

## Predicting Sugar Consumption: Application of an Integrated Dual-Process, Dual-Phase Model

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## Abstract

Excess consumption of added dietary sugars is related to multiple metabolic problems and adverse health conditions. Identifying the modifiable social cognitive and motivational constructs that predict sugar consumption is important to inform behavioral interventions aimed at reducing sugar intake. We tested the efficacy of an integrated dual-process, dual-phase model derived from multiple theories to predict sugar consumption. Using a prospective design, university students ( $N = 90$ ) completed initial measures of the reflective (autonomous and controlled motivation, intentions, attitudes, subjective norm, perceived behavioral control), impulsive (implicit attitudes), volitional (action and coping planning), and behavioral (past sugar consumption) components of the proposed model. Self-reported sugar consumption was measured two weeks later. A structural equation model revealed that intentions, implicit attitudes, and, indirectly, autonomous motivation to reduce sugar consumption had small, significant effects on sugar consumption. Attitudes, subjective norm, and, indirectly, autonomous motivation to reduce sugar consumption predicted intentions. There were no effects of the planning constructs. Model effects were independent of the effects of past sugar consumption. The model identified the relative contribution of reflective and impulsive components in predicting sugar consumption. Given the prominent role of the impulsive component, interventions that assist individuals in managing cues-to-action and behavioral monitoring are likely to be effective in regulating sugar consumption.

*Key words:* sugar intake; intentions; implicit attitudes; reflective-impulsive model; model of action phases; action planning

In the context of a global pandemic of obesity and associated chronic illnesses including diabetes, cardiovascular disease, and certain cancers, the impact of high intake of dietary sugar is a principal concern (Swinburn et al., 2011). Research has indicated that consumption of added sugars in the diet (i.e., sugars added to foods during preparation or processing, or added at the table; Johnson et al., 2009) is related to a number of metabolic problems and adverse health conditions, and is considered a major factor contributing to a positive energy balance and weight gain (Malik, Popkin, Bray, Després, & Hu, 2010). This has led health organizations to publish recommendations for reductions in the intake of added dietary sugars (Johnson et al., 2009; WHO, 2015). For example, the American Heart Association recommends that no more than 100 calories per day (equivalent to about 6 teaspoons of sugar) for women and 150 calories per day (about 9 teaspoons of sugar) for men should be taken as added sugars (Johnson et al., 2009). In response to the proliferation of evidence highlighting the need for dietary sugar reduction in the prevention of chronic illnesses and conditions, researchers have begun to explore the determinants of dietary sugar intake, particularly the psychological and behavioral factors (e.g., de Bruijn & van den Putte, 2009; Naughton, McCarthy, & McCarthy, 2015; van der Horst et al., 2007). The goal of such research is to provide formative evidence that can be used as a basis for effective behavioral interventions to reduce sugar intake. The research has identified belief-based factors from social cognitive theories such as attitudes, intentions, and perceived control as important in predicting sugar consumption. However, research adopting these theories has indicated that they explain modest variance in sugar consumption, and fail to account for the multiple factors and processes that underpin sugar consumption (Tak et al., 2011; van der Horst et al., 2007). In the current study, we aim to extend this research by testing the efficacy of an integrated theoretical model in predicting dietary sugar consumption. Recognizing that intake of dietary sugar may not be solely determined by conscious, reflective processes, the model will account for the non-conscious, impulsive processes that lead to sugar consumption (c.f., Keatley, Clarke, & Hagger, 2012; Perugini, 2005; Pesseau et al., 2014). We also aim to test the role that volitional processes (e.g., planning) have in predicting individuals to enact their intentions.

### **Dual-Process Models of Health Behavior**

A common assumption of the social cognitive and motivational theories applied to predict health behaviors (e.g., theory of planned behavior, social-cognitive theory, health belief model) is that action is determined by a deliberative process (Biddle, Hagger, Chatzisarantis, & Lippke, 2007; Conner & Norman, 2015). The theories assume that individuals act on the basis of evaluating the available information regarding future courses of action (e.g., weighing up perceived costs and benefits) and make decisions accordingly. Other motivational approaches such as self-determination theory (Deci & Ryan, 2000) also assume that actions are based on conscious deliberation. The theory predicts that individuals will be motivated to act if the behavior is perceived as servicing some sort of desired or personally-relevant need. Syntheses of research has demonstrated that constructs from these social cognitive and motivational theories (e.g., internal and external motivation, intentions, attitudes, subjective norm, self-efficacy, risk perceptions) have typically accounted for non-trivial variance in behavior across numerous domains (McEachan et al., 2016; Ng et al., 2012; Rich, Brandes, Mullan, & Hagger, 2015). Nevertheless, effect sizes of the salient predictors on behavior have been modest, with substantive variance in behavior remaining unexplained. Furthermore, there is evidence that measures reflecting factors related to non-conscious, automatic processes such as past behavior and self-reported habit and automaticity account for substantive variance in health behavior independent of the constructs from social cognitive and motivational theories (Allom, Mullan, Cowie, & Hamilton, 2016; Arnautovska, Fleig, O'Callaghan, & Hamilton, 2017; Gardner, 2015).

These findings are consistent with dual-process theories in which behavior is viewed as a function of conscious, reflective processes that involve deliberation over a course of action, consistent with the constructs typically identified in social cognitive and motivational theories, and non-conscious processes that reflect impulsive, spontaneous pathways to action that operate beyond an individual's awareness (Evans & Stanovich, 2013; Sheeran, Gollwitzer, & Bargh, 2013; Strack & Deutsch, 2004). The non-conscious processes likely reflect well-learned patterns of action that are driven by organized knowledge structures or 'schema' activated by the cues or contexts linked to the behavioral response in memory. Such knowledge structures may be represented by implicitly-held attitudes or beliefs toward particular concepts or actions. Research has demonstrated that measures of implicit beliefs, such as the implicit

association test (IAT; Greenwald, Nosek, & Banaji, 2003), have independent effects on behavior in health contexts when included in predictive models alongside explicitly-measured constructs that reflect deliberative, reflective processes (Keatley et al., 2012; Perugini, 2005; Sheeran et al., 2013). Such research has provided new insight into the relative contributions of the explicit and implicit constructs that determine action. Importantly, behaviors like eating highly palatable foods, such as those high in sugar, are reinforced over time through endogenous reward systems via the dopaminergic pathways in the mesolimbic system in the brain. They are therefore more likely to be determined by non-conscious, impulsive pathways (Stice, Figlewicz, Gosnell, Levine, & Pratt, 2013). Drawing from this research, we aim to examine the extent to which implicit attitudes toward sugar, which reflect the impulsive determinants of behavior, impact sugar consumption in a model that incorporates constructs representing both explicit and implicit processes.

