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Predicting sugar-sweetened behaviours with theory of planned behaviour constructs: Outcome and process results from the SIPsmartER behavioural intervention

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Abstract

Objective—Guided by the theory of planned behaviour (TPB) and health literacy concepts, SIP*smart*ER is a six-month multicomponent intervention effective at improving SSB behaviours. Using SIP*smart*ER data, this study explores prediction of SSB behavioural intention (BI) and behaviour from TPB constructs using: (1) cross-sectional and prospective models and (2) 11 single-item assessments from interactive voice response (IVR) technology.

Design—Quasi-experimental design, including pre- and post-outcome data and repeated-measures process data of 155 intervention participants.

Main Outcome Measures—Validated multi-item TPB measures, single-item TPB measures, and self-reported SSB behaviours. Hypothesised relationships were investigated using correlation and multiple regression models.

Results—TPB constructs explained 32% of the variance cross sectionally and 20% prospectively in BI; and explained 13–20% of variance cross sectionally and 6% prospectively. Single-item scale models were significant, yet explained less variance. All IVR models predicting BI (average 21%, range 6–38%) and behaviour (average 30%, range 6–55%) were significant.

Conclusion—Findings are interpreted in the context of other cross-sectional, prospective and experimental TPB health and dietary studies. Findings advance experimental application of the TPB, including understanding constructs at outcome and process time points and applying theory in all intervention development, implementation and evaluation phases.

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Disclosure statement

No potential conflict of interest was reported by the authors.

Keywords

theory of planned behaviour; beverages; behavioural research; quasi experimental; rural population

Background

Excessive sugar-sweetened beverages (SSB) consumption is a highly publicised public health concern. SSB are defined as drinks that contain caloric sweetener, including soft drinks, fruit drinks, sports drinks, energy drinks, sweetened milk and tea and coffee with added sugar. SSB contributes approximately 7% of total energy intake for US adults (Kit, Fakhouri, Park, Nielsen, & Ogden, 2013), and the recommendation of eight fluid ounces per day are being exceeded (Johnson & Yon, 2010). Furthermore, disparities in SSB intake are apparent, as SSB intake is higher among lower socioeconomic and rural adults (Sharkey, Johnson, & Dean, 2011; Thompson et al., 2009; Zoellner, Estabrooks, Davy, Chen, & You, 2012).

While strong scientific data indicate associations among SSB and numerous health issues such as obesity, diabetes, cardiovascular disease, caries and oral health (Fung et al., 2009; Ismail, Sohn, Lim, & Willem, 2009; Johnson et al., 2009; Malik, Schulze, & Hu, 2006; Vartanian, Schwartz, & Brownell, 2007), there has been little attention on evidence-based behavioural interventions to reduce SSB consumption among adults (Tate et al., 2012). While behavioural interventions guided by theory are known to be more effective in changing behaviours (Painter, Borba, Hynes, Mays, & Glanz, 2008), no known theory-based intervention studies aimed at reducing SSB in adults exist, including among low socioeconomic, rural adults who are at high risk of excessive SSB consumption.

The theory of planned behaviour (TPB) is a commonly used theory for predicting behaviour and has been applied to a wide variety of health contexts, including dietary behaviours (Ajzen, 1991; Armitage & Conner, 2001; Conner, Norman, & Bell, 2002; Godin & Kok, 1996; Hardeman et al., 2002; McDermott, 2015). The TPB posits that behavioural intention (BI) is the most proximal determinant of a person's behaviour and that both BI and perceived behavioural control (PBC) can adequately predict behaviour (Ajzen, 1985, 1991, 2002). BI refers to what an individual plans, rather than hopes, to do and PBC refers to the beliefs related to the perceived ease or difficulty of completing a particular behaviour. PBC can exert a direct effect on behaviour, as well as an indirect effect through BI. Other antecedents to BI include an individual's attitudes (i.e. one's positive or negative evaluation towards performing the behaviour) and subjective norms (SN) (i.e. one's perception about the social expectations and motivation to comply with those expectations). According to the TPB, individuals will have a stronger BI to change SSB, when they feel they can do so without difficulty, hold a more positive attitude and perceive social pressure from those who they value. The likelihood that individuals would improve SSB behaviours is influenced by this BI and their perception of capability (Ajzen, 1985, 1991, 2002).

Numerous systematic reviews summarise the usefulness of the TPB to predict BI and behaviours. (Armitage & Conner, 2001; Godin & Kok, 1996; McDermott, 2015; McEachan, Conner, Taylor, & Lawton, 2011). According to these reviews, attitudes, SN and PBC explain about 40–50% of the variance in BI. The variance in predicting behaviour has been found to be lower, with BI and PBC predicting about 14–24% of the variance in health behaviours, and around 20% when predicting dietary behaviours. Relative to these reviews and the evaluation of TPB in the context of specific health and nutrition behaviours (e.g. fruit and vegetables, fat), there is value in exploring fluctuations in SSB-specific cognitions as well as comparing and contrasting the ability of TPB to predict both SSB behaviours and BI and examine. However, there is a lack of TPB literature specific to excessive SSB consumption (McDermott, 2015).

