# Associations Between Repeated Sugar Sweetened Beverage Consumption and the Theory of Planned Behavior Constructs: Attitude, Subjective Norms, Perceived Behavioral Control, Behavioral Intention

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# Abstract

Consumption of sugar-sweetened beverages (SSB) is a risk factor for obesity as 1 SSB per day can increase the risk of obesity by 37%[1]. This study looked at the generalizability of beverage consumption behaviors through changes in the Theory of Planned Behavior (TPB), a framework of individual decision making. We conducted an intervention where participants (n=74) were exposed to assigned repeated beverage consumption of a SSB or unsweetened beverage (USB) and assessed how beverage assignment changed TPB constructs: behavioral intention, perceived behavioral control, instrumental attitude, affective attitude, and subjective norm at pre- and post-intervention to limiting consumption of regular soda and water. Additionally, we looked at body mass index as a covariate in this relationship as it may affect TPB constructs[2]. The effect of exposure to assigned beverage, time, and BMI on TPB constructs was measured using linear mixed models with random intercept and random slope to account for individual differences and time. The intervention decreased subjective norms to limit consumption of water, particularly for those with a lower BMI. Those assigned to USB had a decrease in behavioral intention to limit water consumption while those assigned to SSB had no statistically significant change to limit water consumption. These findings suggest that participants in the study perceived an increase in social pressure to consume water, especially those with a low BMI, and increased intention to consume water if they were assigned to the USB group. In conclusion, the assignment of daily USB consumption may increase intention for water consumption and promote public health interest in improving water consumption, especially populations at risk of dehydration, like the elderly and athletes, should be explored to understand changes in TPB constructs to improve water intake for future research[3,4].

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## CHAPTER 1: STUDY AIMS AND HYPOTHESIS

Sugar-sweetened beverage (SSB) consumption is a risk factor for weight gain and is associated with health issues such as obesity[5]. In one study, researchers found that those who consumed greater than or equal to 1 SSB per day had a 37% higher risk of developing obesity compared to non-consumers[1]. This effect has been replicated in other studies[6]. Although there are known health risks with consumption of SSBs (i.e. obesity, type 2 diabetes, and cardiovascular disease), the prevalence of sugar-sweetened beverage consumption is high: 50.6% of U.S. adults consume SSBs daily[5,7,8]. It is critical to understand individual decisions to consume SSBs, so that interventions that target SSB consumption can change decision-making behavior. The Theory of Planned Behavior (TPB) is a framework which explains health behavior decision-making as a combination of the constructs including subjective norms, attitudes, and perceived behavioral control[9]. Previous research has utilized the TPB model to examine SSB consumption in adolescents and parents, and successfully explained 34% of the variability in participant's intention to limit SSB to less than 1 cup/day by adolescents and parents[10]. However, research has not yet investigated how exposure to an SSB affects TPB constructs toward other beverages with similar or different sweetness. Since SSBs on the market range from regular sodas to fruit juices, the consumption of one type of SSB may influence the motivation to consume other SSBs. In order to reduce the consumption of SSBs in general, researchers need to understand if beverage consumption motivations are specific to a beverage, or are generalizable to other beverages of similar sweetness. Given the importance of understanding decision making for SSB consumption, we are investigating how the exposure to a sweetened or unsweetened beverage leads to changes in TPB model constructs toward other SSBs and non-sweetened beverages.

Aim 1: Assess the impact of repeated consumption of SSB or USB on TPB model constructs (affective attitude, instrumental attitude, subjective norms, perceived behavioral control, and behavioral intention) toward drinking sodas and water. *The exposure of repeated SSB consumption will change TPB constructs such that affective attitudes towards limiting consumption of soda increase, instrumental attitudes toward limiting consumption of soda increase, subjective norms toward limiting consumption of soda increase, perceived behavioral toward limiting consumption of soda increase, and behavioral intention toward limiting soda increase, as compared to the USB group.*

Aim 2: Determine the effect of BMI on the relationship between repeated consumption of SSB or USB on TPB constructs toward drinking sugar-sweetened beverage and water. *Those with a high BMI will change TPB constructs such that affective attitudes towards limiting consumption of soda increase, instrumental attitudes toward limiting consumption of soda increase, subjective norms toward limiting consumption of soda increase, perceived behavioral toward limiting consumption of soda increase, and behavioral intention toward limiting soda increase, as compared to low BMI participants.*

## CHAPTER 2: INTRODUCTION

In the United States, 1 in 3 adults are obese (BMI > 30 kg/m$^2$)[11]. People with obesity have an increased risk of diseases such as Type 2 Diabetes, coronary heart disease, and high blood pressure[12]. The financial cost attributable to obesity in the US was estimated to be up to 78.5 billion dollars in 2008[13]. Given the impact of obesity on health and its cost, it is critical for public health to understand what causes obesity. One factor suggested to contribute to the rise in obesity is the consumption of sugar-sweetened beverages (SSBs)[11]. Research in both longitudinal and cross-sectional studies show that individuals, both adults and adolescents, who consume SSBs have greater weight gain, which can develop into obesity[7,14,15]. Individuals who consumed greater than or equal to 1 soft drink per day had a 37% higher risk of developing obesity compared to non-consumers[1]. Importantly, there are many SSBs on the market, from regular sodas to fruit drinks with added sugars. Consumption of one type of SSB may increase the likelihood of consumption of other sweet foods, to further increase weight gain risk. Sweetness is a strong influence on food selection and sweet preference is positively associated with increased intake of sweet foods[16–18]. The consumption of SSBs, like soda, can [increase/decrease] positive attitudes and perceptions of other sweet foods in normal weight and overweight/obese populations[2]. This suggests that SSB consumption increases the likelihood of consuming other SSBs, however why this effect occurs is not yet established. It is important to understand how and why repeated SSB consumption affects an individual's decision to drink other SSBs, given consumption of SSBs has negative health outcomes from weight gain. In order to prevent weight gain, we need to understand why people consume SSBs and what affects those choices.