### **Motivational and Volitional Components of Action: Dual-Phase Models**

Research applying social cognitive and motivational models in health behavior has identified a shortfall in the strength of the relation between intentions and behavior (Orbell & Sheeran, 1998; Rhodes & de Bruijn, 2013). While intention-behavior relations are often non-trivial in size and statistically significant, the size of the relation is often modest indicating that many individuals may not enact the health behavior even though they intend to do so (Orbell, 2004). Dual-phase models such as the model of action phases (Heckhausen & Gollwitzer, 1987) and health action process approach (HAPA; Schwarzer, 2008) propose that volitional processes such as planning may help ‘bridge the gap’ between intentions and behavior. Such processes are proposed to act in a ‘post-decisional’ manner in a volitional phase that follows the motivational phase. For example, the model of action phases suggests that individuals who furnish their intentions with specific action plans<sup>1</sup>, stating when and where the behavior will be enacted, are more likely to act on their intentions. In this case, the plans serve to moderate the intention-behavior relationship. According to the HAPA, action plans, along with coping plans that focus on managing potential barriers and setbacks, explain why intentions result in behavioral enactment. In this case, the

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<sup>1</sup>Action plans and implementation intentions are frequently conceptualized with identical content (Hagger & Luszczynska, 2014). For the purpose of the current article, we consider them synonymous.

plans serve as mediators of the intention-behavior relationship. Research has supported the moderating and mediating roles for planning in health behavior research providing confirmatory support for the role for volitional processes in explaining and modifying the effects of intention on action (e.g., Hagger et al., 2016; Zhou et al., 2015). Researchers have, therefore, begun to incorporate volitional components in integrated dual-phase models that aim to provide a comprehensive account of the motivational and volitional processes that lead to action. In the current research we aim to incorporate planning constructs that represent volitional processes in the dual-phase approaches alongside intentions in a comprehensive, integrated account of the factors that impact on sugar consumption.

### **Proposed Integrated Model and Hypotheses**

The aim of the current study was to test an integrated dual-process, dual-phase model derived from multiple theories to predict sugar consumption in a sample of university students. The proposed model is presented in Figure 1 and hypothesized relations among model constructs are summarized in Table 1. The motivational phase comprises hypotheses derived from research integrating self-determination theory (Deci & Ryan, 2000) and the theory of planned behavior (Ajzen, 1991). Conceptual (Hagger & Chatzisarantis, 2014) and meta-analytic (Hagger & Chatzisarantis, 2009) reviews have supported the complementarity of these two theoretical approaches in explaining motivated behavior in health contexts. Self-determination theory, as an organismic, needs-based approach, provides a basis for the origin of the proximal belief-based determinants of motivated action from social cognitive models. The theory of planned behavior is a specific form of the reasoned action approach (Fishbein & Ajzen, 2009; McEachan et al., 2016), a generalizable social cognitive approach that identifies the proximal, belief-based predictors of intentional behavior. According to the integrated approach, individuals are likely to align their beliefs about conducting a target behavior in future, such as those from the theory of planned behavior, if the behavior is perceived as servicing outcomes or actions likely to satisfy the psychological need for autonomy (i.e., to feel as if one's actions are self-endorsed and volitional) from self-determination theory. Research adopting the integrated approaches have confirmed that forms of motivation from self-determination theory serve as distal predictors of the social-cognitive antecedents of action from the theory of planned behavior (Hagger & Chatzisarantis, 2009). In the current context, autonomous

motivation to reduce sugar consumption is expected to positively predict intentions to reduce sugar consumption mediated by attitudes, subjective norm, and perceived behavioral control. Controlled motivation is expected to indirectly and positively predict intentions through subjective norm, but not attitudes and perceived behavioral control. Intentions to reduce sugar consumption are expected to mediate effects of the motivational orientations and attitudes, subjective norm, and perceived behavioral control on future sugar consumption. The volitional phase encompasses hypotheses from the model of action phases (Heckhausen & Gollwitzer, 1987) and the HAPA (Schwarzer, 2008). Specifically, action planning is expected to moderate the intention-sugar consumption relationship consistent with the model of action phases, and action planning and coping planning are expected to mediate the effect of intentions on sugar consumption consistent with the HAPA. Taken together, these hypotheses encompass the explicit components that determine action through consciously-mediated, reflective processes. We also predict that implicit attitudes toward sugar will predict sugar consumption independent of the motivational constructs, and there will be no effects of implicit attitudes on intentions, consistent with hypotheses from the reflective impulsive model (Strack & Deutsch, 2004). Model effects are expected to hold when controlling for past sugar consumption. We expect a simultaneous test of the proposed network of relations among model components to exhibit good fit with the data. Results will demonstrate the relative contribution of that constructs from the two phases (motivational and volitional) and two processes (explicit and implicit) make in predicting sugar consumption.

## **Method**

### **Participants, Design and Procedure**

Participants were students studying at two universities in Australia. Students were recruited via an online pool of research study participants and either received course credit or an opportunity to enter a prize draw to win department store vouchers for participation. The study received approval from the institutional review boards of each university. A prospective correlational design was used with participants completing study measures in an initial laboratory visit (T1). Participants completed a follow-up survey containing behavioral measures at a second point in time (T2), two weeks later.

Table 1. Summary of hypothesized direct and indirect effects in the integrated dual-process, dual-phase model for sugar consumption.

Hypothesis	Independent variable	Dependent variable	Mediator(s)	Prediction <sup>a</sup>
<b>Explicit processes, motivational phase</b>				
H <sub>1</sub> : SDT motivation→Social cognitive constructs				
H <sub>1a</sub>	Autonomous motivation	Attitude	–	Effect (+)
H <sub>1b</sub>	Autonomous motivation	Subjective norm	–	Effect (+)
H <sub>1c</sub>	Autonomous motivation	Perceived behavioral control	–	Effect (+)
H <sub>1d</sub>	Controlled motivation	Attitude	–	No effect
H <sub>1e</sub>	Controlled motivation	Subjective norm	–	Effect (+)
H <sub>1f</sub>	Controlled motivation	Perceived behavioral control	–	No effect
H <sub>2</sub> : Social cognitive variables→Intention/Behavior				
H <sub>2a</sub>	Attitude	Intention	–	Effect (+)
H <sub>2b</sub>	Subjective norm	Intention	–	Effect (+)
H <sub>2c</sub>	Perceived behavioral control	Intention	–	Effect (+)
H <sub>2d</sub>	Intention	Sugar consumption	–	Effect (–)
H <sub>3</sub> : Social cognitive variables→Intention→Behaviour				
H <sub>3a</sub>	Attitude	Sugar consumption	Intention	Effect (–)
H <sub>3b</sub>	Subjective norm	Sugar consumption	Intention	Effect (–)
H <sub>3c</sub>	Perceived behavioral control	Sugar consumption	Intention	Effect (–)
H <sub>4</sub> : SDT motivation→Social cognitive variables→Intention/behavior				
H <sub>4a</sub>	Autonomous motivation	Intention	Attitude Subjective norm Perceived behavioral control	Effect (+)
H <sub>4b</sub>	Controlled motivation	Intention	Attitude Subjective norm Perceived behavioral control	Effect (+)
H <sub>4c</sub>	Autonomous motivation	Sugar consumption	Attitude Subjective norm Perceived behavioral control Intention	Effect (–)
H <sub>4d</sub>	Controlled motivation	Sugar consumption	Attitude Subjective norm Perceived behavioral control Intention	Effect (–)
H <sub>5</sub> : Past behaviour→All variables				
H <sub>5a</sub>	Past sugar consumption	Attitude	–	Effect (–)
H <sub>5b</sub>	Past sugar consumption	Subjective norm	–	Effect (–)
H <sub>5c</sub>	Past sugar consumption	Perceived behavioral control	–	Effect (–)
H <sub>5d</sub>	Past sugar consumption	Autonomous motivation	–	Effect (–)
H <sub>5e</sub>	Past sugar consumption	Controlled motivation	–	Effect (–)
H <sub>5f</sub>	Past sugar consumption	Intention	–	Effect (–)
H <sub>5g</sub>	Past sugar consumption	Action planning	–	Effect (–)
H <sub>5h</sub>	Past sugar consumption	Coping planning	–	Effect (–)
H <sub>5i</sub>	Past sugar consumption	Sugar consumption	–	Effect (–)
H <sub>5j</sub>	Past sugar consumption	Implicit attitude	–	Effect (+)
H <sub>5k</sub>	Past sugar consumption	Action planning	–	Effect (–)
H <sub>5l</sub>	Past sugar consumption	Coping planning	–	Effect (–)
<b>Implicit processes, motivational phase</b>				
H <sub>6</sub> : Implicit attitude→Intention/behavior				
H <sub>6a</sub>	Implicit attitude	Intention	–	Effect (+)
H <sub>6b</sub>	Implicit attitude	Sugar consumption	–	Effect (–)
H <sub>6c</sub>	Implicit attitudes	Sugar consumption	Intention	Effect (–)