While the aforementioned reviews indicate the TPB is a reliable predictor of BI and behaviours, a number of limitations are also apparent. First, there is a dearth of experimental research studies that apply the TPB. Even among experimental studies, assessment of TPB constructs are typically limited to pre- and post-intervention snapshots that do allow for consideration of how programme strategies influence TPB constructs throughout the intervention process. Second, inferences from some prior reviews are unclear since conclusions are drawn only on one cross-sectional analyses conducted at one point in time. These analyses seldom examine cross sections at multiple points over time and rarely address the temporality of associations underlying the TPB (i.e. TPB constructs are often used to predict current behaviours, not future behaviours). Third, procedures for developing behavioural specific TPB scales are well-defined, and scales are typically formulated with multiple items per construct using either 5- or 7-point scales (Conner & Sparks, 2005; Glanz, Rimer, & Viswanth, 2008). However, from a pragmatic perspective, when TPB scales are administered at continuous time points over an intervention, understanding the usefulness of single-item scales are needed to promote ease of use and reduce participant burden (de Boer et al., 2004). Addressing these opportunities, including evaluation of process data and prospective modelling of TPB constructs, could provide interventionist with valuable information to improve application and interpretations of TPB-guided behavioural trials.

By applying the TPB in an experimental SSB intervention, this study attempts to address these gaps in the literature. This investigation is a secondary analysis of a six-month, two-arm, matched-contact randomised control trial, Talking Health (Zoellner et al., 2014, 2016). Talking Health targets the Appalachian region of southwest Virginia, where SSB consumption is over three times the national average (Zoellner et al., 2012). The primary trial aim was to determine the effectiveness of a health behaviour intervention on reducing sugar-sweetened beverage intake (SIP*smart*ER) as compared to a matched-contact comparison group. The multicomponent intervention was guided by the TPB (Ajzen, 1985, 1991), health literacy concepts (Berkman et al., 2011), and the RE-AIM evaluation framework (Glasgow, Vogt, & Boles, 1999). Relative to the comparison group, SIP*smart*ER participants significantly improved SSB behaviours (i.e. decrease in kcals and fluid ounces/day), significantly decreased BMI and significantly improved SSB-related attitudes, PBC, and BI (Zoellner et al., 2016). However, the underlying TPB framework to examine predictors of SSB BI and behaviour change have not yet been explored.

Study purpose

Using SIP*smart*ER outcome data, the first objective is to explore and contrast the static prediction of SSB behaviour and BI using cross-sectional models (i.e. at baseline and at six-months) vs. dynamic prediction using prospective models (i.e. baseline TPB constructs prediction of 6-month behaviours). The prediction models were explored using validated multi-item measures (Zoellner et al., 2012), as well as single-item measures. Using process data, the second objective is to explore the prediction of SSB BI and behaviour when assessed via interactive voice response (IVR) telephone calls at 11 time points throughout the intervention. These 11 IVR calls were used as both an intervention and data collection point. Participants were guided through behaviour tracking and action planning processes and received brief theory-based messages. Data about SSB behaviour, BI and TPB constructs were collected. We hypothesised (1) variance similar to other systematic reviews and that cross-sectional analyses will have the largest amount of variance explained in BI and SSB behaviours and (2) the prospective models will have lower explained variance as intervention strategies are intended to change TPB constructs over the 6-month period. We also anticipated that the single-item measures would have significant, yet somewhat less, predictive capabilities as compared to multi-item measures.

Methods

Study design and intervention structure

The current investigation employs a quasi-experimental design, including pre- and post-outcome data and repeated-measures process data. The Institutional Review Board at Virginia Tech approved the study, and all participants gave written informed consent prior to participation. Gift cards in the amounts of $25 and $50 were given at each of the baseline and six-month assessments, respectively, as a compensation for the participants' time.

Two formative studies assisted in SIP*smart*ER content development, including an elicitation study to determine behavioural, normative and control beliefs in the targeted Appalachian region (Zoellner et al., 2012) and a TPB quantitative study to determine appropriate construct targets (Zoellner et al., 2012). Complete details on the trial methods, recruitment strategies, intervention structure, theoretical constructs and key learning objectives for SIP*smart*ER as well as primary outcomes can be found elsewhere (Zoellner et al., 2014, 2016). In brief, the six-month intervention included three small group educational classes, one teach-back call and 11 IVR phone calls. The small group classes were approximately 90–120 min and were delivered during weeks one, six and 17. During classes, participants completed personalised action plans, which included setting behavioural goals and identifying barriers and strategies for overcoming them. Behavioural diaries were also provided to participants to encourage them to record their behaviour (fluid ounces of SSB) daily, since this information was reported during the IVR calls. For participants who were unable to attend class, a missed a class packet was mailed that outlined key content information. About a week later a research assistant called participants and used a semistructured script to verbally review the class information.

A teach-back call was delivered approximately one week following the first class (Porter et al., 2016). Using a structured script, research assistants asked participants to teach-back key concepts from the first class, to explain how they tracked their behaviours and calculated weekly averages. On average, the teach-back call lasted 18.6 (SD = 5.6) minutes.

The purpose of the IVR calls were to reinforce key intervention class messages, introduce new content, deliver brief theory-based messages and guide participants through behaviour tracking and the action planning process. Participants received the IVR calls, weekly for the first three weeks and bi-weekly for the remainder of the intervention. At the beginning of each call, participants were prompted to enter their behaviour from the previous week that they had recorded in their behavioural diaries (fluid ounces of SSB). Based on their progress, participants were routed in one of the three paths: (1) meeting or exceeding goals, (2) not meeting goals, but some progress (i.e. reduction, but not to the planned level), and (3) no progress. Behavioural reinforcement strategies based on the TPB were customised for each path and were intended to increase BI and bolster perceptions of behavioural control. The action planning process guided participants to set new realistic goals for the upcoming weeks and to identify the barriers and strategies to overcome them. IVR calls three to eleven were concluded with supportive messages based on the TPB constructs, health literacy concepts and upcoming classes (details of targeted constructs at each call previously published) (Zoellner et al., 2014). The calls concluded with four single-item TPB construct questions related to instrumental attitudes, affective attitudes, SN and PBC (described further below, see Table 1). The length of IVR calls varied depending on the duration of barriers and strategies identification, but on average latest 6.9 (SD = 1.9) minutes.