*2.1 Theory of Planned Behavior (TPB)*

The Theory of Planned Behavior provides a framework to explain why people chose to consume SSBs[19]. TPB is a theoretical framework that models the planning of deliberate behavior, and can be used to identify ways to change behavior (see Figure 1)[20]. The key constructs in this model are: attitude, or an individual's positive or negative evaluation of performing the behavior (e.g. belief that consuming SSBs is enjoyable, affective, or beneficial, instrumental); subjective norms, or person's perception of the social pressures applied to them to perform or not perform the behavior in question (e.g. those important to someone think it is beneficial to consume SSBs); perceived control, or person's belief in their control over the behavior (e.g. belief that someone could consume SSBs easily if they choose so); and intention, or plan to perform or not perform the behavior (e.g an individual plans to consume SSBs)[9]. Behavioral intention is the central factor in the TPB, as it combines all the motivational constructs that influence intention to act on behavior (see Figure 1)[9]. Higher behavioral intention predicts an individual's behavior, but this is dependent on the individual's control over the behavior[20]. The other constructs of attitude, subjective norms, and perceived behavioral control are independent determinants of behavioral intention and influence each other[20]. Subjective norms capture the social factors which inform decision making such as the role of peer groups for adolescents[21]. The TPB places subjective norms as a direct determinant of intention[20]. Generally, if attitude and subjective norms are affirmative to perform a behavior under high perceived control, then a behavioral intention is stronger[20]. The strength of TPB constructs in explaining the behavior varies based on each behavior[22], but it has been successfully applied to SSB consumption, explaining a good proportion of intake[10,23,24]. Based on the utility of the TPB, it is a good model to understand the SSB consumption decision-making factors. A working model of SSB consumption is shown in

**Figure 1**.

*2.2 Theory of Planned Behavior (TPB) Applied to Sugar-Sweetened Beverage Consumption*

TPB has been applied to SSB consumption in previous studies to understand and describe beliefs and intentions to consume SSBs[10,23,24]. In a study applying the TPB to SSB consumption, Zoellner et al. (2012) found that the TPB model explained 38% of variation in SSB intake[23]. Intentions had the strongest relationship with SSB intake followed by attitudes, perceived behavioral control, and subjective norms[9,23]. Kassem, Lee, Modeste, and Johnston (2003) tested the validity of applying the TPB model to SSB intake, and found that the model explained 64% of the variance in behavior to consume SSBs similar to Zoellner et al. (2012)[25,26]. Much of the existing research has focused on how the TPB model explains a single, specific behavior[10,24,27], but little research has tested how other behaviors impact TPB framework constructs. This is especially relevant since no behavior is performed in isolation; prior experience informs present behavior. In the context of SSB consumption, this raises the question: how does SSB consumption influence TPB constructs and consumption of other SSBs? Sugar is highly reinforcing and motivates people to eat more[28–30]. A possible effect of consuming one kind of SSB is that the reinforcing value of the sugar will increase an individual's motivation to consume other sugary drinks.

This study aimed to test this question exactly: how does consumption of a SSB affect TPB model constructs towards consumption of a different SSB? To answer this question, we measured TPB constructs before and after a three-week intervention where participants were assigned to daily consumption of a 10oz serving of a SSB or USB. This allowed our study to test how repeated exposure to SSB or USB may change behavioral intention, perceived behavioral

control, subjective norms, and attitude toward regular soda and water consumption. We hypothesized that the exposure of repeated SSB intake would change TPB constructs, such that affective attitude towards limiting soda consumption will increase, instrumental attitude towards limiting soda consumption will increase, subjective norms towards soda consumption will increase, perceived behavioral towards limiting soda consumption will increase, and behavioral intention towards limiting soda consumption will increase, compared to the USB group. Additionally, this study examined the impact of weight status (measured via baseline BMI) on the effect of exposure to USB or SSB on TPB constructs. We hypothesized that those with high BMI will have a greater increase in affective attitude towards limiting soda consumption, a greater increase in instrumental attitude towards limiting soda consumption, a greater increase in subjective norms towards limiting soda consumption, a decrease in perceived behavioral control towards limiting soda consumption, and greater increase in behavioral intention toward limiting soda consumption, compared to those with a low BMI.

# CHAPTER 3: METHODS

## *3.1 Participants*

We collected data from 74 young adults participating in a randomized controlled trial to examine response to daily sugar-sweetened beverage (SSB) or unsweetened beverage (USB) consumption. Eligible participants were 18-28 years old and have a body mass index, BMI, of 19-35 $kg/m^3$, due to fMRI limitations[31]. Exclusion criteria included contraindications of fMRI (e.g. metal implants), serious medical problems (e.g. diabetes), any previous treatment for eating disorders or drug or alcohol abuse/addiction, current major psychiatric disorders (e.g. depression,

generalized anxiety disorder), and current dieting.

*3.2 Design*

At the baseline behavioral assessment, prior to the intervention period, participants completed a questionnaire to assess Theory of Planned Behavior (TPB) constructs (behavioral intention, perceived behavioral control, affective attitude, instrumental attitude, and subjective norms) toward consumption of regular soda or water (a selection of questions are available in **Table 1**). All survey responses were scaled on a seven-point Likert scale (1-7).

During the intervention, participants consumed one, 10oz bottle of SSB or USB daily, for three weeks under instruction by the intervention. Beverages were a novel flavor (either strawberry kiwi lemonade or black cherry orange) and the SSB contained as much sugar as soda (23.7gram/10oz). These flavors were selected to ensure that participants could not access the beverages from other sources beyond what was given during the intervention period of the study. Beverages were selected through a pilot study (n=75) that confirmed the beverages to be similarly matched on pleasantness, desirability, and the likelihood to drink[32]. Researchers informed participants not to alter the beverage by adding sugar or alcohol. During the intervention period, participants came to the lab 3x/week to consume their daily beverage in the lab and return empty bottles consumed outside the lab as a check for compliance of beverage consumption.

After the 3-week intervention, participants returned for their second behavioral assessment where participants completed the TPB questionnaire again. This was within 3-11 days after their last assigned beverage is consumed.

### *3.3 Measures*

#### *3.3.1 TPB questionnaire*

The TPB questionnaire was adapted from a validated questionnaire used in a similar study (Zoellner et al., 2017). Zoellner et al. (2017) used the questionnaire to predict SSB consumption during a TPB-based intervention, SIPsmartER, to reduce SSB consumption[27]. The questions were adapted such that the wording changed from "your sugary drinks" to "consumption of the listed beverage" followed by a list of beverages selected from the Beverage Intake Questionnaire (CITATON) including: water, 100% fruit juice, sweetened juice beverage/drink, 100% vegetable juice, whole milk, reduced-fat milk (2%), low fat/fat free milk, regular soft drinks, diet soft drinks/artificially sweetened drinks, sweetened tea, coffee with cream and/or sugar, tea or coffee black with/without artificial sweetener, energy drinks, alcoholic beverage, and meal replacement shakes/protein drinks[33]. All constructs were assessed toward *limiting* consumption of the beverages listed. For the purpose of our study, we limited our analysis to change in TPB constructs toward limiting consumption of regular soft drinks and water. Regular soft drinks were chosen to represent SSBs due to regular soda being a direct comparison between the novel assigned beverage and a calorically similar beverage. "Regular soft drinks" refer to sodas such as colas and root beers. Water was selected as a comparison beverage since it is most like the USB beverage because it is not a sweetened beverage and it contains no calories.

### *3.4 Data Acquisition, preprocessing, and analysis*

Researchers gave participants the TPB questionnaire through Qualtrics on an iPad. All the data analysis was completed in R (v. 3.5.3)[34]. For each construct, questionnaire responses were

averaged to generate a summary score for behavioral intention, perceived behavioral control, subjective norms, affective attitude, and instrumental attitude towards regular soft drink or water consumption.

