the only situation assessed here that could partially explain the increases and decreases in daily amount consumed.

Results also showed that participants with higher perceived habitualness of soft drink consumption increased their intake of soft drinks during lockdown more than participants with average or lower levels of habitualness. After lockdown, this behaviour reversed again: Participants with the highest habitualness of soft drink consumption decreased their intake more than participants with average or low habitualness.

### 4.1. Implications for understanding soft drink consumption

These data and findings are useful for helping to create a detailed understanding of the behaviour of soft drink consumption in natural settings. Based on previous work ([Papies et al., 2021](#)), we had identified 5 typical soft drink and 5 typical water consumption situations. In line with this categorization, participants indeed reported more soft drink consumption occasions in “soft drink situations” (on a day out, at home, at a party or when out with friends, on a holiday or when traveling, when eating out) than in “water situations” (when out and about or shopping, with a meal, before bed or when waking up, at work, during or after exercise) before and after lockdown. This is helpful for guiding research on soft drink consumption in natural contexts and for considering how to target public health interventions.

During lockdown, as predicted, consumption occasions of soft drinks dropped heavily in these situations, except the situation “at home”. Despite this reduction in drinking occasions, the measure of intake amount showed that overall, soft drink consumption amount *increased* during the lockdown, and mediation analyses showed that this was to some degree driven by increased consumption occasions in the home situation. In other words, people made up for the loss of social soft drink consumption situations by drinking more often at home, and this led to a higher overall intake. Intake amount increased particularly among highly habitual drinkers, suggesting that for this group, the ease of access in the home situation may contribute to consumption. This again suggests putting a careful consideration of drinking situations central in intervention development.

We had not initially made differential predictions for the “frequency” and the “amount” measures of soft drink consumption. Similarly, we did not assess what exactly participants rated as one consumption episode when they answered the “frequency” question, or whether portion sizes at home or in other soft drink drinking situations differ. Hence, we cannot provide a more fine-grained analysis of how exactly the consumption patterns shifted to increased intake despite a reduction in drinking occasions. However, responses to open questions suggested that increased access to soft drinks at home during lockdown, along with drinking soft drinks to alleviate boredom, due to their sweet taste, and as a treat may underlie increased intake in the home situation.

These findings are consistent with the grounded cognition perspective on motivated behaviour, which suggests a key role for situated conceptualisations that trigger mental simulations of a behaviour when cued by relevant situations. When participants in this study spent more time at home during lockdown, simulations of consuming and enjoying soft drinks may have been triggered more frequently. Because

simulations of drinking soft drinks are rewarding (Claassen et al., 2022; Papiés et al., 2021), this will have increased soft drink consumption, especially for participants with high self-reported habitualness of consuming soft drinks, who had performed this behaviour frequently in the past. In contrast, simulations of drinking water are less attractive for most people (Rodger et al., 2021), such that while lockdown affected the frequency of water consumption occasions, it had no influence on consumption amount which remained stable over time (see water analyses in the SOM).

In sum, these findings are consistent with the perspective that reward expectations play an important role in motivated behaviour, and that they may be crucial in habitual behaviour as well (Kruglanski & Szumowska, 2020; Maio et al., 2022). Future research may link these findings with research on habit discontinuity (Verplanken et al., 2018; Verplanken & Wood, 2006) to examine the impact of ‘moments of change on’ habitual behaviours that are experienced as rewarding.

Although the hedonic drinking measure we used had a low reliability, we found that hedonic motives are stronger in those with higher soft drink habitualness. This was also reflected in our qualitative findings which showed that people often attributed their consumption to hedonic reasons, such as craving something sweet. Indeed, in previous research on the cognitive representations of soft drinks, a higher consumption frequency was associated with representing soft drinks more in terms of consumption and reward experiences, such as their sweet taste, their mouthfeel, and the pleasure of consuming them (Papiés et al., 2021).