Target population, eligibility and recruitment

The Talking Health trial targeted residents from eight rural southwest Virginia counties. Most of the residents in the targeted counties are White (94.6%), 18% of residents lived below poverty line and the educational attainment was low with 58% having received a high-school diploma or less (‘US Census Bureau,’ 2013).

To be eligible to participate in the study, individuals needed to be fluent in English, be 18 years old or older, consume at least 200 calories from SSBs per day (Hedrick et al., 2012), have no contraindications for moderate-intensity physical activity (Thomas, Reading, & Shephard, 1992) and have reliable access to a telephone. Several strategies were used to reach the target population including flyers, newspaper and radio advertisements, targeted postcard mailings and word of mouth. Research assistants actively recruited participants from community locations including libraries, community colleges, free health clinics, churches, health fairs, childcare centres and festivals. Demographics characteristics were also assessed upon screening.

Outcome data: Theory of planned behaviour constructs & sugar-sweetened beverages

A computer-audio-assisted assessment was used to assess baseline and six-month TPB constructs and beverage intake (Riebl et al., 2013). The validated TPB questionnaire included 14-items, across five subscales, with responses on a 7-point Likert scale (Zoellner et al., 2012) Baseline data indicated acceptable internal consistency for each sub-scale (α = 0.62–0.83) (Table 1) (Gliem & Gliem, 2003).

The BEVQ-15, a validated food-frequency questionnaire, was used to assess past month beverage consumption for 15 beverages (Hedrick et al., 2012). This instrument queries both beverage frequencies (i.e. never or less than 1 time/week, 1 time/week, 2–3 times/week, 4–6 times/week, 1 time per day, 2 times per day, or 3 or more times per day) and portion sizes (i.e. less than 6, 8, 12, 16 or more than 20 fluid ounces). SSB intake is quantified by summing kilocalories and/or fluid ounces from five categories including regular soft drinks, sweetened juice beverage/drink, sweetened tea, coffee with sugar and energy and sports drinks.

Process data: Theory of planned behaviour constructs & sugar-sweetened beverages

A single-item indicator, with strong face and content validity, was selected from four of the multi-item TPB subscales constructs including instrumental attitudes, affective attitudes, SN and PBC (Table 1). These single items were assessed at the teach-back and 11 IVR calls and were measured on a 7-point Likert scale. At baseline, single-items were highly correlated with the multi-item scales ($r = 0.75–0.87$; $p < 0.001$) (Table 1). The SSB BI process variable was conceptualised as the reported goal for fluid ounces of SSB. The SSB behavioural process variable was operationalised as the reported average daily fluid ounces reported during the previous week from the SSB behavioural diaries. Using the IVR system, participants reported their responses through manual entry with their phone key pad or used speech recognition.

Data analysis

All statistical tests were completed using SPSS version 24 (SPSS, Inc, Chicago, Illinois). Descriptive statistics were used to summarise demographic variables. Cronbach alphas and Pearson’s correlations were used to determine the internal consistency of multi-item measures and to explore the relationships among variables. TPB relationships were investigated using sequential multiple regression models, which allows variable entry in a pre-determined order and focuses on changes in the proportion of total variance (R^2) (Keith, 2006). Importantly, the TPB informed the sequential variable entry. When predicting BI (dependent variable), PBC was added in step one and step two included instrumental attitudes, affective attitudes and SN. When predicting SSB behaviours (dependent variable), step one included BI and step two included PBC. To test our hypotheses and explore differences in multi-item vs. single-item measures, a variety of models were explored for the prediction of BI and the prediction of behaviours: (1) cross-sectional analysis at baseline and at six-months and (2) prospective analysis to test baseline TPB constructs prediction of 6-month behaviours. For outcome data, analyses were performed using present at follow-up data; therefore, sample sizes fluctuate somewhat due to missing responses. For IVR process data models, missing data were imputed from Poisson count data prediction models that predict the missing IVR process outcomes based on age, gender, race, marital status, education, work status, disability or not, household income, child presence and the participant’s baseline health literacy status (Cameron & Trivedi, 2005). Based on outlier analysis, six cases were removed from the process analysis for having SSB values > 2.5 SD above the mean (two participants at IVR Call 1 and one participant each at IVR Calls 2, 5, 6, and 9).

To detect a moderate effect size with 80% power and an alpha of 0.05, the multiple regression analyses rule-of-thumb ($n \geq 50 + 8\ m$, where m equals the number of predictor variables) was applied (Green, 1991). A priori hypotheses included a maximum of four predictor variables per model, indicating ≥82 participants are need to provide sufficient power. Our models range from 106 to 155 participants, indicating sufficient power.

Results

Of the 301 participants enrolled, 155 were randomised to SIP*smart*ER and are included in these analyses. The majority of SIP*smart*ER participants were female (81.3%) and Caucasian (91%), with a mean age of 41.4 ± 13.45. Additionally, 33.5% of participants completed less than or equal to high school education, 58.1% earned less than $20,000 per year, 36.8% reported no health insurance, and 34.2% were classified as low health literate.