To assess pre- to post-intervention differences in behavioral intention, perceived behavioral control, subjective norms, affective attitude, and instrumental attitude constructs by intervention group, we used linear mixed models. The LME function from nlme (v. 3.1e137) package was used to fit linear mixed effects models with a random intercept and random slope to assess the effect of sugar of the assigned beverage and time on behavioral intention, perceived behavioral control, subjective norms, affective attitude, or subjective attitude, respectively. Body Mass Index (BMI) was added to the linear mixed model as a fixed effect to investigate the effect of BMI independent of and interaction with beverage assignment and time on behavioral intention, perceived behavioral control, subjective norms, affective attitude, and instrumental attitude constructs. An ANOVA (via the the 'anova' function from the 'stats' package) was used to compare the relative fit of nested models after each effect (e.g. random intercept, random slope, time, beverage assignment, BMI) was added to assess the significance of the whole model[34]. Statistical significance was set at $p<0.05$. The beta ($\beta$) value refers to the standardized regression coefficient and is reported with standard error (SE).

To ensure the normality assumptions for linear mixed models were met, the assumption of linearity was assessed visually in a plot of residuals from the linear mixed model versus outcome (TPB construct: intention, perceived behavioral control, subjective norm, affective attitude, subjective attitude). Levene's test assessed the homogeneity of variance. Lastly, quantile-quantile (qq) plot assessed if the residuals of the model followed a normal distribution.

If a model violated any assumption, the model was transformed.

To test for baseline differences in beverage assignment groups, we conducted a chi-square test for differences in gender and race/ethnicity and independent t-test for differences in BMI and age. Statistical significance was considered at $p<0.05$.

## CHAPTER 4: RESULTS

### *4.1 Participants*

Ninety-two participants were recruited from the University of North Carolina Chapel Hill. Complete data was collected from seventy-four participants. Eighteen participants were excluded due to incomplete or missing data at one timepoint. Participants ranged from 18 to 29 years old with an average age of 21.85 ± 2.59 with 20 males (27%) and 54 females (73%). We observed an average BMI of 23.57 ± 3.344 $kg/m^2$. 57 of the participants were normal weight (18.0-24.9 $kg/m^2$) and 17 were overweight to obese according to Centers for Disease Control and Prevention standards [35]. Other demographic information is listed in **Table 2**.

### *4.2 Effect of Sweetness of Assigned Beverage, Time, and BMI on the Theory of Planned Behavior Constructs*

Affective Attitude: There was no difference in affective attitude toward limiting water or regular soda consumption by time, assigned beverage, or BMI independently. There was no significant interaction of time by group, but there was a significant effect by the interaction of the assigned beverage and BMI (model 2: $\beta= -0.27$, $SE= 0.10$, $p= 0.01$). For the USB assigned group, there was a positive relationship between BMI and affective attitude toward limiting regular soda

consumption (r = 0.31). In contrast, in the SSB group, BMI had a negative relationship with affective attitude toward limiting soda consumption (r= 0.16).

Instrumental Attitude: No difference was detected in the instrumental attitude toward limiting water or regular soda consumption by time, assigned beverage, or BMI. There were no significant interactions between time ang group or BMI and group.

Subjective Norms: Subjective norms significantly decreased toward limiting water consumption both groups at post-intervention, in models with and without BMI (model 1: β=-0.11, SE= 0.05, p= 0.04; model 2: β=-0.12, SE= 0.05, p= 0.03) (**Figure 2B, Figure 3B, and Figure 4**). There was a time by BMI interaction, such that those with higher BMI showed a greater increase in subjective norms towards limiting water consumption over time (r = 0.06), regardless of beverage assignment (model 2: β= -0.14, SE= 0.05, p= 0.01) (**Figure 3B**). There were no other differences in subjective norms toward limiting water consumption by time, assigned beverage, and BMI. There was no difference in subjective norms toward limiting soda consumption over time or between beverage groups.

Perceived Behavioral control (PBC): Independent of time, there was a significant difference between beverage assignment groups in perceived behavioral control to limit water consumption (model 1: β=-0.16, SE= 0.06, p= 0.02; model 2: β=-0.16, SE= 0.06, p= 0.02)(**Figure 2C**). There was no other difference in perceived behavioral control toward limiting soda consumption by time, beverage groups, or BMI. Conversely, there was a significant effect of time on perceived behavioral control toward limiting soda consumption, where perceived behavioral control increased in both groups over time (model 1: β=0.62, SE= 0.07, p< 0.001; model 2: β=0.62, SE= 0.07, p< 0.001) (**Figure 2D**). There were no other differences in perceived behavioral control toward limiting soda consumption by time, assigned beverage, or BMI.

Behavioral Intention (BI): There was a significant group by time interaction that predicted behavioral intention to limit water consumption (model 1:β= 0.19, SE= 0.08, p= 0.02; model 2: β= 0.18, SE= 0.08, p= 0.02). The interaction was such that in the SSB group, behavioral intention to limit water consumption did not change over time, while in the USB group, there was a decrease in behavioral intention to limit water consumption over time (**Figure 2A**). There were no other differences in behavioral intention toward limiting water consumption by time, assigned beverage, or BMI. There was no difference in behavioral intention toward limiting soda consumption by time, beverage groups, BMI.

## CHAPTER 5: DISCUSSION

This study assessed how constructs of the Theory of Planned Behavior (attitude, subjective norms, perceived behavioral control, behavioral intention) change over three weeks of repeated sweetened (SSB) or unsweetened flavored beverage (USB) consumption. We hypothesized that the exposure of repeated SSB consumption will change TPB constructs such that affective attitudes towards limiting consumption of soda increase, instrumental attitudes toward limiting consumption of soda increase, subjective norms toward limiting consumption of soda increase, perceived behavioral toward limiting consumption of soda increase, and behavioral intention toward limiting soda increase, as compared to the USB group. From our analysis, exposure to repeated beverage consumption was associated with significant changes in subjective norms (SN) and behavioral intention (BI). While other constructs showed changes over time or by group, these constructs were unique to show an interaction of group and time or BMI and time.

Exposure of the intervention, regardless of groups, contributed to a decrease in SN to limit water consumption over time. Additionally, there was an interaction of time and BMI on

SN toward limiting water consumption, such that those with lower BMI had a decrease in SN towards limiting water consumption, while those with a higher BMI showed an increase in SN toward limiting water consumption across the intervention. Results suggest that some participants in the intervention perceived less social pressure to limit water consumption; which can be interpreted as greater social pressure to consume water. This effect was found to be stronger in lower BMI participants than higher BMI. The intervention also impacted behavioral intention to limit water consumption such that those in the USB group reported a decrease in BI to limit water consumption over time, while the SSB group reported little change in BI over time. This can be interpreted as those participants who were assigned to consume a USB has a higher BI to consume water by the end of the study, while those in the SSB group saw little to no change in BI to consume water. Combining the selected results, those assigned to the USB condition were more likely to intend to consume water, supported by an increased in perceived social pressure to consume water. This effect was especially stronger for those with a lower BMI. Those in the SSB group had no statistically significant change in intention to limit water intake but did have the effect of increased social pressure to limit water intake particularly those with a high BMI. Given that BI is considered a stronger predictor of behavior[20], the increased BI to consume water in the USB group may signify participants are consuming more water because the tart flavor of the USB does not satisfy their thirst, and they are motivated to drink more water. These results suggest that populations who are at risk for dehydration, like the elderly, children, or athletes, may benefit from daily consumption of USB as it would increase their behavioral intention to consume water[36].