Explicit processes, volitional phase				
H <sub>7</sub> : Intention→Planning				
H <sub>7a</sub>	Intention	Action planning	–	Effect (+)
H <sub>7b</sub>	Intention	Coping planning	–	Effect (+)
H <sub>8</sub> : Planning→Behavior				
H <sub>8a</sub>	Action planning	Sugar consumption	–	Effect (–)
H <sub>8b</sub>	Coping planning	Sugar consumption	–	Effect (–)
H <sub>8c</sub>	Action planning x Intention	Sugar consumption	–	Effect (–)
H <sub>9</sub> : Intention→Planning→Behavior				
H <sub>9a</sub>	Intention	Sugar consumption	Action planning	Effect (–)
H <sub>9b</sub>	Intention	Sugar consumption	Coping planning	Effect (–)

*Note.* SDT = Self-determination theory; <sup>a</sup>Denotes whether the hypothesis specifies a positive (+) effect, a negative (–) effect, or no effect.

At T1 participants completed a survey containing self-report measures of psychological and behavioral constructs and questions capturing demographic characteristics. They also completed an implicit association test (IAT) measuring their implicit preference for sugar. The IAT was conducted in a sound-proofed research laboratory on a personal computer with the task administered using the SocialSci™ experimental software. Participants’ data across each time points was anonymized and matched across time points using a unique code identifier created by the participant. We conducted a statistical power analysis to provide an estimate of the minimum required sample size to test our proposed model. Our estimate was based on the smallest expected effect size among the psychological predictors of the key dependent variable in the model: self-reported sugar consumption at T2. Research applying social cognitive models such as the theory of planned behavior and HAPA in the context of eating behaviors have typically identified medium-sized effects of social cognitive variables (e.g., intentions, self-efficacy) on behavior (e.g., McDermott et al., 2015), while research examining effects of implicit attitudes on behavioral outcomes in similar contexts have indicated small effect sizes (e.g.,  $r = .25$ , Pavlović, Žeželj, Marinković, & Sučević, 2016;  $r = .22$ , Perugini, 2005)<sup>2</sup>. We therefore used the aggregate effect size for implicit attitudes across the latter studies converted to Cohen’s  $f^2$  as the input effect size for our power analysis. We expected this to provide the most conservative minimum sample size estimate for testing our model. We computed our minimum sample size using the G\*Power program (Faul, Erdfelder, Lang, & Buchner, 2007) for a linear multiple regression analysis with eight predictors, with the effect size ( $f^2$ ) set

<sup>2</sup>As there have been no previous studies examining effects of implicit attitudes towards sugar on sugar consumption, we focused on studies examining closely-related behaviors as sources of potential effect sizes including preference for candy (sweets) over fruit (Pavlović et al., 2016) and preferences for snacks over fruit (Perugini, 2005, Study 2).

at 0.07, statistical power set at .80, and alpha ( $p$ ) set at .05. The analysis yielded a minimum sample size estimate of 90.

## Measures

Psychological constructs were measured on previously-validated psychometric instruments developed using standardized guidelines (Ajzen, 2003; Ryan & Connell, 1989) adapted to make reference to the target behavior in the current study. Details of the measures are provided next and a full set of items and responses to scales are available in Appendix A (supplemental materials). Items from each instrument were used as indicators of latent variables representing each model construct in a structural equation model. Participants were initially presented with a written definition of foods and beverages with high added sugar content. High added-sugar foods and beverages were defined as those containing more than 22.5 grams (4.5 teaspoons) of sugar per 100 grams (Rex & Nelson, 2014). Participants were then provided with a list of high-sugar food types with illustrative examples: full-sugar soft drinks (not diet), sweets and candies, buns, pastries, pies, cakes, cookies, biscuits, chocolate snack bars (e.g., Snickers), desserts (e.g., ice-cream), and other items with added sugar (e.g., breakfast cereals, ketchup, jams and sugary spreads). They were asked to consider this definition when responding to subsequent survey items and think about the next two weeks.

**Sugar consumption.** The target behavior was dietary sugar consumption over a two-week period. Participants were asked to report their consumption of high-sugar foods and beverages over the previous two weeks at T1 and T2 on two items reflecting general sugar intake (e.g., “In the course of the past 2 weeks, how often have you consumed foods or beverages that are high in sugar?”) and four items reflecting sugar intake from specific high-sugar food items (e.g., “During the last 2 weeks, I consumed... full-sugar soft drinks”). Items were based on food frequency questionnaire items used in previous research on sugar consumption and foods high in added sugar (Naughton et al., 2015).

**Intention.** Intentions to limit consumption of high-sugar foods and beverages in the next two weeks was measured on a single item (“I try hard to avoid consuming foods and beverages that are high in sugar”).

**Attitude.** Attitude towards limiting consumption of high-sugar foods and beverages was assessed on four semantic differential items (e.g., unpleasant-pleasant) using a common stem: “For me, avoiding consuming foods and beverages that are high in sugar is...”

**Subjective norm.** Subjective norm was measured on four items assessing how likely significant others would want the individual to reduce their intake of high-sugar foods and beverages (e.g., “Most people who are important to me would want me to avoid consuming foods and beverages that are high in sugar”).

**Perceived behavioral control.** Perceived behavioral control was assessed on four items relating to control beliefs over intake of high sugar foods and beverages (e.g., “How much personal control do you have in avoiding consuming foods and beverages that are high in sugar?”).

**Autonomous and controlled motivation.** A measure of autonomous and controlled reasons for reducing consumption of high-sugar foods and beverages was developed based on Ryan and Connell’s (1989) measure. Participants were presented with a common stem: “I avoid consumption of high-sugar foods and beverages because...” followed by six reasons relating to autonomous (e.g., “...I like to avoid consuming sugar”) and controlled (e.g., “...others would be angry at me if I did not.”) motives.

**Action and coping planning.** Action and coping planning were measured by three items each assessing the extent to which participants planned to avoid high-sugar foods and beverages in the next two weeks (action planning; e.g., “I have already planned on how I want to avoid consuming foods and beverages that are high in sugar”) and planned to deal with setbacks (coping planning; e.g., “I have already planned what to do if something interferes with my plans.”).