Of the 155 SIP*smart*ER participants, 114 (74%) completed the 6-month assessment. Class attendance averaged 56% and missed class call completion averaged 12%, for an overall class content receipt rate of 68%. The teach-back call was completed by 67% of the participants and average completion rate for the 11 IVR calls was 53%.

Correlations between SSB and TPB constructs

Using multi-item measures, Table 2 illustrates the correlations matrix, means and standard deviations at baseline (time one) and 6 months (time two). The means illustrate a decrease in SSB from baseline [42.9 (SD = 30.9) fluid ounces] to 6 month [16.3 (SD = 20.3) fluid ounces], as well as improvements in all TPB constructs from baseline to 6 month. Negative correlations are expected between SSB behaviour the TPB constructs (i.e. lower SSB behaviour fluid ounces correlate with higher TPB perceptions) and positive correlations among TPB constructs. At baseline, SSB behaviours were significantly correlated with BI ($r = -0.37$), PBC ($r = -0.30$) and affective attitude ($r = -0.41$), but not with instrumental attitude or SN. BI were significantly correlated with PBC ($r = 0.44$), affective attitude ($r = 0.38$), instrumental attitudes ($r = 0.32$) and SN ($r = 0.24$). At six months, SSB was significantly correlated with all TPB constructs ($r = -0.24$ to -0.51) and BI were significantly correlated with all TPB constructs ($r = 0.24$ to 0.44). Correlations among T1 and T2 constructs are also illustrated in Table 2. As anticipated, the strongest correlations between time points are among matched constructs ($r = 0.26$ to 0.47) with PBC ($r = 0.47$) and SN ($r = 0.40$) having the strongest correlations.

Outcome data: Prediction of SSB behavioural intention

The regression of BI onto TPB variables, for both single-item indicators and multi-item scales are presented in Table 3. The variance in the multi-item cross-sectional analysis to predict BI was 32% at baseline and 32% at 6 months. The variance in the multi-item change score model using changes in PBC, affective attitude, instrumental attitudes and SN to predict change in BI was 20%. Compared to multi-item measures, single-items yielded less prediction in variance: 21% at baseline and 20% at 6 months. Positive β coefficients were expected for attitudes, SN and PBC variables (i.e. as these TPB constructs improve, BI on Likert scale improve). PBC consistently contributes greatest to predicting BI (β coefficients = 0.26–0.47). The β coefficients for attitudes and SN were also significant in multi-item baseline models, but not in the other models.

Outcome data: Prediction of SSB behaviours

Table 4 illustrates results when SSB is regressed onto BI and PBC. The amount of variance in the cross-sectional analysis to predict SSB behaviour was 11% at baseline and 21% at 6 months. The variance in the prospective model using baseline BI and PCB to predict 6-month SSB behaviour was 6%. Negative β coefficients are expected for BI and PBC constructs (i.e. as these TPB constructs improve, SSB behaviour fluid ounces decreases). BI consistently contributes greatest to predicting behaviours (β coefficients = −0.21 to −0.44). PBC does not significantly contribute to any of the models.

Process data: SSB behaviour, behavioural intentions and TPB constructs from interactive voice response calls

IVR call completion averaged 53% (range 47.7–58.7%). Among all participants, the proportion of those achieving goals averaged 37.6% (range 28.8–42.6%), those making some progress averaged 5.7% (range 0.6–18.1%) and those who did not make progress averaged 11.2% (range 6.5–15.6%). As described in Table 5, both SSB behaviours and BI (or goal set amount) improved over time. At the teach-back call, the SSB behaviour and BI were 20.2 and 21.1 fluid ounces, respectively; whereas at IVR call, 11 these values improved to 7.7 and 6.8 fluid ounces, respectively. On average, PBC (range 6.3–6.5) was rated higher than other TPB constructs and instrumental attitudes (range 5.0–5.4) rated somewhat higher than affective attitudes (range 4.6–5.1) and SN (range 4.4–5.0). There were no clear discernable patterns of fluctuations in TPB constructs across the IVR calls.

Process data: Prediction of SSB behavioural intention from interactive voice response calls

Of the 12 IVR regression models to predict BI, all were significant and explained 21% of the variability, on average (range 6% to 38%) (Table 6). The proportion of explained variance generally increased later in the intervention. Since BI in these models were operationalised as goal set amount, negative β coefficients are expected for PBC, attitudes and SN constructs (i.e. as these TPB constructs improve, SSB goal fluid ounces decreases). PBC consistently contributed the most to these models, with significant β coefficients in 10 of 12 models, ranging from −0.26 to −0.69. Subjective norms contributed to six of the models in the direction as hypothesised, and all in the latter half of the intervention (β coefficients −0.11 to −0.24). In IVR call 1, SN significantly contributed in the opposite direction as hypothesised (β coefficient = 0.22). While affective attitudes and instrumental attitudes significantly contributed to the four models, three (IVR calls 4, 8 and 9) were not in the direction hypothesised.

Process data: Prediction of SSB behaviours from interactive voice response calls

All nine IVR models to prospectively predict SSB behaviours were also significant, averaging 30% of predicted variability (range 6–55%) (Table 7). Positive β coefficients were expected for BI (i.e. as SSB goal fluid ounces decreases, SSB behaviour fluid ounces decreases), whereas negative β coefficients are expected for PBC constructs (i.e. as PBC on Likert scale improves, SSB behaviour fluid ounces decreases). BI were consistent predictor of SSB intake in all of the models (β coefficients = 0.18 to 0.69). The addition of PBC in Step 2 significantly contributed to the R^2 increase in two models and yielded significant β coefficients (i.e. IVR call 9–10 and 10–11), but not in the other models.