To our knowledge, this is the first study to examine the effect of a dietary intervention that assigns individuals to daily of a SSB/USB on TPB constructs. Historically, TPB has been

utilized to understand the individual determinants of SSB consumption, or used as a explanation of intervention response. TPB model has explained 38% to 64% of the variability in SSB consumption, which implies that the lowering SN to limit water consumption and lower BI to limit water consumption are predictive of some the participant's actual water consumption[25,27]. Since there is little information on how behavior affects TPB constructs, this study provides valuable insight into how TPB constructs can change over time due to repeated consumption of SSBs. We found that behavioral intention to limit water consumption had statistically significant difference between groups, especially in the USB group. The data suggests the participant's consumption of USB increased intention to consume water, a similarly unsweetened beverage. Subsequently, results imply that effects of consuming a USB generalize to change in TPB constructs toward a similarly unsweet beverage. Although SSB assignment did not have a significant effect on TPB constructs towards regular soda consumption, other research suggests that SSB consumption contributes to changes in other behaviors associated with consumption, like taste preference, that are not directly measured in the TPB framework[2]. Overall, the study suggests that USB consumption has effects on TPB constructs related to water consumption, but daily consumption of an SSB does not produce changes in TPB that generalize to other SSBs.

Although there is no research on the generalizability of behavior with respect to TPB, there is some research on aspects adjacent to the TPB framework. For example, exposure to daily soft drink consumption for one month increased preference for sucrose, especially among participant who did not like sucrose at baseline[2]. Our study did not find assess taste preference, but maybe this sample would show a similar effect between assignment to SSBs and regular sodas. Taste preference measures how much an individual likes a beverage, not how motivated individuals are to consume the beverage[37]. Maybe SSB intake changes preference, but not

motivation. Secondly, young adults who perceive those in their social networks to prefer SSBs are more likely to consume more SSBs themselves[38]. The construct of perceived social preference for SSBs is very similar to perceived norms, however, our study did not find the same effect. Again, there may be a difference between preference and actual behavior.

One limitation of our study is the comparison of the assigned USB to water for analysis. The beverage intake questionnaire options did not assess intake of an unsweetened, flavored beverage. The closest comparison to USB is black coffee with no artificial sweetener added, however, coffee is often consumed with added sugar/cream. We were concerned about measurement error and misreporting due to the likelihood for people to add sugar/cream to coffee. Instead, we chose to compare the USB to water to minimize measurement error. But, the USB has a strong tart flavor that does not directly compare to water. When a bitter beverage, like coffee, is consumed before consuming other foods, it can decrease the intensity of later flavors while water does not enhance or reduce other flavors[39]. If we used a beverage matched in flavor and unsweet to the assigned USB, then the results could have been more similar to SSB and regular soda.

Along with the lack of a perfectly matched comparison group to the USB beverage, the study population drew from a population within a school of public health. This population is likely to be more educated than the general population about the negative health outcomes associated with SSB consumption and may be actively counterbalancing the repeated consumption of the beverage with water. These biases may explain the lack of group difference of social pressures to limit water consumption and an overall decrease in social pressure to limit water consumption. Participants with a public health education are also more likely to hold more

norms of healthier activities like consuming less SSBs and more water to begin with compared to the general population.

Another limitation is the lack of a measurement of actual beverage consumption to relate the TPB measures to the actionable behavior of consuming water or regular soda. The main study has information on food frequency, but it was not utilized due to using the TPB framework as a predictor of behavior. TPB was used as the sole behavioral measure due to the adequate strength of TPB to predict behavior[25,27]. This limits the application of our findings on a broader scale in understanding the effect of repeated SSB or USB on actual consumption of regular soda and water. The behaviors associated with the changes in TPB model during the exposure are restricted to hypothetical behaviors and only describe TPB model. Our findings can be described as risk factors at most to a behavior. For example, high intention to consume water predicts water consumption but there is no stipulation that it leads to participants actually drinking water.

The final limitation is the TPB model used was based on the first model proposed in 1985, since then other researchers have proposed an extension to the TPB for the inclusion of constructs such as past behavior and habit strength [40]. These are commonly proposed for specific health behaviors to enhance the model's ability to explain health behavior. A strength of the current model is how it can be broadly used in behaviors from smoking to physical activity. Azjen recognizes that past behavior does contribute to future behaviors and the possibility of it acting independently on behavioral intention [40]. Since we used the original model instead of an extended model, there could be another construct such as past behavior with SSB which could change the effect from the intervention and influencing the original TPB constructs.

In summary, this study adds to the literature about the relationship of TPB to SSB consumption and water consumption in the context of repeatedly consuming an SSB or USB for

3-week intervention. Future research should be directed at comparing USB to a matched beverage like tea with no additives, more representative population, utilizing an extended theory of planned behavior model, and include a beverage intake measure such as a 24-hour recall or beverage intake frequency questionnaire. This study can be applied to public health and the general population by recommending the intake of USB to increase water intake, especially in populations at risk for dehydration like the elderly or athletes[3,4]. Also, to educate individuals who are consuming SSB with the intention to increase water consumption since that was not found to be true. More research should be done to confirm the validity of the trends seen in this study before a full recommendation is advertised.

**IRB STATEMENT**

This project analyzed data from an IRB approved study 17-0710. The TPB questionnaire used for my project was added in a modification to the existing protocol.

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Appendix A: Tables

Table 1: TPB constructs and questions to assess each construct (Zoellner et al., 2012)

| Construct | Question | Reference Beverages |
|---|---|---|
| Perceived Behavioral Control | Limiting your consumption of the listed beverages to less than 1 cup, 8oz, each day if you wanted to do so would be: Easy/Difficult | • Regular colas and root beers<br>• Diet regular colas and diet root beers<br>• Brewed coffee, tea, espresso and expresso drinks with sweetener<br>• Brewed coffee, tea, espresso and expresso drinks without sweetener<br>• juice, flavored water, and flavored carbonated water with sweetener<br>• juice, flavored water, and flavored carbonated water without sweetener<br>• water |
| Subjective Norms | Most people who are important to you want you to drink less than 1 cup, 8oz, of the listed beverages each day: Agree/Disagree | |
| Affective Attitude | For you, drinking less than 1 cup, 8oz, of the listed beverages each day would be: Enjoyable/Unenjoyable | |
| Instrumental Attitude | For you drinking less than 1 cup, 8 oz, of regular colas and root beers each day would be: Healthy/Unhealthy | |
| Behavioral Intention to consume beverage | You plan to limit your consumption of the listed beverages to less than 1 cup, 8oz, each day: Agree/Disagree | |