**Implicit attitude.** Implicit attitude towards sugar were measured using a single-category implicit association test (SC-IAT; Karpinski & Steinman, 2006) developed for the current study. The SC-IAT was thought to be the most appropriate measure as the target category (sugar) had no clear opposing category, which is necessary for measures using the traditional IAT. Items representing the target category in the SC-IAT were selected from a pool of candidate words and synonyms identified in a thesaurus search that were considered representative of the word ‘sugar’. Items for the attribute categories comprised positive and negative word sets used in previous IATs. Items for the target and attribute categories are provided in

Table 2. The SC-IAT included five blocks of trials. Blocks 1, 2, and 4 were practice blocks consisting of 20 trials. Blocks 3 and 5 were the test blocks comprising 72 trials. The practice blocks were to familiarize participants with the response keys and required participants to respond to the positive and negative attribute categories only using the keyboard. In the test blocks, participants were presented with items from the target category and were required to match them with the appropriate positive or negative attribute category. Response latencies for each item were logged by the computer. Averaged response latencies for items in blocks 3 and 5 were used to compute the *D* measure of implicit attitudes toward sugar consumption using Greenwald et al.’s (2003) improved scoring algorithm, with lower, negative scores representing stronger attitudes.

*Table 2.* Items used in single-category implicit association test as a measure of implicit attitudes toward sugar

Target category item	Positive attribute category items	Negative attribute category items
Sugar	Smile	War
Syrup	Love	Crime
Candy	Friend	Hate
Sucrose	Trust	Torture
Glucose	Fun	Murder
Honey	Happiness	Lies
Lolly	Relax	Disease
Caramel	Joy	Death
Bonbon	Beautiful	Horrible
Icing	Pleasure	Painful

**Demographic variables.** Participants self-reported their age in years, gender, smoking status, University degree type, weight in kilograms, height in metres, ethnicity, and the highest education level attained by their parents. These data were used to describe the sample and to test for variations in sample composition due to attrition. As we aimed to examine the unique effects of the theory-based factors on sugar consumption independent of socio-demographic factors, we also planned to control for age, gender, and body mass index (BMI) in our main analysis as these demographic factors are likely to correlate with health behaviors (e.g., Lo, Waller, Vrinten, Kobayashi, & von Wagner, 2015; Mesters, Wahl, & Van Keulen, 2014). Research has indicated the importance of social cognitive and motivational factors predicting health behavior beyond the effects of socio-demographic variables (Smith et al., 2016; von

Wagner, Good, Whitaker, & Wardle, 2011), and studies examining social cognitive predictors of sugar consumption (e.g., Tak et al., 2011; van der Horst et al., 2007) have typically controlled for these factors.

### **Data Analysis**

We used variance-based structural equation modeling (VB-SEM) to test our hypothesized model. VB-SEM is similar to covariance-based SEM, but is based on ranked data and is therefore distribution-free and is less affected by model complexity, sample size, or departures from normality. Models were estimated using the Warp PLS v5.0 software (Kock, 2015). Missing data were treated using stochastic hierarchical regression imputation. Items from the measures of the psychological and behavioral constructs were set as indicators of latent variables. All paths among constructs detailed in Figure 1 and the hypotheses listed in Table 1 were specified as free parameters in the model. In addition, we statistically controlled for the effects of age, gender, and BMI by releasing free parameters between these variables and all variables in the model.

Validity of the proposed measures was assessed by observing the parameters of the measurement aspects of the SEM. The loading of each indicator on its respective latent factor were expected to exceed .700. Composite reliability coefficients ( $\rho$ ) and average variance extracted (AVE) statistics, which test the sufficiency of scale items as indicators the latent variables and whether the items account for sufficient variance in the factor, both indicators of construct validity, were expected to exceed .700 and .500, respectively. Overall model fit was evaluated using multiple criteria: the goodness-of-fit (GoF) index with values of .100, .250, and .360 corresponding to small, medium, and large effect sizes, respectively, the average path coefficient (APC) and the average  $R^2$  (ARS), both of which should be significantly different from zero for an adequate model, and the average variance inflation factor for model parameters (AVIF) statistic, with values less than 5.000 indicating a well-fitting model (Kock, 2015). Model parameter estimates and standard errors were computed using a robust bootstrap resampling method with 999 replications of the model in samples drawn from, and equal in size to, the actual sample.

## **Results**

### **Participants and attrition analyses**

Twenty-one participants dropped out of the study after completing the initial survey at T1 resulting in a final sample of 90 participants. Demographic characteristics of the sample at the two time points are presented in Appendix B (supplemental materials). Attrition analyses indicated that there were no significant differences in age ( $t(109) = 0.73, p = .466, d = 0.14$ ), gender ( $\chi^2(1) = 0.57, p = .451$ ), BMI ( $t(108) = 0.02, p = .983, d < 0.01$ ), degree type ( $\chi^2(1) = 0.48, p = .491$ ), highest education level attained by participants' mother ( $\chi^2(4) = 1.48, p = .830$ ) and father ( $\chi^2(4) = 2.38, p = .667$ ), ethnicity ( $\chi^2(7) = 6.13, p = .525$ ), and levels of the psychological and behavioral variables (attitude, subjective norm, perceived behavioral control, intention, autonomous motivation, controlled motivation, action planning, coping planning, IAT *D* score, and past sugar consumption; Wilks' Lambda = .92,  $F(9,101) = 0.99, p = .457, d = .19$ ) between participants that dropped out of the study and those that remained in the final sample.

### **Preliminary Analyses**

Measurement model statistics from the VB-SEM confirmed that the latent variables met criteria for construct and discriminant validity. Factor loadings for each latent factor exceeded the .700 criterion supporting the validity of the factors. Composite and Cronbach alpha ( $\alpha$ ) reliability coefficients, AVE, and intercorrelations for model variables are presented in Table 3. Reliability coefficients exceeded the .700 criterion and alpha coefficients indicated adequate internal consistency ( $\alpha$  range = .783 to .891). AVE values approached or exceeded the recommended .500 criterion. We estimated the reliability of the SC-IAT separately using Karpinski and Steinman's (2006) protocol. While the reliability coefficient (adjusted  $r = .48$ ) was slightly lower than the average for standard IATs (Schnabel, Asendorpf, & Greenwald, 2008), it was comparable to that attained for other SC-IATs (2006) and higher than reliabilities observed in other latency-based implicit measures (e.g., Olson & Fazio, 2003). Correlations among the latent variables also indicated no problems with discriminant validity. Goodness of fit statistics revealed acceptable overall fit of the model with the data according to the multiple indices adopted (GoF Index = .498; APC = .164,  $p = .027$ , ARS = .322,  $p < .001$ ; AVIF = 1.176).

Table 3. Factor intercorrelations, composite reliabilities, and average variance extracted for latent variables in the integrated dual-process, dual phase model for sugar consumption.