Discussion

To our knowledge, this is the first TPB investigation to provide process data on TPB models at regular time points throughout a behavioural intervention and to examine the usefulness of single-item vs. multi-item TPB measures. Our paper also contributes to the literature by comparing the amount of variance when cross-sectional and prospective data are examined. A major strength of SIP*smart*ER was application of the TPB to guide cognitive targets for SSB behaviour change. Two formative TPB studies, including an elicitation study (Zoellner et al., 2012) and quantitative study (Zoellner et al., 2012) in the targeted Appalachian region proved to be extremely valuable in developing theory-based and cultural appropriate targeted messages. The steady improvement in SSB behaviours illustrated in Table 5, and the significant 0–6 month improvements in SSB behaviours and TPB constructs (Zoellner et al., 2016) can be attributed to a robust theory-driven approach.

Similar to other studies, the cross-sectional analyses explained ~30% of the variance in BI and was reduced when examined temporally using change in attitudes, SN and PBC (Armitage & Conner, 2001; Godin & Kok, 1996; McEachan et al., 2011). For example, Godin found that health-related behaviours are typically predicted with 34% variance with dietary behaviours at 25% variance, whereas McEachan found dietary behaviours 21% of explained variance. The prediction of SSB behaviour followed the same pattern – stronger relationships cross sectionally and weaker relationships when assessed prospectively (Manning, 2009; McEachan et al., 2011). These changes in the strength of relationship are not surprising given the principle of compatibility formulated by Fishbein and Ajzen (2010). Specifically, the relationships between TPB constructs and behaviour are hypothesised to be stronger when the assessment of each are correspondent in terms of the action (behaviour), target (the participant), context (the presence or absence of intervention) and time (baseline, 6 months). As such, the less correspondent the assessment of TPB constructs are to the behavioural assessment the weaker the relationship. In our study, concurrent assessments of behaviour at baseline and 6 months (i.e. cross-sectional analyses) have the strongest relationships. This is consistent with the principle of correspondence. The reduced magnitude of relationship between TPB variables assessed at baseline and behaviour assessed at 6 months is also consistent with the principle of correspondence due to the changing context (intervention is introduced) and time (assessment of cognitions and behaviour are more distal). Specifically, SSB content and behavioural strategies provided during the 6-month intervention were purposefully developed and implemented to influence the TPB constructs over a 6-month period.

When examining the process data, PBC was high immediately following the teach-back call and remained higher than the other TPB constructs throughout the intervention. This is likely attributed to the use of personalised action plans at each intervention time point (i.e. classes, teach-back call and IVR calls), which is a behavioural change strategy used specifically to target perceptions of control. Of the targeted theoretical constructs at each intervention point (Zoellner et al., 2014), PBC was targeted most frequently and consistently. Also, PBC was constantly the strongest predictor for BI, a finding that aligns with other TPB studies. However, we anticipated that attitudes and SN would also predict BI, which occurred at baseline, but not within the prospective or change models. When predicting behaviour, BI was consistently the strongest predictor, a finding that is also supported in the literature. Yet contrary to our theoretical hypothesis, PBC did not significantly add additional behavioural prediction beyond BI. Our correlation matrix can be compared to a recent review of dietary studies which compared TPB correlation differences between healthy eating patterns and restricted eating patterns and provide some insight into this finding (McDermott, 2015; McDermott et al., 2015). Relative to McDermott's findings on restrictive eating patterns, which fit the classification of the SSB behaviours targeted in our intervention, our correlations for PBC-BI and BI behaviour are remarkably similar; however, our PBC behaviour correlation is somewhat stronger and our attitude-BI and SN-BI is considerably weaker. This finding suggests that avoiding health compromising SSBs may evoke different cognitions as compared to choosing health promoting foods (e.g. fruits and vegetables) and even to other health compromising foods (e.g. high calorie snacks, junk food). While still significant, SN provided the weakest association with BI and contributed little to the prediction models. This finding implies that perceptions about social expectations of consuming SSB have less influence on SSB behaviours.

In addition to the single items having good content validity and high correlation with multi-item, they also had similar, yet somewhat less predictive capabilities as multi-item measures. The direction and level of significance between single- and multi-item scale is consistent with theorised relationships, with the exception of the baseline model for instrumental and affective attitudes. In both multi- and single-item scales, the PBC consistently provides the greatest prediction for BI. Although multi-item scales are typically preferred over single-item measures because of increased reliability, single-item scales have successfully been used in other types of health-related and social science studies (Berlin, Singleton, & Heishman, 2013; de Boer et al., 2004; Cunny & Perri, 1991; Kotz, Brown, & West, 2013). Single items are often criticised because of their vulnerability to measurement errors, and potential bias in meaning and interpretation (Hoeppner, Kelly, Urbanoski, & Slaymaker, 2011). Yet from a practical point of view, single-item indicators offer advantages such as shorter survey length, lower respondent burden and reduced costs (Hoeppner et al., 2011). Our study provides emerging evidence for the utility of single-item indicators for attitude, SN and PBC constructs.