Table 2: Demographic information of the total sample and groups by assigned beverage sweetness

| | Total (n=74) | SSB group (n=40) | USB group (n=34) | Chi square test of goodness of fit | Wilcox Sum Rank Test |
|---|---|---|---|---|---|
| BMI[a] | 23.57 (3.34) | 23.40(3.17) | 23.77 (3.58) | | Z= 1.114 p= 0.87 |
| Age[a] | 21.85 (2.59) | 21.95 (2.75) | 21.72 (2.42) | | Z=0.845 p= 0.80 |
| *Ethnicity* | | | | $\chi^2$ (1) = 0.05 p=0.82 | |
| Hispanic/Latino/a | 7 | 3 | 4 | | |
| Not Hispanic/Latino/a | 67 | 37 | 30 | | |
| *Race* | | | | $\chi^2$ (4) = 8.59 p= 0.07 | |
| American Indian Alaska Native | 0 | 0 | 0 | | |
| Asian | 22 | 11 | 11 | | |
| Black or African American | 7 | 7 | 0 | | |
| Native Hawaiian | 0 | 0 | 0 | | |
| White | 41 | 21 | 20 | | |
| Middle Eastern or Northern African | 2 | 1 | 1 | | |
| Other | 2 | 0 | 2 | | |
| *Gender* | | | | $\chi^2$ (1) = 0.03 p= 0.87 | |
| Male | 20 | 10 | 10 | | |
| Female | 54 | 30 | 24 | | |

[a]Mean(SE)

Table 3: Model 1, standardized regression coefficients to describe the effect of time and assigned beverage sweetness on TPB measures toward regular soda consumption

| TPB Measure | Linear Mixed Model | β | Standard Error | P Value |
|---|---|---|---|---|
| Affective | Intercept | 0.009 | 0.105 | 0.934 |
| Attitude | Time-T2 | -0.030 | 0.059 | 0.620 |
| | SSB-USB | -0.030 | 0.105 | 0.779 |
| | Time-T2: SSB-USB | -0.007 | 0.059 | 0.910 |
| Instrumental | Intercept | 0.017 | 0.111 | 0.878 |
| Attitude | Time-T2 | 0.064 | 0.041 | 0.121 |
| | SSB-USB | -0.072 | 0.111 | 0.519 |
| | Time-T2: SSB-USB | 0.012 | 0.041 | 0.769 |
| Subjective | Intercept | 0.013 | 0.104 | 0.901 |
| Norms | Time-T2 | 0.015 | 0.061 | 0.804 |
| | SSB-USB | 0.001 | 0.104 | 0.995 |
| | Time-T2: SSB-USB | -0.046 | 0.062 | 0.455 |
| Perceived | Intercept | 0.036 | 0.068 | 0.601 |
| Behavioral | Time-T2 | 0.617 | 0.066 | P< 0.001* |
| Control | SSB-USB | 0.061 | 0.068 | 0.378 |
| | Time-T2: SSB-USB | -0.021 | 0.066 | 0.758 |
| Behavioral | Intercept | 0.006 | 0.103 | 0.954 |
| Intention | Time-T2 | -0.085 | 0.063 | 0.183 |
| | SSB-USB | 0.042 | 0.103 | 0.683 |
| | Time-T2: SSB-USB | -0.013 | 0.063 | 0.839 |

* P<0.05

a: transformation of TPB measure to correct for non-normality of residuals and improve fit of model

Table 4: Model 1, standardized regression coefficients to describe the effect of time and assigned beverage sweetness on TPB measures toward water consumption

| TPB Measure | Linear Mixed Model | β | Standard Error | P Value |
|---|---|---|---|---|
| Affective | Intercept | -0.009 | 0.095 | 0.922 |
| Attitude | Time-T2 | -0.087 | 0.069 | 0.212 |
| | SSB-USB | -0.061 | 0.095 | 0.520 |
| | Time-T2: SSB-USB | -0.081 | 0.069 | 0.249 |
| Instrumental | Intercept | -0.013 | 0.100 | 0.897 |
| Attitude | Time-T2 | -0.112 | 0.060 | 0.066 |
| | SSB-USB | 0.010 | 0.100 | 0.919 |
| | Time-T2: SSB-USB | -0.084 | 0.060 | 0.167 |
| Subjective | Intercept | -0.018 | 0.104 | 0.865 |
| Norms | Time-T2 | -0.111 | 0.053 | 0.042* |
| | SSB-USB | 0.038 | 0.104 | 0.720 |
| | Time-T2: SSB-USB | -0.081 | 0.054 | 0.136 |
| Perceived | Intercept | -0.013 | 0.098 | 0.895 |
| Behavioral | Time-T2 | -0.156 | 0.064 | 0.017* |
| Control | SSB-USB | -0.172 | 0.098 | 0.084 |
| | Time-T2: SSB-USB | 0.031 | 0.064 | 0.633 |
| Behavioral | Intercept | -0.006 | 0.088 | 0.943 |
| Intention | Time-T2 | -0.111 | 0.076 | 0.150 |
| | SSB-USB | -0.103 | 0.088 | 0.248 |
| | Time-T2: SSB-USB | 0.188 | 0.076 | 0.016* |

Significant results are denoted as *, $P<0.05$

a: transformation of TPB measure to correct for non-normality of residuals and improve fit of model

Table 5: Model 2, standardized regression coefficients to describe the effect of time, assigned beverage sweetness, and BMI on TPB measures toward regular soda consumption