Variable	AVE	$\alpha$	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Sugar consumption	.481***	.783	.847													
2. Past behavior	.501***	.792	.726***	.855												
3. Intention	–	–	-.337**	-.288**	–											
4. Implicit attitude	–	–	-.320**	-.161	.032	–										
5. Attitude	.691***	.851	-.345***	-.388***	.457***	.109	.899									
6. Subjective norm	.631***	.803	-.024	.059	.329**	.119	.206	.872								
7. PBC	.755***	.892	-.328**	-.415***	.306**	.170	.574***	.145	.925							
8. Action planning	.811***	.883	-.248*	-.266**	.635***	.023	.551***	.319**	.451***	.928						
9. Coping planning	.821***	.891	-.244*	-.252*	.392***	.067	.364***	-.027	.439***	.544***	.932					
10. Aut. motivation	.546***	.878	-.362***	-.300**	.565***	.087	.707***	.287**	.487***	.573***	.467***	.905				
11. Con. motivation	.465***	.834	-.037	.024	.235*	.007	.183	.380***	-.038	.285**	.091	.445***	.874			
12. Gender	–	–	.088	.143	.058	-.046	-.062	.016	-.156	-.005	-.032	-.040	.174	–		
13. BMI	–	–	.050	-.098	.106	.026	.124	.145	.033	.181	-.111	-.010	-.014	-.301**	–	
14. Age	–	–	-.188	-.230*	.147	.021	.344***	.062	.221*	.193	.116	.195	-.091	-.169	.318**	–

Note. Composite reliability coefficients shown on principal diagonal; AVE = Average variance extracted;  $\alpha$  = Cronbach alpha coefficient; Past behavior = Past sugar consumption; PBC = Perceived behavioral control; Aut. motivation = Autonomous motivation; Con. motivation = Controlled motivation

\*\*\* p < .001 \*\* p < .01 \* p < .05.

## Model Effects

Standardized parameter estimates for hypothesized relations among model factors are presented in Figure 1<sup>3</sup>. Overall, the model accounted for 29.6% of the variance in intentions to reduce sugar intake and 69.2% of the variance in sugar consumption. Tests of hypothesized effects in the model outlined in Table 1 are reported in the next sections.

**Explicit processes, motivational phase.** We predicted effects of motives from self-determination theory on the social cognitive variables from the theory of planned behavior (H<sub>1</sub>). As predicted, autonomous motivation had statistically significant and positive direct effects on attitudes (H<sub>1a</sub>), subjective norm (H<sub>1b</sub>), and perceived behavioral control (H<sub>1c</sub>), and controlled motivation had a significant positive effect on subjective norm (H<sub>1e</sub>), but no effect on attitudes (H<sub>1d</sub>). Contrary to hypotheses, we found a significant negative effect of controlled motivation on perceived behavioral control (H<sub>1f</sub>). We also predicted that the social cognitive variables would predict intentions and behavior, consistent with the theory of planned behavior (H<sub>2</sub>). As hypothesized, attitudes (H<sub>2a</sub>) and subjective norm (H<sub>2b</sub>) were significant positive predictors of intentions, but perceived behavioral control was not, leading us to reject this hypothesis (H<sub>2c</sub>). There was a significant negative effect of intentions on sugar consumption, as predicted (H<sub>2d</sub>). We also predicted indirect effects of the social cognitive variables in sugar consumption mediated by intentions (H<sub>3</sub>). There were significant negative indirect effects of attitudes (H<sub>3a</sub>) and subjective norm (H<sub>3b</sub>) on sugar consumption mediated by intentions as predicted, but no indirect effects of perceived behavioral control (H<sub>3c</sub>) on sugar consumption, leading to a rejection of the latter hypothesis. We also expected indirect effects of self-determined motives on intentions and behavior mediated by the social cognitive variables (H<sub>4</sub>). We found a significant positive indirect effect of autonomous motivation on intention mediated by attitudes, subjective norm, and perceived behavioral control consistent with our hypothesis (H<sub>4a</sub>). There was, however, no indirect effect of controlled motivation on intention, so this hypothesis was rejected (H<sub>4b</sub>). There was a significant negative indirect effect of autonomous motivation (H<sub>4c</sub>) on sugar consumption consistent with our hypothesis, but no indirect effect of controlled motivation

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<sup>3</sup>Full parameter estimates including direct, indirect, and total effects are presented in the table in Appendix C (supplemental materials).



(H<sub>4d</sub>) on sugar consumption, so we rejected this hypothesis. Past sugar consumption was a significant predictor of the majority of the model variables, as predicted (H<sub>5</sub>); effects of past consumption on subjective norm (H<sub>5b</sub>), intention (H<sub>5f</sub>), and action planning (H<sub>5g</sub>) were the exceptions.

**Implicit processes, motivational phase.** We predicted that implicit attitudes toward sugar would predict intentions and sugar consumption (H<sub>6</sub>). We found a statistically significant negative direct effect of implicit attitudes on sugar consumption (H<sub>6b</sub>), but no effect of implicit attitudes on intention (H<sub>6a</sub>) and no indirect effect of implicit attitudes on sugar consumption through intentions (H<sub>6c</sub>).