Importantly, all the IVR regression models were significant, including the 12 BI models that explained approximately 21% of variability on BI (range 6–38%) and the nine prospective

IVR regression models that explained about 30% of variability on BI (range 6–55%). The average amount of variance in these process models align with other reviews. This is attributed, in part, to the more temporally matched nature of TPB cognition and SSB behavioural assessments, as the IVR calls were spaced one to four weeks apart when compared to the 6 month time period between baseline and assessment of the primary outcome. As compared to longer follow-ups, the TPB is known to provide stronger prediction with shorter follow-up due to a closer temporal correspondence between TPB construct and SSB behavioural assessments (McEachan et al., 2011). Also, our analytical approach in these process IVR calls respect the causal associations underlying the TPB, where current PBC and BI are used to predict future behaviours. It is worth noting that every IVR call targeted PBC and BI. For example, BI were facilitated by goal setting and PBC was facilitated by the identification of barriers and strategies. During intervention development, this decision was made based on theory tenants and the abundance of TPB research that demonstrates the direct relationships with PBC and BI on behaviours. Our preliminary data also emphasised the contributions of BI and PBC on behaviours (Zoellner et al., 2012). The menu of barriers and strategies were primarily identified from the formative phases guiding the development of SIPsmartER (Zoellner et al., 2012).

Two methodological implications should be considered when interpreting our findings. First, the BI scale is operationalised differently in the outcome (i.e. Likert scale) and process (i.e. ounces of goal set) measures. While both measures align with construct definitions, this variation in measurement may attribute to differences seen in the outcome vs. process regression models and also influence the hypothesised direction of beta coefficients (Courneya, 1994). Second, the IVR call completion was 53%. While we appropriately used last-observation data forward approach, the missingness patterns may also influence interpretation of the process data models. However, to support consistency in analytic approach between outcome and process data, we also computed the IVR process data models using only present at follow-up data. A few nuanced differences emerged with the present at follow-up data models, most notably the R^2 tended to increase approximately 2–6% in the BI prediction models and increase approximately 20% in the SSB prediction models. In Tables 6 and 7, we illustrate the more conservative models using imputed data and do not provide present at follow-up models from our process data due to concerns with small sample sizes. Notwithstanding these limitations, our study was conducted in a medically underserved region with known disparities in SSB behaviours, was adequately powered, used TPB behaviour instruments with good scale properties, used less-subjective behaviour assessment methods (e.g. food-frequency questionnaire and diaries) and applied experimental methods at both outcome and process levels to understand and advance practical application of the TPB.

Our findings fill several gaps in the TPB literature and also indicate a number of opportunities for future research. In future intervention studies, it would be of interest to determine whether IVR could be targeted to improve low TPB constructs. In our study, the goal setting process and behavioural reinforcement strategy was tailored based on SSB goal progress, yet the supportive messages (e.g. PBC, SN, Attitudes) were consistent for all participants, regardless of their TPB construct ratings. Focused manipulation in this manner, would help further advance the practical application of TPB-guided interventions. On the contrary, this would substantially complicate programmatic features of the IVR system. Within our current intervention data, additional research is also needed to determine the role of past SSB behaviour, intention stability and potential moderating variables (e.g. age, gender, SES) in the prediction models. Exploring these factors with experimental data would provide additional insights into unique aspects of factors that influence changes in SSB behaviours.

Conclusion

Despite heighted focus regarding the impact of SSB overconsumption on poor health and chronic disease, there has been little attention on theory-based behavioural interventions to reduce SSB consumption among adults, particularly among low SES, rural adults who are at great risk for high SSB consumption. SIP*smart*ER is the first known theory-based intervention to explicitly focus on SSB behaviours among adults. Our intervention addresses several limitations noted in a systematic review regarding the use of TPB in behaviour change interventions (Hardeman et al., 2002), including application of the TPB in all phases of the intervention reduce SSB consumption, including development, implementation and evaluation. Our findings document important differences when using the TPB to explain variance in behaviour and BI cross sectionally and prospectively. In our innovative behavioural strategies, we use a combination of small group class and IVR technology to address underlying behavioural cognitions contributing to overconsumption of SSB. Our work can be applied by other behavioural interventionist who wish to use single-item indicators in intervention process evaluations to understand changes in cognition throughout an intervention. Understanding ongoing theoretical relationships is crucial, so that effective theory-based behavioural interventions, like SIP*smart*ER, can be better targeted, adapted and translated to other high-risk populations.

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Table 1

Correlations between sugar-sweetened beverage theory of planned behaviour single-item indicators and multi-item scales ($n = 151$).

Construct	Number of questions in multi-item scale	Cron-bach's α	Sample size	Questions[a]	Pear-son's Correla-tion[b]
Behavioural intentions	2	0.83	151	You plan to limit your sugary drinks to less than 1 cup each day. *Disagree/agree* How many days per week do you intend to limit your sugary drinks to less than 1 cup? *0–7*	n/a
Perceived behavioural control	3	0.68	151	**Limiting your sugary drinks to less than 1 cup of sugary drinks each day if you wanted to do so would be:** ***Easy/difficult*** You have complete personal control over limiting your sugary drinks to less than 1 cup each day, if you really wanted to. *Disagree/agree* Limiting your sugary drinks to less than 1 cup each day is mostly up to you if you wanted to. *Disagree/agree*	0.75[c]
Affective attitudes	3	0.74	151	**For you, drinking less than 1 cup of sugary drinks each day would be:** ***Enjoyable/unenjoyable*** *Pleasant/unpleasant* *Exciting/unexciting*	0.87[c]
Instrument-al attitudes	3	0.80	153	**For you, drinking less than 1 cup of sugary drinks each day would be *Healthy/unhealthy*** *Wise/unwise* *Harmful/beneficial*	0.86[c]
Subjective norms	3	0.62	152	**Most people who are important to you want you to drink less than 1 cup of sugary drinks each day.** ***Agree/disagree*** For most people whose opinions you value, how would they feel about you drinking less than 1 cup of sugary drinks each day? *Disapprove/approve* Most people who are important to you will drink less than 1 cup of sugary drinks each day. *Untrue/true*	0.81[c]

Note: responses to all questions are on a 7-point Likert scale.