#### 4.2. Applied implications

While previous research has suggested that soft drink consumption occurs in specific drinking contexts (e.g., McNaughton et al., 2020), our results showed that when these situations became less accessible, people readily made up for this, in this case by drinking soft drinks more often at home. This was the case for people with both high and average soft drink consumption habitualness who increased their consumption, and those with low habitualness who maintained the same amount of daily soft drink consumption, despite the reduction in drinking occasions. For health interventions aimed at reducing unhealthy beverage consumption, this implies that changing context or removing situational cues may not be enough to curb a behaviour that is represented as highly rewarding. Instead, rewarding alternatives, or attempts to make the behaviour much more costly (for instance, through lowering access to soft drinks at home by banning the sale of large soft drink packages or multipacks, or through introducing a high sugar tax), may be the only effective way of reducing their consumption (Hollands et al., 2015).

In addition, while we found an overall effect of lockdown on frequency of consumption occasions and amount consumed, our findings suggest large consumption differences within participants and situations. Indeed, some participants reported increased access to soft drinks (19%) in the home situation during lockdown while others reported decreased access (17%), similar to findings from a large cross-country study examining food consumption changes due to a COVID-19 lockdown period (Janssen et al., 2021). This highlights the importance of considering both individual and individual x environmental influences when developing health behaviour interventions (Fedlmeier et al., 2022; Ordovas et al., 2018).

Finally, our findings regarding hydration status showed that a large proportion of participants were likely underhydrated. In addition, our analyses indicated negative correlations between soft drink consumption amount and hydration status, at two separate time points, while higher water consumption was correlated positively with hydration status. These associations should be explored further, for example to establish whether drinking more soft drinks is associated with drinking less fluids overall. Overall, attempts to improve the public’s hydration behaviours should focus on both decreasing soft drink consumption and increasing water intake.

#### 4.3. Strengths and limitations

To the best of our knowledge, this is the first study that examines the impact of situational changes in a natural observational study on beverage consumption. However, as a limitation, the lockdown period assessed in this study was not the first lockdown that participants encountered, thus, their consumption behaviours may have already been affected by previous lockdowns. In addition, we did not control for other factors that may be associated with lockdown, for example increases in stress, loneliness, illness, or changes in eating patterns, which could have affected soft drink intake (Robert et al., 2022). Moreover, our measure of consumption was self-reported and retrospective for one of the time points, which raises some issues concerning recall accuracy. Notwithstanding these concerns, our findings are in line with other studies that found that, for some people, lockdown increased unhealthy behaviours (e.g., Jaeger et al., 2021; Robinson et al., 2021). For a more stringent test of the effect of lockdown on soft drink consumption one could compare how consumption changed across locations in England varying in levels of lockdown restrictions (Craig et al., 2017).

Finally, some of the drinking situations assessed may overlap with each other, such that for example the situation “at home” refers to the same physical environment but is less specific than the situation “when waking up”. Similarly, “with a meal” partially overlaps with the situation “when eating out”. Defining situations and their key, relevant features for triggering behaviour is notoriously difficult, hence partially overlapping situations may be simply the result of the complexity of studying natural behaviours outside of the laboratory. However, future research may attempt to operationalise key situations more precisely. In addition, we did not assess habitualness for each situation separately, which prevents us from establishing the observed overall shift in consumption related to increased habitualness in the home situation. More fine-grained, situated assessments could address this issue in future research (Dutriaux et al., 2021).

#### 4.4. Conclusion

This study provides detailed insight into soft drink consumption patterns, and how these have been affected by temporary shifts in consumption contexts. Our findings demonstrate the key role of social, out-of-the-home consumption situations in soft drink consumption, but also show how these were easily replaced by drinking soft drinks at home during lockdown. These findings are consistent with research showing that unhealthy eating behaviours increased during COVID-19 lockdowns and suggest that interventions to curb soft drink consumption need to go beyond the targeting of specific consumption situations.

#### Disclosure statement

Declarations of interest: none.

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#### Authors’ contributions

The authors’ responsibilities were as follows. EKP, MAC, and ML contributed to the study conception and design. ML collected data for Experiment 1 and MAC for Experiment 2. ML conducted the analyses for Experiment 1 and MAC for Experiment 2. The manuscript was written by EKP and MAC. All authors read and approved the final manuscript.



## Ethics statement

The research protocol was approved by the College of Science and Engineering Ethics Committee, University of Glasgow (application number: 300200055). All methods were carried out in accordance with relevant guidelines and regulations. Written informed consent was obtained from participants prior to participation.

## Declaration of competing interest

No potential conflict of interest was reported by the authors.

## Data availability

See "Comments" section

## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.appet.2023.106579>.

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