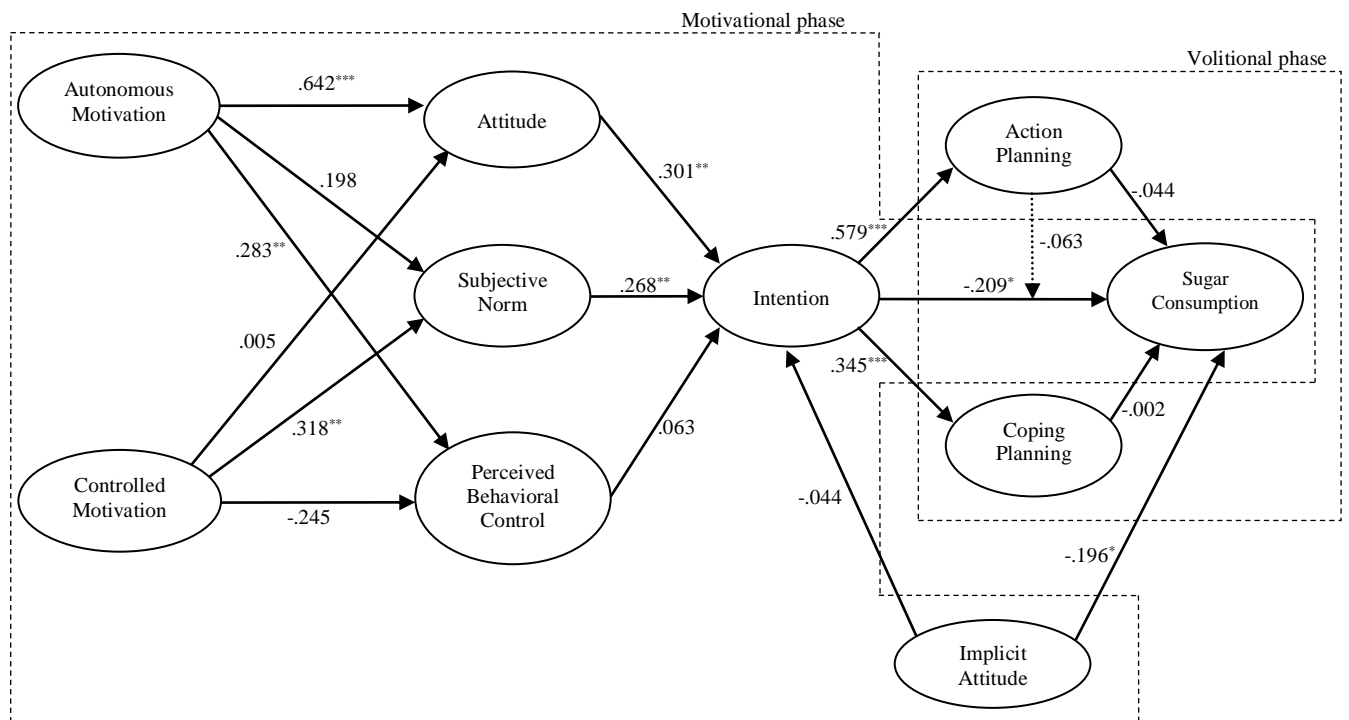


Figure 1. Standardized path coefficients for structural equation model of relations among the integrated dual-process, dual-phase model of sugar consumption. All variables depicted were measured at the initial laboratory visit (T1) with the exception of sugar consumption, which was measured at follow-up two weeks later (T2). Effects of control variables (past behavior, BMI, age, and gender) are not shown in the diagram. Intention, implicit attitudes, and the control variables (age, gender, BMI) were estimated as single-indicator latent variables with their variance fixed at unity. By convention, these constructs are represented by ellipses rather than rectangles. However, these constructs are not considered “true” latent variables as their measurement error is not explicitly modeled (Kock, 2015).

**Explicit processes, volitional phase.** We expected intentions to predict the planning constructs (H<sub>7</sub>). Intentions statistically significantly and positively predicted both action (H<sub>7a</sub>) and coping planning (H<sub>7b</sub>), as hypothesized. We also predicted that the planning variables, and their interaction with intention, would predict sugar consumption (H<sub>8</sub>), consistent with the model of action phases (Heckhausen & Gollwitzer, 1987). However, contrary to hypotheses, there were no effects of action planning (H<sub>8a</sub>) and

coping planning ( $H_{8b}$ ), or their interaction ( $H_{8c}$ ), on sugar consumption. We also hypothesized that the planning variables would mediate effects of intentions on sugar consumption ( $H_9$ ), consistent with the HAPA (Schwarzer, 2008). However, we found no indirect effects of intention on sugar consumption mediated by action ( $H_{9a}$ ) and coping ( $H_{9b}$ ) planning.

### **Discussion**

The purpose of the current study was to test a comprehensive dual-process, dual-phase integrated model derived from multiple theories to identify the processes that determine dietary sugar consumption. The model proposed that sugar consumption is a function of conscious, deliberative processes encompassed by motivational orientations and social cognitive beliefs from self-determination theory and the theory of planned behavior, respectively, and impulsive, non-conscious processes represented by implicit attitudes toward sugar. The model also proposed that enactment of intentions is determined by action and coping planning in a post-decisional volitional phase of action. Results indicated that intentions to limit sugar intake, representing the reflective process of action, and implicit attitudes toward sugar, representing impulsive processes, were significant predictors of sugar consumption. Intentions were predicted by attitudes, subjective norm, and, indirectly, autonomous motives. There were no significant effects for controlled motives and perceived behavioral control. There were also significant indirect effects of autonomous motivation on sugar consumption through the social cognitive variables and intentions, but not for controlled motivation. Action planning and coping planning were predicted by intentions, but did not mediate the intention-behavior relationship, and there was no interactive effect of action planning and intention on sugar consumption.

Effects of intentions and implicit attitudes on behavior implicate both reflective and impulsive processes in the prediction of sugar intake. This is consistent with dual process models of behavior (e.g., Evans & Stanovich, 2013; Hagger, 2016; Strack & Deutsch, 2004) and previous research (e.g., Keatley et al., 2012; Perugini, 2005; Proulx et al., 2014) that has simultaneously investigated effects of both processes in other health behaviors. Although there is increased recognition of the importance of accounting for both processes when predicting health behavior, the most salient emerging question from such research is not whether the two processes predict, but, rather, the relative contribution of each. In the

context of sugar consumption, current evidence indicates that both processes are of equal importance. Findings are consistent with previous research on the social cognitive predictors of behaviors related to sugar consumption, such as consumption of high-sugar soft drinks, which has identified the prominent role of intentions, but also important contributions from variables reflecting impulsive processes, such as self-reported behavioral automaticity (de Bruijn & van den Putte, 2009; Naughton et al., 2015; Tak et al., 2011; van der Horst et al., 2007). The current study is, however, the first to demonstrate the role for implicitly-held cognitions as a predictor of dietary sugar consumption in the context of a dual process model. Current findings are congruent with the notion that sugar consumption is an extremely rewarding behavior regulated by well-learned behavioral patterns reinforced by dopamine-mediated pathways in the mesolimbic system in the brain (Stice et al., 2013). Implicit attitudes toward sugar, therefore, reflect these impulsive tendencies and are likely developed over time through the rewarding experience of sugar consumption. The intentional constructs to reduce sugar consumption must, therefore, compete with implicit beliefs in accounting for behavior.

It must, however, be stressed that the size of the effects for both explicit and implicit constructs were small. In addition, the majority of the explained variance (35.1%) was accounted for by past behavior. This shortfall in explanatory value of the current model could be attributed to constructs that were not measured in the current research and methodological artifacts. Unmeasured constructs may be other implicitly-held beliefs that may account for variance in the behavior, such as self-control and motives. They may also include individual difference constructs that may have pervasive effects on impulsive actions, such as impulsivity and self-regulatory capacity.

Intentions to reduce sugar consumption were a function of attitudes and subjective norm, and, indirectly, autonomous motivation. This is consistent with other research integrating self-determination theory and the theory of planned behavior in health contexts (e.g., Hagger & Chatzisarantis, 2009; Hamilton, Cox, & White, 2012). Current findings corroborate the importance of self-endorsed motives that are congruent with the individual's true sense of self as the basis for the beliefs that determine intentions. Individuals who hold personally-endorsed motives to reduce dietary sugar are more likely to align their attitudes and norms to reduce their sugar consumption in future, and more likely to intend to

do so. Controlled motives seem to have a less important role, consistent with research on self-determination theory suggesting that such beliefs are less likely to be related to uptake and maintenance of health behavior. Interestingly, perceived behavioral control was unrelated to autonomous motivation and intentions to reduce sugar consumption. This was contrary to hypotheses, and the majority of research in health behavior, which has typically provided support for the role of perceived behavioral control in predicting intentions (McEachan et al., 2016; Rich et al., 2015), including behaviors related to sugar consumption (de Bruijn & van den Putte, 2009; Naughton et al., 2015; van der Horst et al., 2007). In the current study, it may be that effects of perceived behavioral control were subsumed by other constructs in the model. Correlations between perceived behavioral control and attitudes, past behavior, and the planning constructs, in particular, were large in magnitude and statistically significant (see Table 3), which means any effects of perceived behavioral control may have been attenuated by these constructs. The constructs that remained as predictors, therefore, reflect those that account for unique variance in intentions to reduce sugar consumption.