[a]The single-item indicator question is bolded. The response scale is italicised.

[b]Pearson's Correlation comparing single-item indicator to multi-item scale using baseline data.

[c]All correlations between the single-item indicators and multi-item scales are significant at $p < 0.001$.

Table 2

Correlations between sugar-sweetened beverage behaviour and theory of planned behaviour using multi-item measures at baseline (T1) and six-month assessment (T2).

	SSB T1	BI T1	PBC T1	AA T1	IA T1	SN T1	*n*	Mean (SD)
SSB T1	1.00						154	42.9 (30.9)
BI T1	−.37**	1.00					151	4.4 (2.0)
PBC T1	−.30**	.44**	1.00				151	5.2 (1.5)
AA T1	−.41**	.38**	.41**	1.00			151	3.7 (1.3)
IA T1	−.02	.32**	.11	.11	1.00		153	5.4 (1.4)
SN T1	.09	.24**	.13	−.09	.21**	1.00	152	4.8 (1.3)
	SSB T2	BI T2	PBC T2	AA T2	IA T2	SN T2	*n*	Mean
SSB T2	1.00						114	16.3 (20.2)
BI T2	−.51**	1.00					113	6.0 (1.5)
PBC T2	−.36**	.43**	1.00				113	6.0 (1.2)
AA T2	−.25**	.33**	.43**	1.00			114	4.6 (1.4)
IA T2	−.24**	.41**	.20*	.28**	1.00		114	6.3 (1.1)
SN T2	−.22*	.23*	.08	.30**	.33**	1.00	114	5.2 (1.4)
	SSB T1	BI T1	PBC T1	AA T1	IA T1	SN T1	*n*	Mean
SSB T2	.26**	−.21*	−.21*	−.17	−.01	−.04	110–113	–
BI T2	−.13	.37**	.26**	.09	.14	.001	109–112	–
PBC T2	−.26**	.20*	.47**	.22*	.001	−.02	109–112	–
AA T2	−.24*	.33**	.24*	.33**	.08	.06	110–113	–
IA T2	−.15	.24*	.16	−.07	.35**	.11	110–113	–
SN T2	−.19*	.22*	.01	−.09	.12	.40**	110–113	–

Notes: SSB = fluid ounces of sugar-sweetened beverages reported, BI = behavioural intention scale, PBC = perceived behavioural control scale, AA = affective attitudes scale, IA = instrumental attitudes scale, SN = subjective norms scale.

* $p < 0.05$;

** $p < 0.01$.

Table 3

Prediction of sugar-sweetened beverage behavioural intention (BI) from theory of planned behaviour constructs: cross-sectional models and multi-item vs. single-item measures.

		Baseline time point cross sectional[a] n = 148		Six-month time point cross sectional[b] n = 113	
		Multi item	**Single item**	**Multi item**	**Single item**
Step 1 Model	R^2	.16***	.17***	.27***	.13***
Step 2 Model	R^2	.32***^	.21***^	.32***^	.19***^
Perceived behavioural Control (PBC)	β Step 2	.26***	.37***	.47***	.32**
Affective attitudes	β Step 2	.31***	.14	.09	.09
Instrumental Attitudes	β Step 2	.17*	.12	.15	.17
Subjective norms (SN)	β Step 2	.23***	.16*	.10	.16

Notes: Step 1 included PBC and Step 2 included addition of instrumental attitudes, affective attitudes, and SN. Analysis performed using present-at-follow-up data; variations in sample size are due to loss to follow-up at six months and missing data.

^ $R^2\Delta < 0.05$

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$;

[a] Baseline time point cross sectional: PBC, attitudes, and SN to predict BI.

[b] Six-month time point cross sectional: PBC, attitudes, and SN to predict BI.

Table 4

Prediction of sugar-sweetened beverage (SSB) behaviour from theory of planned behaviour constructs: Cross-sectional and prospective models.

		Baseline time point cross sectional[a] ***n*** **= 149**	**6-month time point cross sectional**[b] ***n*** **= 113**	**Baseline to 6-month prospective**[c] ***n*** **= 109**
Step 1 Model	R^2	.09 ***	.21 ***	.07 **
Step 2 Model	R^2	.11 ***	.21 ***	.06 *
behavioural Intentions (BI)	*β* Step 2	−.24 **	−.44 ***	−.27 **
Perceived behavioural control (PBC)	*β* Step 2	−.16	−.06	−.03

Notes: Step 1 included BI and Step 2 included addition of PBC. Analysis performed using present-at-follow-up data; variations in sample size are due to loss to follow-up at six months and missing data.

^ $R^2 \Delta < 0.05$

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$;

[a] Baseline time point cross sectional: BI and PBC to predict SSB behaviour.

[b] 6-month time point cross sectional: BI and PBC to predict SSB behaviour.

[c] Baseline to 6-month prospective: Baseline BI and PBC to predict 6-month SSB behaviour.

Table 5

Goal achievement, reported behaviour and behavioural intentions and theory of planned behaviour constructs for the IVR calls.