| TPB Construct | Linear Mixed Model | β | Standard Error | P Value |
|---|---|---|---|---|
| Affective Attitude | Intercept | -0.007 | 0.101 | 0.948 |
| | Time-T2 | -0.031 | 0.060 | 0.611 |
| | SSB-USB | -0.025 | 0.102 | 0.803 |
| | BMI | 0.024 | 0.102 | 0.812 |
| | Time-T2 : SSB-USB | -0.003 | 0.060 | 0.959 |
| | Time-T2 : BMI | 0.056 | 0.060 | 0.353 |
| | SSB-USB : BMI | -0.266 | 0.101 | 0.011* |
| | timeT2 : SSB-USB : BMI | -0.003 | 0.059 | 0.963 |
| Instrumental Attitude | Intercept | 0.015 | 0.111 | 0.896 |
| | Time-T2 | 0.064 | 0.041 | 0.128 |
| | SSB-USB | -0.063 | 0.112 | 0.575 |
| | BMI | 0.134 | 0.112 | 0.236 |
| | Time-T2 : SSB-USB | 0.012 | 0.041 | 0.764 |
| | Time-T2 : BMI | -0.019 | 0.042 | 0.653 |
| | SSB-USB : BMI | -0.061 | 0.112 | 0.585 |
| | timeT2 : SSB-USB : BMI | -0.025 | 0.041 | 0.545 |
| Subjective Norms | Intercept | 0.009 | 0.105 | 0.933 |
| | Time-T2 | 0.015 | 0.062 | 0.805 |
| | SSB-USB | 0.007 | 0.105 | 0.949 |
| | BMI | 0.042 | 0.105 | 0.695 |
| | Time-T2 : SSB-USB | -0.044 | 0.062 | 0.483 |
| | Time-T2 : BMI | -0.011 | 0.062 | 0.866 |
| | SSB-USB : BMI | -0.115 | 0.105 | 0.275 |
| | timeT2 : SSB-USB : BMI | -0.042 | 0.062 | 0.495 |
| Perceived Behavioral Control | Intercept | 0.036 | 0.069 | 0.605 |
| | Time-T2 | 0.617 | 0.067 | P< 0.001* |
| | SSB-USB | 0.065 | 0.069 | 0.347 |
| | BMI | 0.019 | 0.069 | 0.784 |
| | Time-T2 : SSB-USB | -0.019 | 0.067 | 0.774 |
| | Time-T2 : BMI | -0.043 | 0.067 | 0.526 |
| | SSB-USB : BMI | -0.054 | 0.068 | 0.429 |
| | timeT2 : SSB-USB : BMI | -0.053 | 0.067 | 0.433 |
| Behavioral Intention | Intercept | -0.002 | 0.103 | 0.987 |
| | Time-T2 | -0.088 | 0.062 | 0.163 |
| | SSB-USB | 0.043 | 0.103 | 0.675 |
| | BMI | -0.027 | 0.104 | 0.794 |
| | Time-T2 : SSB-USB | -0.006 | 0.062 | 0.917 |
| | Time-T2 : BMI | 0.077 | 0.062 | 0.219 |
| | SSB-USB : BMI | -0.146 | 0.103 | 0.161 |

| | | | |
|---|---|---|---|
| timeT2 : SSB-USB : BMI | -0.066 | 0.062 | 0.285 |

Significant results are denoted as *, P<0.05

a: transformation of TPB measure to correct for non-normality of residuals and improve fit of model

Table 6: Model 2, standardized regression coefficients to describe the effect of time, assigned beverage sweetness, and BMI on TPB measures toward water consumption

| TPB Construct | Linear Mixed Model | β | Standard Error | P Value |
|---|---|---|---|---|
| Affective Attitude | Intercept | -0.015 | 0.096 | 0.880 |
| | Time-T2 | -0.087 | 0.069 | 0.213 |
| | SSB-USB | -0.062 | 0.096 | 0.518 |
| | BMI | 0.052 | 0.097 | 0.592 |
| | Time-T2 : SSB-USB | -0.083 | 0.069 | 0.237 |
| | Time-T2 : BMI | 0.049 | 0.070 | 0.487 |
| | SSB-USB : BMI | -0.010 | 0.096 | 0.915 |
| | timeT2 : SSB-USB : BMI | 0.084 | 0.069 | 0.227 |
| Instrumental Attitude | Intercept | -0.016 | 0.101 | 0.873 |
| | Time-T2 | -0.110 | 0.061 | 0.075 |
| | SSB-USB | 0.012 | 0.101 | 0.908 |
| | BMI | -0.012 | 0.102 | 0.907 |
| | Time-T2 : SSB-USB | -0.082 | 0.061 | 0.182 |
| | Time-T2 : BMI | -0.003 | 0.061 | 0.958 |
| | SSB-USB : BMI | -0.085 | 0.101 | 0.405 |
| | timeT2 : SSB-USB : BMI | 0.002 | 0.061 | 0.972 |
| Subjective Norms | Intercept | -0.024 | 0.106 | 0.820 |
| | Time-T2 | -0.116 | 0.051 | 0.026* |
| | SSB-USB | 0.031 | 0.106 | 0.771 |
| | BMI | -0.016 | 0.107 | 0.878 |
| | Time-T2 : SSB-USB | -0.079 | 0.051 | 0.129 |
| | Time-T2 : BMI | 0.141 | 0.051 | 0.008* |
| | SSB-USB : BMI | 0.015 | 0.106 | 0.887 |
| | timeT2 : SSB-USB : BMI | 0.031 | 0.051 | 0.542 |
| Perceived Behavioral Control | Intercept | -0.012 | 0.099 | 0.904 |
| | Time-T2 | -0.159 | 0.064 | 0.015* |
| | SSB-USB | -0.178 | 0.099 | 0.078 |
| | BMI | -0.082 | 0.100 | 0.416 |
| | Time-T2 : SSB-USB | 0.035 | 0.064 | 0.590 |
| | Time-T2 : BMI | 0.082 | 0.064 | 0.201 |
| | SSB-USB : BMI | 0.050 | 0.099 | 0.615 |
| | timeT2 : SSB-USB : BMI | -0.025 | 0.063 | 0.690 |
| Behavioral Intention | Intercept | -0.005 | 0.088 | 0.951 |
| | Time-T2 | -0.113 | 0.077 | 0.145 |

| | | | |
|---|---|---|---|
| SSB-USB | -0.096 | 0.088 | 0.279 |
| BMI | 0.145 | 0.088 | 0.105 |
| Time-T2 : SSB-USB | 0.183 | 0.077 | 0.020* |
| Time-T2 : BMI | -0.081 | 0.077 | 0.298 |
| SSB-USB : BMI | 0.031 | 0.087 | 0.726 |
| timeT2 : SSB-USB : BMI | -0.029 | 0.076 | 0.704 |

Significant results are denoted as *, P<0.05

a: transformation of TPB measure to correct for non-normality of residuals and improve fit of model

Appendix B: Figures

Figure 1: Theory of Planned Behavior model for limiting sugar-sweetened beverage consumption and affected constructs by intervention