It is important to note that the indirect effects of autonomous motivation, attitudes, and subjective norm on sugar consumption were relatively small ( $\beta$  range =  $-.055$  to  $-.063$ ). While indirect effects are typically smaller than direct effects in multiple mediator models, the main reason for the small effects is the relatively modest effect of intentions on behavior. Aside from measurement limitations, the weak intention-behavior effect may be due to the strong and pervasive influence of past behavior in model. Past sugar consumption was highly correlated with sugar consumption ( $r = .718$ ,  $p < .001$ ; Table 3), had the strongest effect on sugar consumption in the final model, as well as significant effects on the majority of the other variables in the model, and accounted for almost half of the explained variance in sugar consumption. This should not be surprising given the relatively close proximity (two weeks) in the two measures. Together, the strong and pervasive effects of past behavior on sugar consumption likely reduced the effect of intentions. The fact that we found independent effects for intention and implicit attitudes, and indirect effects of distal predictors, in the context of the strong effects for past behavior is notable and indicates that, despite limitations of the current study, our data support the predictive validity of our model in accounting for unique variance in sugar consumption.

In addition, while the volitional components of action and coping planning were related to intentions, they had no mediation or moderation effect with intention on sugar consumption, despite significant correlations between the planning measures and sugar consumption (see Table 3). This finding may also be due to the pervasive effects for past sugar consumption in the model. These limitations notwithstanding, current results do not provide evidence to support the role of volitional components in the effect of intention on sugar consumption. Ruling out a role for planning in determining sugar consumption may be premature based on these data alone, especially since the current model is a static depiction of the decision-making process rather than a dynamic depiction that describes changes in constructs over time. However, the current model should provide an initial basis to question the multiple roles of planning in the conversion of intentions to action. And the current research is not the first to question the role of planning, other research has revealed null effects and suggest that effects of planning may vary by behavior type (e.g., Jackson et al., 2005; Meslot, Gauchet, Allenet, François, & Hagger, 2016).

### **Study limitations**

The current research has numerous strengths including (a) a focus on sugar consumption, a relatively under-researched, but important, dietary behavior; (b) the adoption of an integrated dual-process, dual-phase theoretical approach and appropriate measures; and (c) a the use of confirmatory analytic techniques to test model effects. However, there are a number of limitations that should be acknowledged. First, the relatively small effects observed between model variables may reflect problems with the methods used. For example, we used a single item measure of intentions, so we were unable to estimate the reliability of this measure. Further, measurement of behavior through a relatively brief self-report measure is also an important limitation. Although many studies have adopted self-reported behavioral measures in model tests in health behavior contexts, corroboration through more comprehensive diaries or tracking sugar intake using ecological momentary assessment (Carels, Douglass, Cacciapaglia, & O'Brien, 2004) or photographic methods (Ovaskainen et al., 2007) may provide more accurate estimates. In addition, although our short-term follow up of behaviour (two weeks) had the advantage of maximizing participants' recall in our self-report measure of sugar consumption, the

short-term follow-up should be recognised as an important limitation as it did not enable assessment of long-term predictive validity. Using more comprehensive measures of sugar consumption over an extended period would provide effective evaluation of long-term model effectiveness. It should also be recognized that relations among the psychological constructs measured at T1 were based on theory alone as the current design did not permit inferences of directionality or causation (Hagger & Chatzisarantis, 2016). Longitudinal designs, particularly panel designs that enable cross-lagged relations among model constructs, are advocated in future tests to better account for the ordering and directionality of effects in the model.

A further caveat is that the variables included in our model were confined to those identified in previous conceptual (Hagger & Chatzisarantis, 2014) and empirical (Hagger & Chatzisarantis, 2009; Keatley et al., 2012; Penseau et al., 2014) research integrating motivational, volitional, and implicit components. While there is increasing research supporting such approaches, it is important to note that they may not account for all processes or components. For example, different types of self-efficacy and risk perceptions identified in the HAPA (Schwarzer, 2008) and emotional processes (Conner, McEachan, Taylor, O'Hara, & Lawton, 2015) were not considered. We view the integrated model tested in the current study as a flexible framework to guide the identification of the multiple components and processes that relate to health behavior. We hope the test will provide impetus for future research that seeks to further extend the model and integrate additional components. Finally, we acknowledge that the final sample size was relatively small which may have affected the stability of model parameter estimates and the precision of the standard errors. Our bootstrap resampling method with a large number of replications provided robust parameter estimates and standard errors. However, such simulation analyses should not be considered a panacea for the need for large sample sizes or true replications of model effects. We advocate replication of the current findings in larger, more diverse samples, which may provide converging evidence for the generalizability of proposed pattern of effects in our model.

## **Conclusion**

Current findings support the basic premises of an integrated dual-process, dual-phase model in predicting dietary sugar consumption. Intentions to reduce sugar intake and implicit attitudes toward

sugar were independent predictors of sugar consumption, albeit with small effects. Results are consistent with findings of other research that has applied models incorporating multiple processes to explain health behavior, and provide preliminary evidence for the contribution both reflective and impulsive processes in predicting sugar consumption. Current findings should be viewed as preliminary given this is a single study in a student sample. Corroboration of current effects should be considered a priority for future research. Confirmation of consistent effects of implicit attitudes as predictors of dietary sugar intake may have ramifications for the types of interventions likely to be effective in regulating sugar consumption. For example, environmental restrictions and self-monitoring may be effective means to control cue presentation and restrict the enactment of automatic behavioral tendencies in behaviors that have a strong automatic component.

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*Scale Items for Constructs of the Integrated Dual-Process, Dual-Phase Model of Sugar Consumption*

Variable	Item	Scale
Intention	I try hard to avoid consuming foods and beverages that are high in sugar.	1 = “completely disagree, 4 = ”completely agree”.
Attitude	For me, avoiding consuming foods and beverages that are high in sugar in the next week is...	1 = “of no use, 7 = “useful” 1 = “unimportant, 7 = “important 1 = “unenjoyable”, 7 = “enjoyable 1 = “unpleasant”, 7 = “pleasant”
Subjective norm	Most people who are important to me would want me to avoid consuming foods and beverages that are high in sugar. Most people I know would approve of me avoiding consuming foods and beverages that are high in sugar. People who are important to me would_____of me avoiding consuming foods and beverages that are high in sugar. Most people close to me expect me to avoid consuming foods and beverages that are high in sugar.	1 = “strongly disagree, 7 = “strongly agree” 1 = “strongly disagree, 7 = “strongly agree” 1 = “disapprove very strongly, 7 = “approve very strongly” 1 = “extremely unlikely, 7 = “extremely likely”
Perceived behavioral control	How much personal control do you have in avoiding consuming foods and beverages that are high in sugar? I am confident I can completely avoid consuming foods and beverages that are high in sugar. I am in complete control over avoiding consuming foods and beverages that are high in sugar. I believe I have the ability to avoid consuming foods and beverages that are high in sugar.	1 = “no control”, 7 = “complete control” 1 = “extremely unconfident, 7 = “extremely confident” 1 = “strongly disagree, 7 = “strongly agree” 1 = “strongly disagree, 7 = “strongly agree”
Autonomous motivation	I try to reduce my sugar consumption in my food in my daily life because... ...I like to avoid consuming sugar. ...I feel like it’s the best for me. ...it is a challenge. ...it feels important to me personally to accomplish this goal. ...it is interesting to see my own improvement. ...avoiding consuming sugar is important to me.	1 = “not at all true”, 7 = “very true” 1 = “not at all true”, 7 = “very true” 1 = “not at all true”, 7 = “very true” 1 = “not at all true”, 7 = “very true” 1 = “not at all true”, 7 = “very true” 1 = “not at all true”, 7 = “very true”
Controlled motivation	I try to reduce my sugar consumption in my food in my daily life because... ...others would be angry with me if I did not. ...I would feel like a failure if I did not. ...people would think I’m a weak person if I do not. ...I worry that I would get in trouble with others if I did not. ...I feel guilty if I do not. ...I want others to acknowledge that I am doing what I have been told I should do.	1 = “not at all true”, 7 = “very true” 1 = “not at all true”, 7 = “very true” 1 = “not at all true”, 7 = “very true” 1 = “not at all true”, 7 = “very true” 1 = “not at all true”, 7 = “very true” 1 = “not at all true”, 7 = “very true”
Action	I have already planned on how I want to avoid consuming foods and beverages that are high in sugar. I have already planned when to avoid consuming foods and beverages that are high in sugar.	1 = “not at all, 4 = “completely” 1 = “not at all, 4 = “completely”