	Call	TB *n* = 155	IVR1 *n* = 153	IVR2 *n* = 154	IVR3 *n* = 155	IVR4 *n* = 155	IVR5 *n* = 154	IVR6 *n* = 154	IVR7 *n* = 155	IVR8 *n* = 155	IVR9 *n* = 154	IVR10 *n* = 155	IVR11 *n* = 155
Fluid ounces reported (Behaviour)	Mean	20.2	30.0	25.0	19.5	17.2	12.5	9.7	8.9	9.5	9.5	7.1	7.7
	(SD)	(21.5)	(29.2)	(21.1)	(17.5)	(16.1)	(10.7)	(10.8)	(8.0)	(8.1)	(9.6)	(8.1)	(9.2)
Fluid ounces of goal set (Behavioural Intention)	Mean	21.1	23.0	19.7	14.8	12.5	9.7	8.9	9.5	8.6	7.7	6.2	6.8
	(SD)	(18.9)	(25.8)	(19.2)	(14.2)	(10.7)	(10.8)	(8.0)	(8.1)	(7.4)	(7.0)	(6.1)	(7.4)
Perceived behavioural control	Mean	6.35	6.38	6.37	6.41	6.45	6.28	6.47	6.36	6.39	6.48	6.41	6.48
	(SD)	(1.03)	(.88)	(.89)	(.85)	(.79)	(1.07)	(.71)	(.86)	(.76)	(0.78)	(.80)	(.69)
Affective attitudes	Mean	4.60	4.62	4.63	4.79	4.78	4.82	4.77	4.86	4.70	5.13	4.98	4.89
	(SD)	(1.31)	(1.27)	(1.13)	(1.19)	(1.22)	(1.30)	(1.23)	(1.25)	(1.21)	(1.22)	(1.25)	(1.26)
Instrumental attitudes	Mean	5.83	5.24	5.15	5.30	5.29	5.26	4.98	5.22	4.99	5.11	5.25	5.41
	(SD)	(1.40)	(1.07)	(1.13)	(.98)	(.96)	(1.12)	(1.06)	(1.08)	(1.05)	(.93)	(.83)	(.92)
Subjective norms	Mean	4.43	4.47	4.37	4.60	4.55	4.58	4.53	4.67	4.82	5.03	5.09	4.97
	(SD)	(1.64)	(1.35)	(1.47)	(1.44)	(1.48)	(1.39)	(1.44)	(1.37)	(1.53)	(1.20)	(1.26)	(1.30)

Notes: Analysis performed using last observation carried forward imputation methods; variations in sample size are due to exclusion of cases based on outlier analysis.

Table 6

Prediction of sugar-sweetened beverage behavioural intentions from theory of planned behaviour constructs with the same IVR call.

	Call	TB n = 155	IVR1 n = 153	IVR2 n = 154	IVR3 n = 155	IVR4 n = 155	IVR5 n = 154	IVR6 n = 154	IVR7 n = 155	IVR8 n = 155	IVR9 n = 154	IVR10 n = 155	IVR11 n = 155
Step 1 Model	R^2	.10***	.05**	.04**	.09***	.21***	.23***	.12***	.15***	.27***	.26***	.24***	.35***
Step 2 Model	R^2	.09***	.11***^	.06*	.09***	.24***^	.22***	.14***	.20***^	.33***^	.31***^	.29***^	.38***^
Perceived behavioural control	β Step 2	−.28**	−.12	−.12	−.33***	−.47***	−.55***	−.30**	−.26**	−.40***	−.69***	−.45***	−.54***
Affective attitudes	β Step 2	−.08	−.21*	−.16	−.02	−.03	.07	−.04	−.14	−.21	.29**	.01	<.01
Instrumental attitudes	β Step 2	.07	.13	.13	.03	.17*	<−.01	.07	−.06	.07**	.11	−.13	−.05
Subjective norms	β Step 2	<.01	.22**	.05	.11	.11	.08	−.19*	−.19*	−.15*	−.11	−.24***	−.21***

Notes: Step 1 included PBC and Step 2 included addition of instrumental attitudes, affective attitudes, and SN. Analysis performed using last observation carried forward imputation methods; variations in sample size are due to exclusion of cases based on outlier analysis.

^ $R^2\Delta < 0.05$

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$.

Table 7

Prospective prediction of reported sugar-sweetened beverage behaviour in the following IVR call from theory of planned behaviour constructs.

		TeachBack to IVR 1 ***n* = 153**	**IVR 1 to IVR 2** ***n* = 154**	**IVR 2 to IVR 3** ***n* = 154**	**IVR 4 to IVR 5** ***n* = 154**	**IVR 5 to IVR 6** ***n* = 154**	**IVR 6 to IVR 7** ***n* = 154**	**IVR 7 to IVR 8** ***n* = 155**	**IVR 9 to IVR 10** ***n* = 154**	**IVR 10 to IVR 11** ***n* = 155**
Step 1 Model	R^2	.05**	.32***	.25***	.31***	.04**	.30***	.54***	.30***	.54***
Step 2 Model	R^2	.06**	.31***	.25***	.32***	.05*	.29***	.55***	.37***^	.55***^
Behavioural intentions	β Step 2	.20*	.58***	.49***	.49***	.18*	.55***	.69***	.39***	.66***
Perceived behavioural control	β Step 2	−.12	.05	−.06	−.15	−.11	<−.01	−.11	−.32***	−.15*

Notes: Step 1 included BI and Step 2 included addition of PBC. Analysis performed using last observation carried forward imputation methods; variations in sample size are due to exclusion of cases based on outlier analysis.

^ $R^2\Delta < 0.05$

* $p < 0.05$;

** $p < 0.01$;

*** $p < 0.001$.