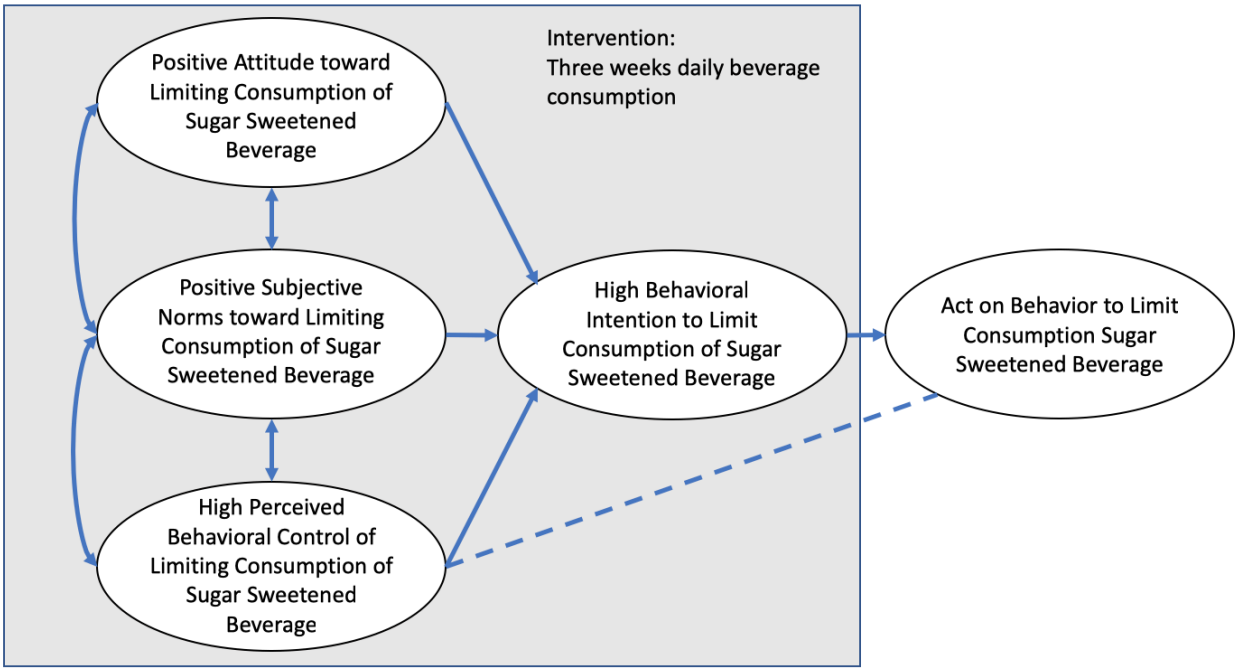
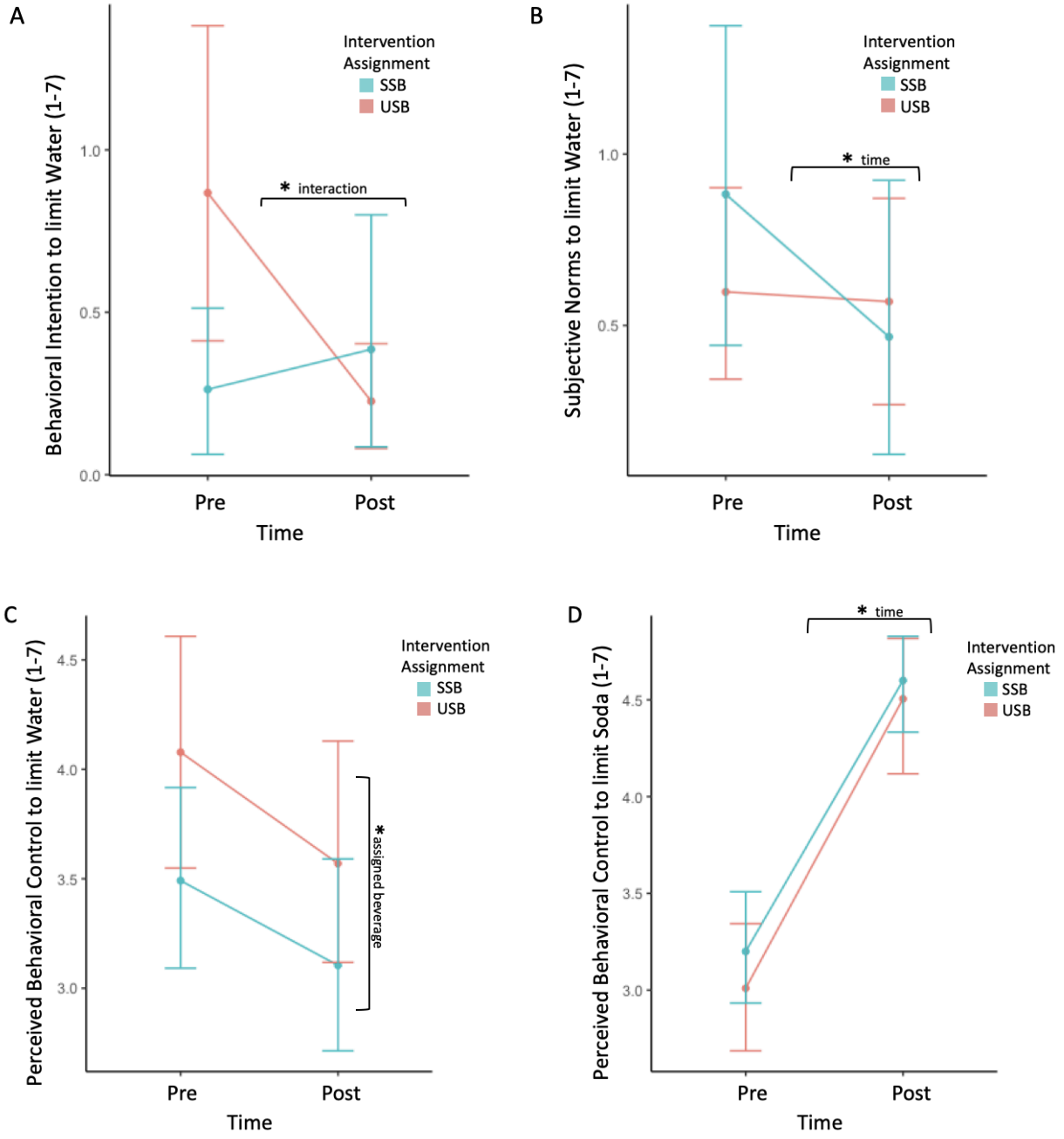
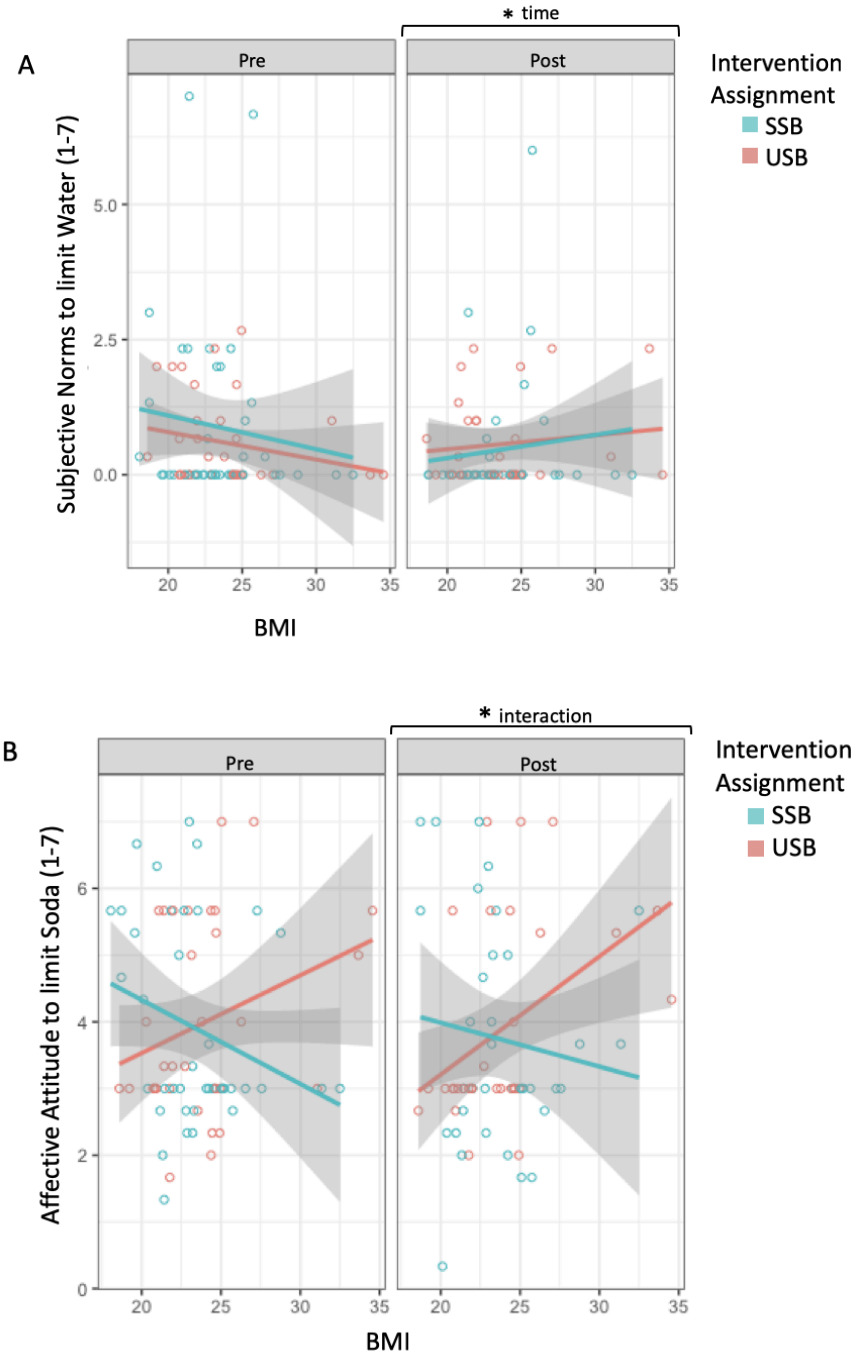