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planning	I have already planned where to avoid consuming foods and beverages that are high in sugar.	1 = "not at all, 4 = "completely"
Coping	I have already planned what to do if something interferes with my plans.	1 = "not at all, 4 = "completely"
planning	I have already planned what to do in difficult situations to stick to my intentions. I have already planned what to do with possible setbacks.	1 = "not at all, 4 = "completely" 1 = "not at all, 4 = "completely"
Past sugar	During the last 2 weeks, I consumed... full-sugar soft drinks (not diet)	1 = "never", 6 = "more than once a day"
consumption	During the last 2 weeks, I consumed...:sweets (candies, lollies)	1 = "never", 6 = "more than once a day"
and sugar	During the last 2 weeks, I consumed...:buns, pastries, pies, cakes, cookies, biscuits	1 = "never", 6 = "more than once a day"
consumption	During the last 2 weeks, I consumed...:chocolate, chocolate snack bars (e.g. Snickers), toffees	1 = "never", 6 = "more than once a day"
	In the course of the past two weeks, how often have you consumed foods or beverages that are high in sugar?	1 = "almost never, 7 = "every day"
	I consumed foods and beverages that are high in sugar the following number of times in the past two weeks.	1 = "0-5 times", 6 = "21+ times"

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## Appendix B

*Participant Characteristics and Descriptive Statistics for Study Variables for Participants Completing the Initial Survey (Time 1) and Follow-up Survey (Time 2)*

Variable	Time 1	Time 2
Participants, <i>N</i>	111	90
Age, <i>M</i> years (SD)	22.86 (7.92)	23.12 (7.87)
BMI, <i>M</i> (SD) <sup>a</sup>	23.46 (4.40)	23.46 (4.34)
Gender ( <i>n</i> female, <i>n</i> male)	91, 59	61, 29
Degree type		
Undergraduate	109	88
Postgraduate	2	2
Ethnicity		
White/Caucasian	91	73
South-east Asian	8	8
African	5	3
Chinese	2	2
Maori/Pacific islander	2	1
Middle eastern/Arabic	2	2
South Asian	1	1
Mother education level <sup>c</sup>		
Junior school	7	6
Senior school	39	32
Post-school vocational degree/diploma	23	18
University undergraduate degree	28	24
University postgraduate degree	14	10
Father education level <sup>c</sup>		
Junior school	8	5
Senior school	50	42
Post-school vocational degree/diploma	25	21
University undergraduate degree	13	10
University postgraduate degree	15	12
Psychological variables, <i>M</i> (SD)		
Attitude	3.65 (1.11)	3.73 (1.09)
Subjective norm	3.77 (0.96)	3.81 (0.93)
Perceived behavioral control	4.05 (1.07)	4.08 (1.03)
Intention <sup>e</sup>	2.44 (0.93)	2.49 (0.90)
Autonomous motivation	3.91 (1.44)	3.99 (1.34)
Controlled motivation	2.25 (0.97)	2.27 (0.91)
Action planning	2.33 (0.91)	2.43 (0.90)
Coping planning	1.94 (0.78)	2.00 (0.81)
Implicit attitude <sup>d</sup>	-0.58 (0.49)	-0.54 (0.49)
Past sugar consumption	3.58 (1.38)	3.57 (1.28)
Sugar consumption	–	3.42 (1.28)

*Note.* <sup>a</sup>One participant did not report their height and weight. <sup>b</sup>Two participants did not report their smoking status; <sup>c</sup>Represents the highest education level attained by father or male-caregiver and mother or female-caregiver; <sup>d</sup>Implicit association test d-measure using Greenwald, Nosek, & Banerji's (2003) improved scoring algorithm.

## Appendix C

*Standardized Parameter Estimates for the Direct, Indirect, and Total Effects in the Integrated Dual-Process, Dual Phase Model for Sugar Consumption.*

Effect	$\beta$	<i>P</i>
<b>Direct effects</b>		
Autonomous motivation→Attitude	.642	<.001
Autonomous motivation→Subjective norm	.198	.076
Autonomous motivation→PBC	.283	.002
Controlled motivation→Attitude	.005	.484
Controlled motivation→Subjective norm	.318	.001
Controlled motivation→PBC	-.245	.052
Attitude→Intention	.301	.004
Subjective norm→Intention	.268	.002
Perceived behavioral control→Intention	.063	.282
Intention→Behavior	-.209	.013
Implicit attitude→Intention	-.044	.384
Implicit attitude→Behavior	-.196	.011
Intention→Action planning	.579	<.001
Action planning→Behavior	-.044	.321
Intention→Coping planning	.345	<.001
Coping planning→Behavior	-.002	.492
Action planning x Intention→Behavior	-.063	.303
Past behavior→Attitude	-.193	.038
Past behavior→Subjective norm	.024	.447
Past behavior→PBC	-.401	.007
Past behavior→Intention	-.152	.117
Past behavior→Behavior	.655	<.001
Past behavior→Autonomous motivation	-.319	.012
Past behavior→Controlled motivation	-.242	.232
Past behavior→Implicit attitudes	-.248	.023
Past behavior→Action planning	-.094	.192
Past behavior→Coping planning	-.200	.089
<b>Indirect effects</b>		
Attitude→Intention→Behavior	-.063	.041
Subjective norm→Intention→Behavior	-.056	.032
Perceived behavioral control→Intention→Behavior	-.013	.266
Implicit attitude→Intention→Behavior	.009	.373
Autonomous motivation→Attitude, Subjective norm, PBC→Intention	.264	.004
Controlled motivation→Attitude, Subjective norm, PBC→Intention	.071	.121
Autonomous motivation→Attitude, Subjective norm, PBC→Intention→Behavior	-.055	.035
Controlled motivation→Attitude, Subjective norm, PBC→Intention→Behavior	-.015	.129
Intention→Action planning, Coping planning→Behavior	-.026	.348
<b>Total effects</b>		
Attitude→Behavior	-.071	.058
Subjective norm→Behavior	-.063	.041
Perceived behavioral control→Behavior	-.015	.287
Autonomous motivation→Behavior	-.062	.047

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Controlled motivation→Behavior	-.017	.148
Intention→Behavior	-.235	.021
Implicit attitude→Behavior	-.185	.020

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*Note.* <sup>a</sup>Effect represents total indirect effect through multiple mediators. PBC = Perceived behavioral control; Behavior = Sugar consumption; Past behavior = Past sugar consumption.