Figure 2: Graphical representation of statistically significant effects of time and assigned beverage sweetness on TPB measures




* P<0.05, Linear mixed model with random slope and random intercept by participant; time and beverage assignment as fixed effects on TPB constructs
A: Behavioral Intention toward water consumption; B: Subjective Norms toward water consumption; C: Perceived Behavioral Control toward water consumption; D: Perceived Behavioral Control toward regular soda consumption

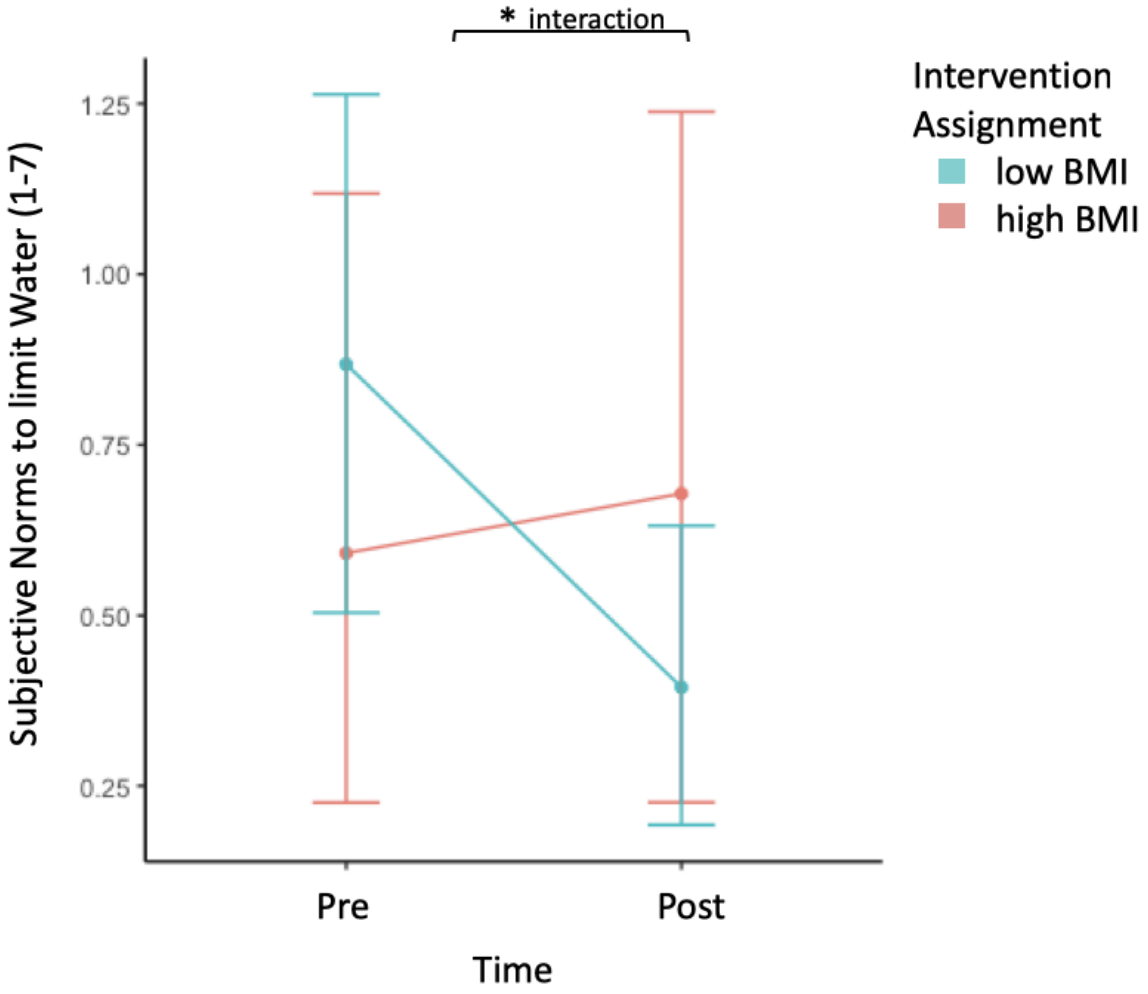
Figure 3: Graphical representation of statistically significant effects of time, assigned beverage sweetness, and BMI on TPB measures




Significant results are denoted as *, P<0.05; Linear mixed model with random slope and random intercept by participant; time, beverage assignment, and body mass index (BMI) as fixed effects on TPB constructs

A: Subjective Norms toward water consumption; B: Affective Attitude to limit Soda

Figure 4: Graphical representation of statistically significant interaction between BMI and time on subjective norms to limit water consumption




Significant results are denoted as *, P<0.05; Linear mixed model with random slope and random intercept by participant; time, beverage assignment, and body mass index (BMI) as fixed effects on TPB constructs